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Original Article

Comparing the Effect of Balance and Coordination Exercise on Different Platforms as on Floor, Swiss Ball & Foam in Geriatric Population – A Randomized Control Trial

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ABSTRACT

Background/Purpose: Due to the rise in hospitalization morbidity and mortality among the elderly population, balance issues pose a significant problem for healthcare. Studies on the prevention of falls in the elderly have shown that exercise regimens can reduce the risk of falling and improve daily activities. This study aimed to investigate the effect of specific balance training of elderly population on uneven surface in comparison to general balance training on even surface.

Methods: The participants were randomly assigned to Group A (floor or even surface training), Group B (Swiss ball training), or Group C (Foam platform training).The Berg Balance Scale, Functional Reach Test, and non-equilibrium coordination test were used for pre- and post-assessment.

Results: In the present study, balance and coordination training on floor, swiss ball and foam platform resulted in a significant difference between the pre- and post-assessment of BBS and the coordination of the right and left sides. In addition, functional reach testing (FRT) revealed that while there was a significant improvement following swiss ball and foam platform training, there was no significant change between pre and post assessment after floor training.

Conclusion: Balance training on an uneven surface, predominantly a foam platform, led to significant improvements in balance and coordination compared to training on a swiss ball or a flat surface.

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Balance, swiss ball, foam platform, flat surface, elderly adults.

1. INTRODUCTION

Approximately 7.4% of the global population is comprised of people aged 60 and above, making them part of what is known as the geriatric population.[1] In next coming years, it will become essential for more healthcare professionals to clinically evaluate and treat the geriatric group of population.[2] The elderly are fastest growing segment of our population. Health care providers around the world are increasingly worried about the growing problem of elderly people being unable to maintain their balance, which increases the risk of serious injury from falls and even death. It has been estimated that nearly one in three people over the age of 65 will experience a fall on a yearly basis.[3]

Aging is an ongoing process, which mostly reflects the person's chronological age, and process is unique in every single person.[4] Aging is a very common factor that leads to loss of bone density especially in females, degenerative changes of bone, symptoms of arthritis, muscular weakness, atrophy of muscles, visual impairment, hearing impairment and many more.[5] Due to more impairments, elderly persons are at high risk of loss of balance and coordination which leads to fall.[6] The inability of older persons to keep their postural control is the primary contributor to the increased risk of falling that they experience. The capacity to synchronize many systems in a continuous cycle is essential for maintaining postural control. These systems include the sensory systems (i.e., vestibular, visual, and somatosensory), the cognitive system (central nervous system), and the musculoskeletal system. Changes in a person's visual, vestibular, and somatosensory inputs, as well as changes in the central processing and muscular effectors, are all part of the normal ageing process and occur in all individuals.[3,6] As people get older, their vestibular function and their sense of perception both begin to decline, which can affect their quality of life.[7]

Several therapeutic approaches have been demonstrated to be effective for the prevention of falls among older adults, and there is a large body of literature documenting the beneficial effects of physical activity training programs in reducing the risk of falling as well as the number of falls that occur in the elderly.[8,9] According to earlier studies, balance training also increases the strength of the muscles in the lower extremities.[10,11]

Since there has been a shift towards more practical kinds of balance training, many new balance training devices have been developed. Most of these devices provide a movable surface, allowing users to vary the difficulty of their workouts by moving across or along them. The idea behind these items is straightforward by training on an unstable surface, the patient or client will be subjected to new and different balancing challenges, hence strengthening the neural connection between their brain and feet. Participants in balance training perform exercises that include static versus dynamic stability postures, lessening the base of support (bipedal versus tandem versus one-leg stance), changes in the height of the center of gravity, alteration in the standing platforms (such as floor, wobble boards, wobble cushions, foam, or perturbation platforms), as well as minimizing the source of sensory input, all while attempting to simulate perturbations that lead to falls during daily activities.[12-14]

Sport science studies reveal that balancing training on unstable surfaces considerably improves balance compared to balancing training on stable surfaces, which was previously used in trials to help the elderly avoid falls and their accompanying injuries.[15] This could be due to enhanced proprioception, which is mediated by skin receptors in the foot and by mechanoreceptors in the joints and muscles. An increase in afferent input from mechanoreceptors in the muscles and joints, brought on by postural sway on unstable surfaces, has been shown to improve both proprioception and posture.[16,17]

