ORIGINAL RESEARCH ARTICLE

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Effect of 6 weeks of balance training on different heights of medium-density foam in geriatric population

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Abstract

Background: In older adults, progressive aging leads to a gradual decrease in physical and mental well-being, increasing the risk of fall-associated injuries and ultimately changing the quality of life. This increase in fall accidents is due to the impaired balance in older adults. To prevent such incidents, the incorporation of balance training in the rehabilitation of the geriatric population will help in challenging the vestibular system and activates the mechanoreceptors that lead to enhancing the postural stability on an unstable surface. The foam-based balance training helps to effectively improve balance; however, the height and type of foam used for the treatment and assessment purpose varies, and the suitable height of foam required for balance training is still unexplored. Hence, the study aims to determine the efficacy of various heights of medium-density foam for balance training in community-dwelling older adults.

Methods: Forty older adults ranged between 60 to 75 years were randomly chosen and divided into intervention and control groups. Both the group practiced balance training on a firm surface for 2 weeks and later intervention group received foam-based balance training on either 1″, 2″, and 3″ medium-density foam. The balance and fear of fall were measured using Mini-BesTest Scale (MBS) and Fall Efficacy Scale-I (FES-I) respectively. Furthermore, the MBS and FES-I scores were recorded on the pre-, post-2 weeks, and post-6 weeks of foam-based balance training.

Results: The MBS and FES-I show a statistically significant difference (<0.05) in pre- and post-interventions and control groups. The components of MBS merely show a significant difference in effect size in the intervention group, and it indicates poor clinical relevance in using a specific height of foam for balance training in older adults. However, within group analysis, the 3″-inch medium-density foam shows the medium effect size (>0.5) in all components of MBS as compared to other groups.

Conclusion: The specific height of foam used for foam-based balance training does not effectively differ the clinical decision-making in planning rehabilitation; rather, a long duration of balance training helps to improve balance in older adults.

Keywords: Balance, Fall Efficacy Scale-I, Foam, Geriatric, Mini-BesTest

Background

The prevalence of falls is high in the geriatric population, as progressive aging affects several body systems such as musculoskeletal, neuromuscular, and sensorimotor functions. The decrease in muscle mass and strength to overcome gravitational forces makes them difficult in tolerating upright posture and they get more

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Kadam *et al. Bulletin of Faculty of Physical Therapy*   (2022) 27:17

Page 2 of 7

prone to fall accidents [1]. These accidents develop a fear of falls and fall-related injuries resulting in a long hospital stay that leads to delay in functional recovery. Moreover, older adults spent up to 83% of hospital admission by getting bedridden [2]. Thus, fall accidents become an important reason for morbidity and mortality in geriatrics.

The Centers for Disease Control and Prevention suggest 25 to 40% of the independently living geriatric population has at least one episode of fall in a year and two-thirds of patients sustain an injury because of fall [3]. Factors contributing to falling are classified as intrinsic and extrinsic factors. Intrinsic factors are those which include physiological adaptations associated with aging, health issues, and alcohol consumption, whereas extrinsic factors are associated with environmental changes, such as slippery floors, wet floors, diffused lights, obstacles, and improper footwear [4]. The gait and balance disorders in the elderly are identified as important contributing factors for falls leading to functional impairments, disability, and poor quality of life.

Balance is a synergistic interaction between physiologic and cognitive elements that allow precise and quick responses on stable and unstable surfaces. Balance is a complex skill involving the function and unification of sensory inputs, the planning, and the execution of a task, to achieve a goal requiring to maintain a stable posture. While performing the difficult task, balance helps to maintain the center of gravity within the base of support in a challenging sensory environment [5]. Previous literature has shown that balance training is effective in improving balance and lower limb muscle strength in the community-dwelling elderly population [6]. Incorporating unstable surfaces helps to activate mechanoreceptors, vestibular system, and cutaneous receptors of the skin which efficiently improve postural stability by standing on the foam surface. Hence, the foam acts as an important sensory modality to improve balance in the elderly.

Gschwind et al. reported several reliable assessment tools to evaluate balance and fear of fall in geriatrics [7]. In our study, we intend to evaluate dynamic balance using the Mini-BesTest Scale (MBS) as an outcome measure in older adults. It is a 14-item test that comprises four components: anticipatory transitions, postural responses, sensory orientation, and dynamic gait. Each sub-item is scored from 0 to 2, where a score of 0 implies severe balance impairment and a score of 2 implies no balance impairment. The maximum score of 28 points indicates balance performance. It shows moderate to good inter-rater reliability (ICC 0.71) in community-dwelling older adults [8]. Furthermore, to assess the fear of fall in participants, a 16-item Fall Efficacy Scale-I (FES-I) was used. It shows an excellent internal consistency (Cronbach's alpha = 0.96 and 0.92) and test-retest reliability (ICC = 0.96 and 0.83) in a community-dwelling older adult [9].

