(ISSN: 0973-7049(P))

The Bioscan AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES 21(2): S.I (2), 21617-21632, 2026 www.thebioscan.com

Comparative Effects of Stable and Unstable Surface Balance Training on Postural Control in Older Adults: A Secondary Analysis of a Randomized Controlled Trial

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DOI:https://doi.org/10.63001/tbs.2026.v21.i02.S.I(2).pp21617-21632

KEYWORDS

Older adults; Postural control; Balance training; Stable surface; Unstable surface; Berg Balance Scale; Timed Up and Go Test; Falls Efficacy Scale–International; Geriatric rehabilitation.

Article Info

Received: 25.04.2026

Accepted: 13.05.2026

Published: 23.05.2026

Abstract

Background
Postural control is essential for maintaining functional independence and preventing falls in older adults. Age-related declines in sensory integration, muscle strength, and neuromuscular coordination contribute to impaired balance and mobility. Balance training is an established intervention for improving postural stability; however, the comparative effectiveness of stable and unstable surface training remains uncertain.

Objective
To compare the effects of stable and unstable surface balance training on postural control, functional mobility, and fear of falling among community-dwelling older adults.

Methods
This secondary analysis used data from a randomized controlled trial involving 60 community-dwelling older adults aged 65–80 years. Participants originally received six weeks of supervised balance training on a firm surface (n = 20), foam surface (n = 20), or dynamic surface (n = 20). For this analysis, participants were regrouped into a stable surface group (firm surface; n = 20) and an unstable surface group (foam and dynamic surfaces combined; n = 40). Training was conducted three times weekly for six weeks. **Outcome** measures included the Berg Balance Scale (BBS), Timed Up and Go (TUG) Test, and Falls Efficacy Scale–International (FES-I). Between-group comparisons were performed using independent-samples *t*-tests, with statistical significance set at $p < 0.05$.

Results
Both groups demonstrated improvements in postural control, functional mobility, and fear of falling following the intervention. The unstable surface group achieved significantly higher post-intervention BBS scores than the stable surface group ($p < 0.001$), indicating greater improvement in postural control. No significant between-group difference was observed in post-intervention TUG performance ($p = 1.000$). Although post-intervention FES-I scores differed significantly between groups ($p = 0.003$), this finding should be interpreted with caution because baseline FES-I scores were also significantly different.

Conclusion
Both stable and unstable surface balance training were effective in improving balance, functional mobility, and confidence among older adults. Unstable surface training provided additional benefits for postural control, while functional mobility improved similarly in both groups. Progressive incorporation of unstable surface exercises may be considered as part of comprehensive geriatric balance rehabilitation programmes.

(ISSN: 0973-7049(P))

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INTRODUCTION

Population ageing has emerged as one of the most significant demographic transitions worldwide. Improvements in healthcare, nutrition, sanitation, and medical technology have substantially increased life expectancy, resulting in a growing proportion of older adults within the global population. Although increased longevity reflects advances in public health, it is also accompanied by a higher prevalence of age-related functional impairments that compromise independence and quality of life. Among these impairments, deterioration in postural control is one of the most common and clinically significant problems affecting older adults. Reduced postural stability limits the ability to perform everyday activities safely and substantially increases the risk of falls, disability, hospitalization, and long-term dependency. Consequently, maintaining postural control has become a primary objective of geriatric rehabilitation.

Postural control refers to the ability to maintain the body's centre of mass within the limits of the base of support during both static and dynamic activities. It is a complex motor skill that depends on the continuous integration of sensory information from the visual, vestibular, and somatosensory systems with appropriate neuromuscular responses generated by the central nervous system. Effective postural control enables individuals to maintain upright posture, adapt to environmental changes, and perform functional movements such as standing, walking, turning, reaching, and climbing stairs without losing balance. Any impairment in these sensory or motor components reduces stability and increases susceptibility to falls.