Swiss ball provides instability or resistance, which used on core muscles to regain the balance by improving strength and flexibility of abdominal muscles. Swiss ball is used for training the core, improving posture, improving balance and stability. The core group of muscles are important because it provides proximal stability for distal mobility.[18,19] A small number of studies have shown that stepping on a foam platform stimulates proprioceptive impulses for postural reflexes from skin receptors in the sole and mechanoreceptors in the joints and muscles.[16]

Keeping this in regards, the present study aimed to investigate the balance and coordination in a geriatric population using three training strategies: floor training, swiss ball training, and foam platform training. The study included subjects with moderate risk of fall, as the confounding factors are minimum as compared to high risk factors. Moreover, attempting to apply the same care plan to all "high risk" patients cannot address each patient's unique risk factors. The result of this study may help the physiotherapists in applying the best training for balance and coordination in elderly population and there preventing frequent falls.

2. METHODS

2.1. Study Design

An experimental Pre-Post study design was used in the study.

2.2. Study Setting

Participants (both males and females) were randomly selected from Om Jara Nivas (Old age home) and Prayas Senior Citizen Home of Odisha.

2.2.1. Sampling technique

Convenience Sampling is employed in this study since it is the most convenient method of recruiting subjects. External validity is not promoted by convenience sampling. Despite its inherent disadvantages, convenience sampling is frequently employed to enrol participants for a study since it is simple to implement. Convenience sampling can be utilised in conjunction with almost any study design, not just clinical trials.

2.2.2. Sample size

A total of 81 people were divided into 3 groups in order to achieve statistical significance with a two-tailed alpha of 0.05 and 90% power.

2.2.3. Inclusion and exclusion criteria

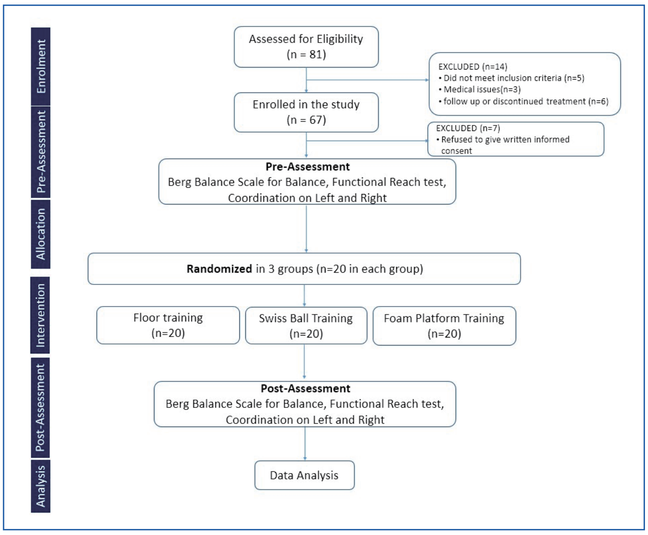
Participants in the age group of 60 to 75 years from both gender and having moderate risk of fall (assessed by BBS <21 and >40) were included in the study. Participants suffering from any neurological disease such as stroke, Hemiplegia, Parkinson or any acute musculoskeletal injuries or any acute congestive heart failure, or any cognitive or sensory impairment or having severe visual deficit were all excluded.

2.3. Procedure

Based on the inclusion and exclusion criteria, 67 elderly participants were selected and enrolled from 81 participants screened. All of them were informed in detail about the type and nature of the study and were advised about the risks and benefits of participating in the study in their local language. Written informed consent was obtained once the participants were acquainted with risks and benefits of participating in the study. However, seven participants were excluded as they refused to give written informed consent to enroll in the study (Figure 1).

Further, the remaining 60 participants were randomly divided in 3 groups - Group A, training on floor or even surface (n=20), Group B, training on Swiss ball (n=20), and Group C, training on Foam platform (n=20). Group A received training for balance and coordination on floor or even surface on day one and were further given home regimes to continue for 4 weeks. Group B and Group C received four weeks training (four times/week) for balance and coordination on swiss ball and foam platform respectively.