Several studies have shown the effectiveness of balance training using different modalities such as foam and performance-based balance activities to help in improving balance in the elderly [6, 10, 11]. The use of foam-based exercises is among the most commonly used methods to improve balance across various neuromuscular conditions. There is a deficit in literature to understand the suitable height of foam required to improve balance when training on an unstable surface. A study by Naik et al. [12] stated that the density of the foam used for balance exercises affects the outcome. They reported that low-density foam is useful to improve balance in community old age homes followed by medium-density foam, although the height of foam used was not mentioned. The height and density of the foam surface vary with different clinical settings. Also, the authors of Bestest and Mini-BesTest recommend the use of 4-inch medium-density Tempur foam for balance assessment [8, 12]. Moreover, the height of the foam used during balance assessment also has an influence on the balance outcome in older adults. Hence, the purpose of the study is to find the suitable height of medium-density foam required to effectively improve balance during foam-based balance training in community-dwelling older adults.

Method

The study was conducted in a community-based senior citizen center. After receiving ethical approval from Ethical Committee and permission from the senior citizen club, the study was initiated. Forty healthy elderly individuals ranging from 60 to 75 years of age group, free from cognitive deficit according to MOCA Scale qualifying score of >26, free from depression according to Geriatric Depression Scale (GDS) score of 0–4, and corrected refractive error were included in the study. Those who were having major medical problems like uncontrolled diabetes and hypertension, neurological problems like stroke, Parkinson's, neuropathies, musculoskeletal problems such as severe osteoarthritis knees, recent or old fractures or surgeries of a lower limb, vestibular problems within the last 6 months, and major visual and perception problems were excluded. Before participation, we explained the purpose and procedure of the study, and informed consent was taken from participants in understandable language.

The pilot study was done considering the small number of samples prior to this study, and the sample size was calculated using OpenEpi (with a 95% of confidence interval and a statistical power of 80%). Each group was allotted with 6 participants as we rounded off into 10 which also considered the dropouts. The 10 participants

Kadam *et al. Bulletin of Faculty of Physical Therapy*   (2022) 27:17

Page 3 of 7

were in respective groups, i.e., 3 experimental groups and 1 control group. Hence, the overall sample size was 40 for the study. The participants were randomized into 4 groups using a random number generated through https://www.randomizer.org/. During the study, there was a dropout of 3 participants.

The randomized group was divided as follows:

i. The group performing a balance training on 1″ medium-density foam
ii. The group performing a balance training on 2″ medium-density foam
iii. The group performing a balance training on 3″ medium-density foam
iv. Control group: performing balance training on a stable surface

A prior demonstration was given to all participants and a warm-up session of 10 min included an active range of motion exercises of cervical, upper, and lower limb, followed by 9 performance-based balance exercises that resemble simple tasks performed in day-to-day activities such as double stance standing with a wide BOS, standing with a narrow base of support, heel raises, mini squats, rising from a standard chair, spot marching, one-leg standing, tandem standing, and leg swinging back and forth [11]. Lastly, the cool-down session included self-stretching for wrist flexors and extensors, triceps, ankle dorsiflexors and plantar flexors, and breathing exercises for relaxation. Ten repetitions and 2 sets of each exercise were performed. Two rest intervals of 2 min were given in between 25 min of balance training session to minimize the fatigue. Participants in the intervention and control groups were asked to attend a 45-min session on alternate days a week for 6 weeks under the supervision of a therapist.

The FES-I scale was administered in regional language (Hindi and Marathi version) to cater to older adults not always fluent in English. During the session, the MBS and FES-I score was recorded for pre-, post-2 weeks, and post-6 weeks.

Statistical analysis
MS-Excel 2016 was used for data entry and basic descriptive statistical analysis. Test of normality was done using Statistical Package for Social Sciences software version 24. The data are represented as mean±standard deviation (SD). Normality of data was confirmed using the Kolmogorov-Smirnova test which is used when the sample size is less than 2000. The significance of the test was considered at 5% of the level of significance. The differences between and within groups were calculated using a two-way repeated measure analysis of variance

(ANOVA). If a statistically significant interaction effect was detected, Bonferroni-corrected post hoc tests were conducted. The normally distributed data variables were analyzed with the help of parametric tests, i.e., paired *t*-test or repeated measure test for within or intra-group and independent or unpaired *t*-test for between or inter-group analysis. Cohen *d* effect size suggested that $d = 0.2$ be considered a "small," 0.5 represents a "medium," 0.8 a "large," and > 0.8 is a very large effect.