Advancing age is associated with progressive physiological changes that adversely affect postural control. There is a gradual decline in muscle mass, muscle strength, joint flexibility, proprioceptive acuity, visual perception, vestibular function, and reaction time. These changes diminish the body's ability to respond rapidly to internal and external perturbations, resulting in increased postural sway and delayed protective responses. Age-related deterioration of lower-limb muscle strength and impaired proprioception are particularly important contributors to balance deficits because they reduce the ability to generate effective corrective movements during functional activities. Furthermore, degenerative changes within the central nervous system slow sensory processing and motor planning, making postural adjustments less efficient.

Impaired postural control is one of the strongest predictors of falls in older adults. Falls represent a major public health concern because they are associated with fractures, soft tissue injuries, head trauma, reduced mobility, institutionalization, and increased mortality. Beyond their physical consequences, falls frequently result in fear of falling, which leads many older adults to restrict their daily activities despite having adequate physical capability. Reduced physical activity contributes to muscle weakness, decreased endurance, impaired balance, and further functional decline, creating a vicious cycle of inactivity and increasing dependence. Therefore, interventions that improve postural control are essential not only for preventing falls but also for preserving mobility, independence, and quality of life.

Balance training is one of the most effective physiotherapy interventions for improving postural control in older adults. It consists of structured exercises designed to challenge the body's ability to maintain stability under varying conditions. Through repeated practice, balance training enhances neuromuscular coordination, improves proprioceptive function, strengthens postural muscles, and facilitates more efficient sensory integration. Previous research has consistently demonstrated that regular balance training improves static and dynamic balance, functional mobility, gait performance, and confidence while reducing the risk of falls among community-dwelling older adults.

Conventionally, balance exercises are performed on stable or firm surfaces, where somatosensory input from the feet remains reliable and consistent. Firm surfaces provide a secure base of support, allowing individuals to develop fundamental balance strategies while minimizing the risk of instability. Such exercises are particularly suitable during the early stages of rehabilitation and for individuals with severe balance impairments. Although training on stable surfaces improves balance performance, it may provide relatively limited sensory stimulation once the individual adapts to the exercises.

In recent years, unstable surface training has gained considerable attention in neurological and geriatric rehabilitation because it introduces greater challenges to the postural control system. Unstable surfaces such as foam pads, balance cushions, wobble boards, and sand reduce the reliability of somatosensory information obtained from the feet and ankles. Consequently, the central nervous system is required to rely more heavily on visual and vestibular information while simultaneously increasing activation of stabilizing muscles to maintain equilibrium. This process, commonly referred to as **sensory reweighting**, enhances the body's ability to adapt to changing environmental conditions and improves overall postural control.

Training on unstable surfaces also increases neuromuscular demand by requiring continuous postural adjustments throughout each exercise. Greater activation of ankle, knee, hip, and trunk stabilizing muscles enhances joint stability, improves intermuscular coordination, and promotes more effective anticipatory and reactive balance strategies. These neuromuscular adaptations may translate into superior improvements in functional mobility compared with conventional firm-surface training. As a result, unstable surface exercises have become an important component of contemporary physiotherapy programmes for fall prevention and balance rehabilitation.

Several randomized controlled trials and systematic reviews have demonstrated the effectiveness of unstable surface training in improving balance among older adults. Foam-based balance exercises have been shown to enhance postural stability by challenging proprioceptive mechanisms, whereas dynamic surfaces such as wobble boards provide multidirectional instability that further stimulates neuromuscular adaptation. However, despite increasing evidence supporting unstable surface interventions, relatively few studies have directly compared the overall effects of **stable** versus **unstable** surface balance training. Most investigations have evaluated individual surfaces separately, making it difficult for clinicians to determine whether unstable environments offer clinically meaningful advantages over traditional firm-surface exercises.

Understanding the comparative effectiveness of stable and unstable surface training is important for evidence-based physiotherapy practice. If unstable surface training produces superior improvements in postural control, clinicians may consider introducing progressive instability into rehabilitation programmes to maximize functional recovery. Conversely, if both approaches demonstrate similar effectiveness, treatment selection may be guided by patient safety, equipment availability, and individual functional status. Therefore, identifying the optimal training environment has direct implications for rehabilitation planning, exercise progression, and fall-prevention strategies.