Figure 1. Consort flow chart of the study design



Swiss ball training included sitting exercises, standing exercises, prone exercises, trunk rotations, exercises to improve core stability, and exercises to improve balance and coordination for 20 minutes, 4 times a week for 4 weeks. The exercises were provided to the patients to improve balance and coordination on foam platform were double-leg standing, single-leg standing, neck movements, free leg swinging, heel and toe raises, trunk rotation, walking in place. The exercises were given for a duration of 20mins, 4 session per week for 4 weeks.

Demographics details were obtained in terms of age, gender and fall of risks. All the participants underwent pre-assessment for balance using Berg Balance Scale & Functional Reach Test and coordination using 12 task points of non-equilibrium test form. Warm-up activities on a Swiss ball or foam platform were given for 5 minutes at the start of the training session. There were brief rest intervals between each set of exercises. Cool-down exercises were performed at the end of the training program.

2.4. Evaluation Tools

2.4.1. Balance test: Berg Balance Scale

The Berg Balance Scale (BBS) was used to quantify balance on floor, Swiss ball and foam platform. It consists of 14 tasks that take roughly 20 minutes to complete and include static balance (e.g., standing unaided with feet together) and dynamic balance (e.g., planting an alternating foot on a step while standing unsupported). Each task is graded from 0 (severely impaired balance) to 4 points (excellent balance), having an overall score scale from 0 to 56 points. Berg Balance Scale score of 41-56 indicates low risk of fall with good balance, 21- 40 indicates moderate risk of fall with fair balance and 0-20 indicates high risk of fall with impaired balance.[20]

2.4.2. Functional reach test

The FRT was administered using the previous study.[21] After the examiner explained and demonstrated the FRT, each participant completed one practice trial and three test trials. A levelled yardstick connected to the wall at the height of the participant's right acromion was used to determine functional reach. An examiner stood 4 feet away from the yardstick and recorded the participant's beginning and end reach locations to determine the participant reaching distance. Participant stood comfortably with their feet shoulder-width apart, formed a loose fist, and put their right arm parallel to the yardstick without contacting the wall (initial position). Participants then moved forward as far as they could without losing their balance (end position). The starting and final locations of the third metacarpal along the yardstick were recorded. Participants were allowed to stand on their toes, however contacting the wall, walking while reaching forward, or hanging onto their clothes with their left hand rendered the experiment null and void. If the trial was found to be invalid, it was repeated a maximum of five times to reach three valid trials. The functional reach was computed as the mean difference between the beginning and final positions for the three-test trials.

2.4.3. Coordination test

The non-equilibrium exercise form was used to quantify the coordination on floor, swiss ball and foam platform. This test is composed of 12 types of non-equilibrium tasks such as finger to nose, finger to therapist's finger, finger to finger, finger opposition, mass grip, pronation/ supination, tapping (hand), tapping (foot), toe to examiners finger, heel on shin, drawing a circle (hand) and drawing a circle (foot). For each question, the grading key is from 0 to 4; 0 for activity impossible, 1 for severe impairment, 2 for moderate impairment, 3 for minimal impairment, and 4 for normal performance. Total score for this coordination test ranges between 0 to 48.

2.5. Statistical Analysis

Statistical analysis was performed with the help of SPSS v.25.0 Demographic data were expressed as mean and standard deviation (SD). The data was assessed for normality using Shapiro-Wilk test. Paired t-test was used to find out the changes within the group (before and after intervention) for all the three groups. One-way analysis of variance (ANOVA) was used to compare the baseline values between the three groups. A 2 x 3 repeated measures ANOVA was applied to see the difference between and within the three groups. A Bonferroni post-hoc analysis was performed using the least significant difference (LSD) to compare the mean changes among the three groups (floor, swill ball and foam platform) and to detect which of these three have more impact.

3. RESULTS

It was observed that there was significant difference between pre to post assessment of BBS and coordination of right and left in all the three different groups. However, functional reach test (FRT) showed that there was no significant change between pre to post assessment following floor training but there was significant change following swiss ball and foam platform training (Table 1).