Results
A repeated-measures ANOVA with a Greenhouse-Geisser correction determined that mean values for MBS in each group differed statistically significant between time points ($P < 0.001$). Post hoc tests using the Bonferroni correction revealed that balance training on firm surface conducted between pre- and post-2 weeks elicited no change in MBS. However, foam-based balance training for 4 weeks had been shown an increase in mean values of each group, which was statistically significant ($P < .000$) (Figs. 1 and 2; Tables 1, 2, 3, and 4).

Also, based on the results of the paired sample *t*-test analysis at a 5% significance level, there is a significant statistical reliable difference between the pre- and post-treatment values with a *P*-value less than the 5% significance level (i.e., $0.001 < 0.05$) in the study and therefore it justifies the improvements in health outcome post-intervention. Hence, participants performing balance training in intervention groups, i.e., 1″, 2″, and 3″ foam-based balance training, and control group show statistical significance (<0.05) in MBS and FES-I, which indicates that balance training for long duration helped to achieve improvement in balance performance in older adults.

Discussion
The main objective of this study was to determine the suitable height of foam for balance training in community-dwelling older adults. It was observed that there was a significant improvement in all groups, showing that the 6-week balance training yielded a positive result in improving balance in the elderly. There was also a significant change in individual sections like anticipatory, reactive postural control, sensory orientation, and dynamic gait components of Mini-BesTest in all groups. However, the marginal score difference in each group with respect to select study variables and small effect size values (less than 0.5) in respective groups indicates partial clinical relevance. Furthermore, the efficacy of using 1″ medium-density foam to improve anticipatory and dynamic gait is meager in the case of senior people or aged sample respondents, whereas the 3″ medium-density foam group shows an effective change (>0.5) in all components of