The present study was undertaken as a **secondary analysis of a randomized controlled trial** to compare the effects of stable and unstable surface balance training on postural control in older adults. Stable surface training included exercises performed on a firm surface, whereas unstable surface training comprised exercises performed on foam and dynamic surfaces. Postural control was evaluated using the Berg Balance Scale, while functional mobility and fear of falling were assessed using the Timed Up and Go Test and the Falls Efficacy Scale–International, respectively. By examining the influence of surface stability on rehabilitation outcomes, this study aims to provide clinically relevant evidence that can assist physiotherapists in selecting the most effective balance training strategies for older adults.

The findings of this study are expected to contribute to the growing body of evidence supporting exercise-based interventions for fall prevention in the elderly. Demonstrating the relative effectiveness of stable and unstable surface training may help clinicians design structured, progressive, and individualized rehabilitation programmes that improve postural control, reduce fall risk, enhance confidence, and promote healthy ageing and functional independence.

MATERIALS AND METHODS

Study Design

The present study is a **secondary analysis of a randomized controlled trial (RCT)** that was conducted to examine the effectiveness of balance training performed on surfaces with different levels of stability among older adults. In the original trial, participants were randomly allocated to one of three intervention groups: firm surface, foam surface, or dynamic surface balance training. For the purpose of this secondary analysis, participants were regrouped according to the type of training surface. Those who received balance training on a firm surface were included in the **stable surface group**, while participants trained on foam and dynamic surfaces were combined into the **unstable surface group**. This approach allowed comparison of the overall effects of conventional stable-surface training with balance training performed under greater proprioceptive challenge.

Study Setting

The study was carried out in the Department of Physiotherapy, Pacific Medical College and Hospital, Bedla, Udaipur, Rajasthan, India. Ethical approval for the study was obtained from the Institutional Ethics Committee of Pacific Medical University before participant recruitment. The purpose and procedures of the study were explained to all eligible participants, and written informed consent was obtained prior to enrolment.

Participants

A total of **60 community-dwelling older adults** between **65 and 80 years of age** participated in the study. Participants were recruited using the predefined eligibility criteria and were randomly assigned during the original trial. For the current analysis, the participants were categorized into two groups according to the stability of the training surface.

- **Stable Surface Group (n = 20):** Participants who performed balance exercises on a firm surface.
- **Unstable Surface Group (n = 40):** Participants who performed the same balance exercises on either a foam surface or a dynamic balance surface.

This regrouping was performed to investigate whether training on unstable surfaces provides additional benefits for postural control compared with conventional firm-surface training.

Inclusion Criteria

Participants were included in the study if they:

- Were between **65 and 80 years** of age.
- Were able to stand independently, with or without an assistive device.
- Were able to walk independently.
- Were willing to participate in the study.
- Provided written informed consent.

Exclusion Criteria

Participants were excluded if they had:

- Neurological disorders affecting balance or gait.
- Vestibular disorders.
- Severe musculoskeletal conditions limiting participation in exercise.
- Significant visual impairment that could influence balance performance.
- Cognitive impairment affecting their ability to understand or follow instructions.
- Any unstable cardiovascular or other medical condition that contraindicated participation in exercise.

Intervention

All participants completed a **six-week supervised balance training programme**, with sessions conducted **three times per week**. Each treatment session lasted approximately **30 to 40 minutes** and consisted of a warm-up period, balance training exercises, and a cool-down session.

The warm-up lasted **5–10 minutes** and included gentle range-of-motion exercises and light stretching. This was followed by **20–25 minutes of balance training**, after which participants completed a **5-minute cool-down** consisting of stretching and relaxation exercises.

Stable Surface Training

Participants in the stable surface group performed all exercises on a firm floor. The exercise programme included double-leg standing, semi-tandem standing, tandem standing, single-leg standing, weight-shifting activities, forward and lateral reaching tasks, heel-to-toe walking, sit-to-stand practice, and walking with changes in direction. As participants progressed, the exercises were made more challenging by reducing hand support, narrowing the base of support, increasing the duration of each task, and introducing more complex movement patterns.