One way analysis of variance (ANOVA) results showed that there was no significant difference in the pre-assessment of all the outcome variables between the three groups when compared for BBS (F=0.157, p=0.855), functional reach test (F=0.155, p=0.856), or coordination on left (F=0.21, p=0.812) and right (F=0.517, p=0.599). However, the post assessment showed significant difference in BBS (F=82.37, p <0.01), FRT (F=21.49, p <0.01), Coordination left (F=22.60, p <0.01) and right (F=23.47, p <0.01) between the 3 groups following swiss ball training (Table 2)

Posthoc test showed that there was significant change in BBS score between floor and swiss ball training (Mean difference, MD=-8.15, p <0.001), between floor and foam platform training (MD=-12.35, p <0.001), and even between swiss ball and foam platform training (MD=-4.20, p <0.001). FRT showed significant different between floor and swiss ball training (MD=-4.73, p <0.001), floor and foam platform training (MD=-6.76, p <0.001) but the different was not significant between the swiss ball and foam platform training (MD=-2.03, p=0.14). Further, there was significant difference in the coordination on the left between the floor and swiss ball (MD=-5.40, p=0.02), floor and foam platform (MD=-12.55, p <0.001), and between swiss ball and foam platform (MD=-7.15, p <0.001). Similar results were found when comparing the coordination on the right (Table 3).

Table 1. Paired t test between the pre and post assessment of all the outcome variables in the 3 different training group

Outcome Variables	Group	Pre	Post	Mean Diff.	95% CI		t value	*p* value
					Lower	Upper		
BBS	Floor	27.6±2.72	30.15±2.56	-2.55	-3.80	-1.30	-4.28	*p* <0.001
	Swiss Ball	27.85±2.96	38.3±3.5	-10.45	-11.85	-9.05	-15.67	*p* <0.001
	Foam Roller	28.15±3.57	42.5±3.15	-14.35	-16.53	-12.17	-13.81	*p* <0.001
FRT	Floor	12.75±1.92	13.25±4.37	-0.50	-2.21	1.21	-0.61	0.55
	Swiss Ball	12.85±1.66	17.98±2.71	-5.13	-6.63	-3.63	-7.14	*p* <0.001
	Foam Roller	13.05±1.61	20.005±2.67	-6.955	-8.54	-5.37	-9.21	*p* <0.001
Coordination Left	Floor	30.1±7.53	32.9±8.21	-2.80	-4.09	-1.52	-4.56	*p* <0.001
	Swiss Ball	30.45±4.44	38.3±5.43	-7.85	-10.94	-4.76	-5.32	*p* <0.001
	Foam Roller	31.15±2.32	45.45±2.87	-14.3	-16.08	-12.52	-16.83	*p* <0.001
Coordination Right	Floor	35.1±7.53	32.85±8.23	2.25	1.16	3.34	4.31	*p* <0.001
	Swiss Ball	35.85±60.6	40.2±5.24	-4.35	-6.01	-2.70	-5.49	*p* <0.001
	Foam Roller	37.05±4.35	45.55±2.96	-8.5	-9.69	-7.31	-14.94	*p* <0.001

Pre and post training assessment of different tasks under BBS were analyzed in the three groups (Figure 2). All the 14 components measured at pre-assessment that is before training showed no significant different between the three groups and presented with the similar findings of impaired balance with moderate risk of fall. There was significant difference in different activities of BBS following balance and coordination training on swiss ball and foam platform, however, foam platform training showed more striking improvement in balance will risk of fall.

Table 2. One-way analysis of variance test within the three groups before and after training