Kadam *et al. Bulletin of Faculty of Physical Therapy*   (2022) 27:17

Page 4 of 7
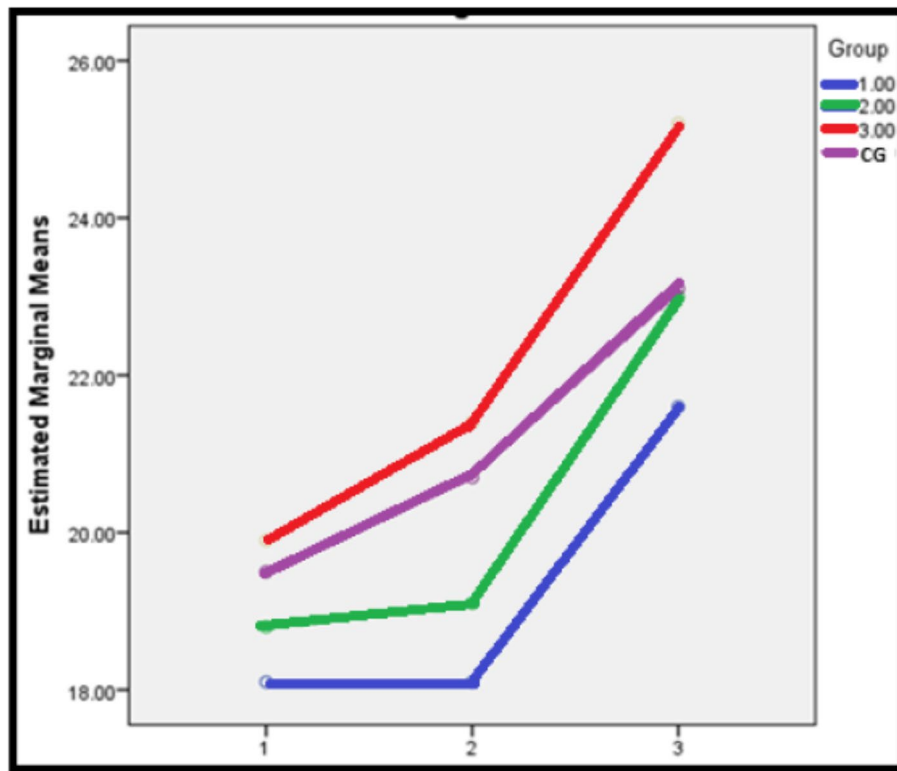
Fig. 1 Estimated marginal means of Mini-BesTest Score in 1″, 2″, 3″, and control group. Note: The lines in figure represents respective group participants are performing on 2″ foam—green, 3″ foam—red, 1″ foam—blue, and control group—purple
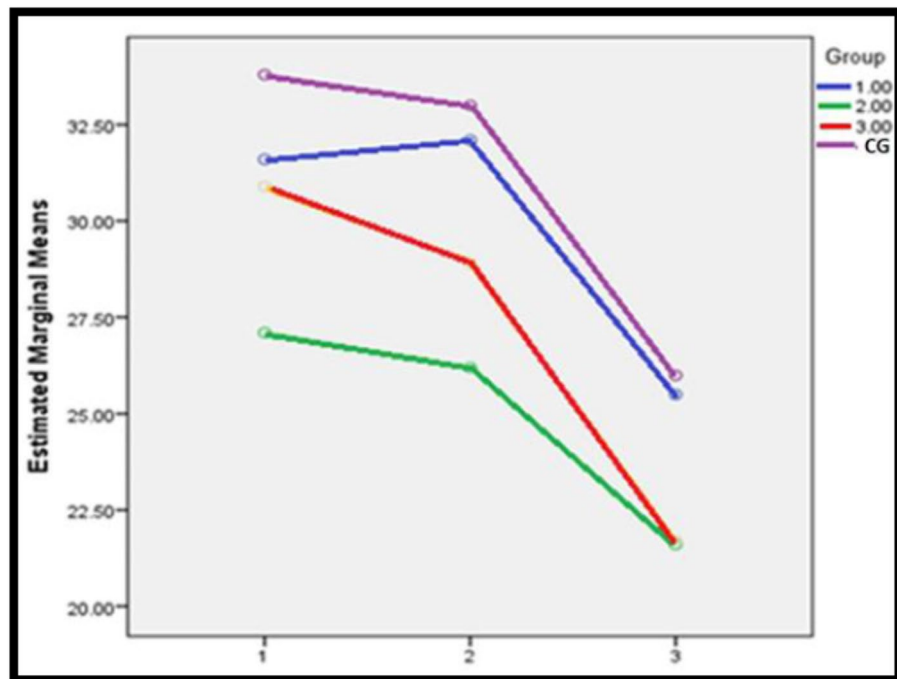
Fig. 2 Estimated marginal means of Fall Efficacy Scale-I in 1″, 2″, 3″, and control groups. Note: The lines in the figure represent respective group participants are performing on 2″ foam—green, 3″ foam—red, 1″ foam—blue, and control group—purple

Table 1 Baseline characteristics of participants

Groups	Age (mean±SD)	MOCA (mean±SD)	GDS (mean±SD)
1″ foam	66.5±6.08	26.1±1.66	4.9±2.58
2″ foam	68.1±5.11	25.6±1.58	4.1±1.85
3″ foam	67±3.23	26.3±1.42	4.5±2.01
Control	67.3±4.95	25±3.16	4.8±1.55

MBS as compared to other foam-based balance training and control group.

The MBS score resulted statistically significant (<0.05), which implies that no matter the specific height of foam used for balance training, but practicing for long duration appears to improve balance in community-dwelling older adults. The FES-I score was statistically significant (<0.05) in intervention and control groups suggesting that the long-term balance training on the stable and

Table 2 Comparison of Mini-BesTest Score in intervention groups

	Pre Mean (SD)	Post-2 wks Mean (SD)	Post-6 wks Mean (SD)	*F*-value	Significance
1″ foam-based group	18.10 (3.84)	18.10 (3.21)	21.60 (3.80)	17.640	**.001**
2″ foam-based group	18.80 (3.52)	19.10 (3.24)	23.00 (3.43)	39.952	**.000**
3″ foam-based group	19.90 (1.85)	21.40 (1.07)	25.20 (1.98)	45.947	**.000**
Control group	19.50 (1.84)	20.70 (2.45)	23.10 (3.21)	12.923	**.002**

Table 3 Comparison of the Fall Efficacy Scale-I score in intervention groups

	Pre Mean (SD)	Post-2 wks Mean (SD)	Post-6 wks Mean (SD)	*F*-value	Significance
1″ foam-based group	31.60 (8.30)	32.10 (9.29)	25.50 (6.68)	15.998	**.001**
2″ foam-based group	27.10 (4.48)	26.20 (3.67)	21.60 (3.53)	14.337	**.001**
3″ foam-based group	30.90 (9.24)	28.90 (10.65)	21.70 (1.33)	6.657	**.026**
Control group	33.80 (9.43)	33.00 (10.56)	26.00 (7.37)	20.243	**.000**