Outcome Variables	Time	Training	Mean±*SD*	95% Confidence Interval		F value	*P* value
				Lower Bound	Upper Bound		
Age		Floor	67.30±4.12	65.37	69.23	0.346	0.709
		Swiss Ball	67.85±4.21	65.88	69.82		
		Foam Platform	66.80±3.62	65.11	68.49		
BBS	Pre	Floor	27.60±2.72	26.33	28.87	0.157	0.855
		Swiss Ball	27.85±2.96	26.46	29.24		
		Foam Platform	28.15±3.57	26.48	29.82		
	Post	Floor	30.15±2.56	28.95	31.35	82.366	$p<0.001$
		Swiss Ball	38.30±3.50	36.66	39.94		
		Foam Platform	42.50±3.15	41.02	43.98		
FRT	Pre	Floor	12.75±1.92	11.85	13.65	0.155	0.856
		Swiss Ball	12.85±1.66	12.07	13.63		
		Foam Platform	13.05±1.61	12.30	13.80		
	Post	Floor	13.25±4.37	11.21	15.30	21.487	$p<0.001$
		Swiss Ball	17.98±2.71	16.71	19.25		
		Foam Platform	20.01±2.67	18.76	21.25		
Coordination Left	Pre	Floor	30.10±7.53	26.58	33.62	0.21	0.812
		Swiss Ball	30.45±4.44	28.37	32.53		
		Foam Platform	31.15±2.32	30.06	32.24		
	Post	Floor	32.90±8.21	29.06	36.74	22.601	$p<0.001$
		Swiss Ball	38.30±5.43	35.76	40.84		
		Foam Platform	45.45±2.87	44.10	46.80		
Coordination Right	Pre	Floor	35.10±7.53	31.58	38.62	0.517	0.599
		Swiss Ball	35.85±6.06	33.01	38.69		
		Foam Platform	37.05±4.35	35.02	39.08		
	Post	Floor	32.85±8.23	29.00	36.70	23.471	$p<0.001$
		Swiss Ball	40.20±5.24	37.75	42.65		
		Foam Platform	45.55±2.96	44.16	46.94		

Table 3. Posthoc test of different outcome variables showing difference between the three groups before and after training

Dependent Variable	Time	Group	Group	Mean Difference	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
BBS	Post	Floor	Swiss Ball	-8.15	$p<0.001$	-10.50	-5.80
		Floor	Foam Platform	-12.35	$p<0.001$	-14.70	-10.00
		Swiss Ball	Foam Platform	-4.20	$p<0.001$	-6.55	-1.85
FRT	Post	Floor	Swiss Ball	-4.73*	$p<0.001$	-7.28	-2.19
		Floor	Foam Platform	-6.76*	$p<0.001$	-9.30	-4.21
		Swiss Ball	Foam Platform	-2.03	0.14	-4.57	0.52
Coordination Left	Post	Floor	Swiss Ball	-5.40*	0.02	-9.91	-0.89
		Floor	Foam Platform	-12.55*	$p<0.001$	-17.06	-8.04
		Swiss Ball	Foam Platform	-7.15*	$p<0.001$	-11.66	-2.64
Coordination Right	Post	Floor	Swiss Ball	-7.35*	$p<0.001$	-11.83	-2.87
		Floor	Foam Platform	-12.70*	$p<0.001$	-17.18	-8.22
		Swiss Ball	Foam Platform	-5.35*	0.02	-9.83	-0.87

Only those participants who had a moderate risk of falling were included in the study in accordance with the inclusion criteria. Twenty individuals in three groups were at moderate risk of falling. After receiving balance and coordination training, the likelihood of falling was further evaluated in each of the three groups (Figure 3). Training on the floor showed that there was no change in the risk of falling. Swiss ball training decreased risk of falling from moderate (*n*=20) to low risk (n=10) and moderate risk (n=10) of falling. On the other hand, training on foam platform resulted in utmost decrease in the moderate risk of fall (n=20) to low risk (n=17) and moderate risk of falling (n=3).

4. DISCUSSION

Balance is the cornerstone of an individual's ability to move and operate independently. Balance control, on the other hand, deteriorates with age, and impaired balance is a key risk factor for falls in older persons.[22] Balance is the ability to maintain equilibrium while one's center of gravity fluctuates (dynamic balance), as in walking and running, and when it remains motionless (static balance), as in standing or sitting). To maintain equilibrium requires the coordinated effort of a number of neurological and biomechanical components, most notably the visual, vestibular, and somatosensory systems). Balance is the result of a synergistic interaction of physiologic and cognitive factors that allows for precise and speedy reactions on both stable and unstable surfaces. The assumption that an uneven surface will give a stronger challenge to the trunk musculature and boost the user's dynamic balance has led to the promotion of performing strength workouts on a Swiss ball.[15] The present study aimed to investigate the balance and coordination in a geriatric population using three training strategies: floor training, swiss ball training, and foam platform training.

Exercises for prevention are most frequently utilized to lower risk in elderly people who have deteriorating balance abilities. Because of their restricted motor ability, older persons with limited mobility may find it difficult to benefit from aerobic and resistance training for balance and coordination. As a result, exercise that requires less locomotion, such as balance or coordination exercises, may deliver equivalent advantages to older persons with varying mobility skills.[23] For elderly people, low-impact, low-impact, and high-interest coordination exercises are favored since they have a strong training effect.[24] The cerebellum, which is important for motor control and motor learning[25], is activated during coordinated exercise,

Figure 3. Fall risk of the geriatric participants in different groups

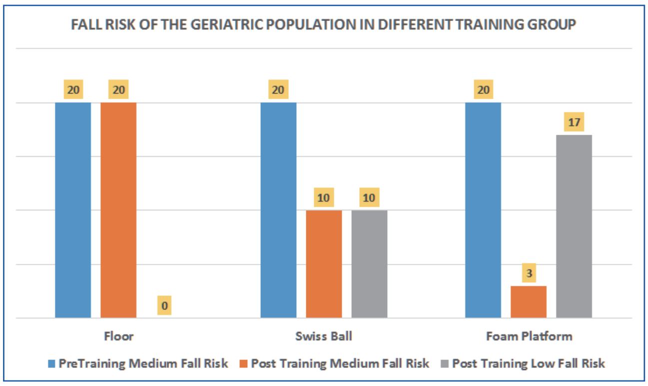
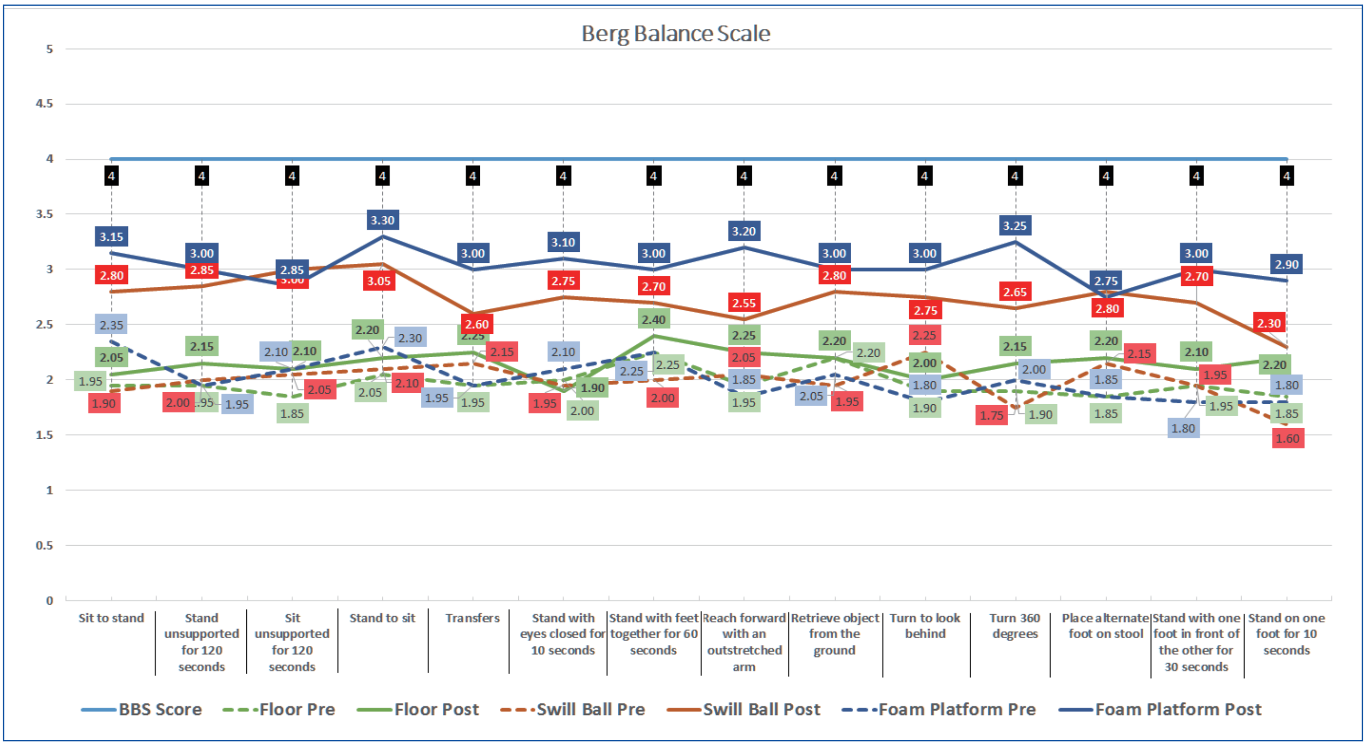