Table 4 Mini-BesTest Scale component-wise score summary

Intervention group	Variable	Pre Mean	Pre SD	Post-6 weeks Mean	Post-6 weeks SD	Diff Mean	Diff SD	Effect size	*t*-value	*P*-value
1″ foam	Anticipatory	5.20	0.63	5.50	1.43	−0.30	1.34	0.22	0.709	0.496
	Reactive postural control	3.60	1.71	5.00	1.25	−1.40	1.51	0.93	2.941	0.016*
	Sensory orientation	3.20	0.92	5.20	0.79	−2.00	0.67	3.00	9.487	0.001*
	Dynamic gait	6.10	2.13	5.80	1.69	0.30	1.64	0.18	0.580	0.576
2″ foam	Anticipatory	4.80	0.42	6.50	1.43	−1.70	1.16	1.47	4.636	0.001*
	Reactive postural control	4.30	1.16	4.80	0.92	−0.50	0.97	0.51	1.627	0.138
	Sensory orientation	3.40	0.70	6.70	1.42	−3.30	1.42	2.33	7.359	0.001*
	Dynamic gait	6.30	1.95	4.90	1.29	1.40	1.51	0.93	2.941	0.016*
3″ foam	Anticipatory	5.00	0.67	7.20	0.63	−2.20	0.92	2.39	7.571	0.001*
	Reactive postural control	3.70	0.82	5.50	0.71	−1.80	1.40	1.29	4.070	0.003*
	Sensory orientation	3.80	1.14	6.70	0.95	−2.90	1.29	2.25	7.127	0.001*
	Dynamic gait	7.30	1.64	5.90	0.88	1.40	1.96	0.72	2.264	0.049*
Control group	Anticipatory	5.00	0.47	6.80	0.79	−1.80	0.63	2.85	9.000	0.001*
	Reactive postural control	4.10	0.57	4.80	1.23	−0.70	1.34	0.52	1.655	0.132
	Sensory orientation	3.50	1.08	6.10	0.88	−2.60	1.26	2.06	6.500	0.001*
	Dynamic gait	7.10	1.29	5.40	0.84	1.70	0.95	1.79	5.667	0.001*

Kadam *et al. Bulletin of Faculty of Physical Therapy*   (2022) 27:17

Page 6 of 7

unstable surface had shown a reduction in the fall frequency in community-dwelling older adults. These balance exercises help to achieve confidence and reduce the fear of falls while performing dynamic tasks.

Many researchers have used various modalities to improve balance in the geriatric population, and incorporation of the unstable surface during balance training helped to increase the sensitivity of mechanoreceptors in muscles. Zouita et al. suggested that balance training for long duration on unstable surfaces helps older adults to efficiently utilize their sensory inputs and improve attention demands which help to reduce the postural sway by using this biofeedback [6]. Furthermore, practicing on foam surface helps to facilitate proprioceptive input to the spinal cord which helps in postural stability by activating postural reflex when there is increased body sway on an unstable surface [13]. Several studies on improving balance using unstable surfaces suggest that balance improvement occurs due to activation of cutaneous receptors on feet and mechanoreceptors in the muscle which results in adaptive changes in the regulating mechanisms at supraspinal levels [13, 14].

Our study has few limitations: we included only men due to the easy availability of male participants at the senior citizen center. The participants were also living an active lifestyle and belong to the same community. Therefore, the findings of our study cannot be generalized to a wide range of the geriatric population. We recommend future researchers to widen the scope of the study by conducting on a large sample size. Also, the influence of foam-based balance training helps to improve several physical factors such as postural sway and other postural adaptations which can be assessed by using advanced tools and balance equipments.

Conclusion

The 6 weeks of balance training for community-dwelling older adults conducted on foam and firm surfaces concludes that balance training for a longer duration is effective in improving balance and reducing the fear of falls in an elderly population. The height of foam does not affect the clinical decision-making for a foam-based balance rehabilitation program in the elderly. Hence, the clinicians should consider the duration of treatment to effectively improve balance in geriatrics while planning balance training intervention.

Abbreviations
MBS: Mini-BesTest; GDS: Geriatric Depression Scale; FES-I: Fall Efficacy Scale-I.

Declarations

Ethics approval and consent to participate
The ethical approval was received from the Research Committee of Chaitanya Medical Foundation College of Physiotherapy, Chinchwad, Pune. The participants were given a prior explanation regarding the purpose and methodology of the study in regional language. The prior participation consents were taken in the participant's regional language.

Consent for publication
N/A

Competing interests
The authors declare that they have no competing interests.

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