Figure 2. Pre and post assessment of Berg Balance Scale score in different groups performing balance training on floor, swiss ball and foam platform



which has been shown to affect several higher-level cognitive processes, including selective attention, working memory, and verbal learning and memory.[26,27]

Balance training guidelines recommend that unstable components be used in balance training with older persons.[11] One of the most popular ways to enhance balance in a variety of neuromuscular problems is through foam-based exercises. Several studies have found that standing on a foam rubber pad impacts skin receptors in the soles as well as mechanoreceptors in joints and muscles, providing useful proprioceptive information for postural stability.[28] Studies from the past also show that exercises done on uneven surfaces, like a Swiss ball, can be more active than exercises done on flat surfaces and help prevent damage to the muscles and joints by improving dynamic balance.[18,19]

In the present study, balance and coordination training on floor, swiss ball and foam platform resulted in a significant difference between the pre- and post-assessment of BBS and the coordination of the right and left sides. In addition, functional reach testing (FRT) revealed that while there was a significant improvement following swiss ball and foam platform training, there was no significant change between pre and post assessment after floor training. The results of this study revealed that there were no significant differences between the three groups in the pre-assessment of the outcome variables- BBS, functional reach test, and coordination on the left and right. However, following different training programs, significant differences was reported in BBS, FRT, and left and right coordination between the three groups.

The BBS score changed significantly between floor and swiss ball training, floor and foam platform training, and even swiss ball and foam platform training, as shown by post hoc analysis. FRT revealed statistically significant differences between floor and swiss ball training, floor and foam platform training, but not between swiss ball and foam platform training. According to earlier study, balance training using a foam rubber pad enhances proprioception in the lower limbs as well as the sensitivity of the cutaneous receptors in the soles.[16] These changes could account for the beneficial effects of foam rubber pad training on balance seen in the present study.

In addition, there were substantial differences in coordination on the left between the floor and the swiss ball, the floor and the foam platform, and the swiss ball and the foam platform. Similar findings was obtained when examining the coordination on the right. Older individuals' cognitive performance, as measured by the Chinese Dementia Rating Scale, was considerably enhanced by an 8-week coordination training program based on 11 movements, including finger, hand, eye, and leg coordination while the subject is sitting.[23]

In the present study, the risk of falling remained unchanged after training on the floor. Swiss ball training decreased risk of falling from moderate (*n*=20) to low risk (*n*=10) and moderate risk (*n*=10) of falling. However, training on a foam platform led to the greatest reduction in fall risk, from moderate (*n*= 20) to low (*n*=17) and moderate (*n*=3). Maintaining balance without falling is critical for carrying out daily tasks without damage. Impaired balance is a concern in elderly persons in general, and in adults with intellectual impairment (ID) in particular.[29] The central nervous system and somatic proprioceptors collaborate to refine movement patterns. Exercising on a Swiss ball may raise proprioceptive demands and stress critical muscles.[30,31]

4.1. Limitation of the Study

There are some limitations to this study that should be taken into account. The first limitation of our study is that our sample size was too low to rule out the possibility of bias and cannot be extrapolated to the entire geriatric population. Second, neither the size of swiss ball or the density of foam platform was taken into consideration. Third, no functional measurements were taken to ascertain if any functional improvement was made with respect to ADLs.

5. CONCLUSION

Conducting any balance exercise on an uneven surface as foam platform significantly increased the benefits of the movement and coordination. Due to the variability of the uneven surface, the brain and muscles are engaged at a deeper level to keep the body upright and balanced. In addition, the deep intrinsic stability system of the foot-ankle-knee complex are also activated to a much greater degree, building strength and joint integrity.

CONFLICTS OF INTEREST

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

FUNDING

No funds, grants, or other support was received for the submitted work.

ETHICAL STATEMENT

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional research committee (MRIIRS/FAHS/DEC/2021- N006 dated 16th April, 2021). This study was performed in accordance with the Helsinki Declaration of 1964, and its later amendments. The study confirm that all subjects provided informed consent to participate in the study and it also confirm that participants provided consent for publication if any identifying information is included in the manuscript.

DATA AVAILABILITY

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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