Unstable Surface Training

Participants in the unstable surface group performed the same balance exercises using foam balance pads and dynamic balance surfaces such as wobble boards. These unstable surfaces reduced the reliability of somatosensory input from the feet and required participants to make continuous postural adjustments to maintain stability. As a result, greater activation of the lower-limb and trunk stabilizing muscles was required throughout the exercises.

The progression of exercises included bilateral standing, tandem standing, single-leg standing, weight-shifting activities, multidirectional reaching, dynamic stepping, perturbation training, and gait exercises performed on unstable surfaces. All treatment sessions were supervised by an experienced physiotherapist to ensure participant safety and proper execution of the exercises.

Outcome Measures

Outcome assessments were performed at baseline before the intervention and repeated after completion of the six-week training programme.

Primary Outcome Measure

Berg Balance Scale (BBS)

Postural control was assessed using the **Berg Balance Scale (BBS)**, a widely used and validated clinical measure of functional balance in older adults. The scale consists of **14 functional tasks**, each scored from **0 to 4**, resulting in a maximum score of **56 points**. Higher scores indicate better balance performance and a lower risk of falling.

Secondary Outcome Measures

Timed Up and Go Test (TUG)

Functional mobility was evaluated using the **Timed Up and Go (TUG) Test**. Participants were instructed to stand up from a standard chair, walk a distance of three metres, turn around, walk back to the chair, and sit down. The time taken to complete the task was recorded in seconds. Shorter completion times indicated better functional mobility.

Falls Efficacy Scale–International (FES-I)

Fear of falling was assessed using the **Falls Efficacy Scale–International (FES-I)**. This questionnaire evaluates the level of concern experienced by older adults while performing various daily activities. Lower scores indicate greater confidence in performing activities without fear of falling.

Ethical Considerations

Ethical approval for the study was obtained from the Institutional Ethics Committee of Pacific Medical University, Udaipur, Rajasthan. All procedures were conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Participants were informed about the purpose, benefits, and potential risks of the study before providing written informed consent. Confidentiality of participant information was maintained throughout the study, and participants were free to withdraw from the study at any stage without affecting their routine care.

Statistical Analysis

Data were analysed using the Statistical Package for the Social Sciences (SPSS). Descriptive statistics were calculated and presented as mean ± standard deviation (SD) for continuous variables and as frequencies and percentages for categorical variables.

The normality of data distribution was assessed using the Shapiro–Wilk test. Changes within each group between pre- and post-intervention assessments were analysed using the paired t-test, while comparisons between the stable and unstable surface groups were performed using the independent samples t-test. Categorical variables were analysed using the Chi-square test wherever applicable. A p-value of less than 0.05 was considered statistically significant for all statistical analyses.

RESULTS

A total of **60 community-dwelling older adults** completed the study and were included in the final analysis. Based on the type of balance training surface used during the intervention, participants were categorized into two groups: the **Stable Surface Group** (firm surface; $n = 20$) and the **Unstable Surface Group** (foam and dynamic surfaces combined; $n = 40$). All participants completed the six-week intervention programme, and no dropouts were reported during the study.

Baseline Characteristics

The baseline demographic characteristics of the participants were comparable between the two groups. Comparison of baseline outcome measures revealed no statistically significant difference in **Berg Balance Scale (BBS)** scores between the stable and unstable surface groups ($p = 0.840$), indicating similar baseline balance performance.

However, significant differences were observed in baseline **Timed Up and Go (TUG)** and **Falls Efficacy Scale–International (FES-I)** scores. Participants in the unstable surface group demonstrated higher TUG times and FES-I scores than those in the stable surface group ($p < 0.05$), suggesting relatively poorer functional mobility and greater fear of falling prior to the intervention.

Table 1. Baseline comparison of outcome measures

Outcome Measure	Stable Surface (n = 20) Mean ± SD	Unstable Surface (n = 40) Mean ± SD	t-value	p-value
TUG (seconds)	24.85 ± 3.83	29.25 ± 2.49	-4.67	<0.001
BBS Score	42.05 ± 1.82	41.95 ± 1.75	0.20	0.840
FES-I Score	23.90 ± 1.37	25.65 ± 2.79	-3.26	0.002

Post-intervention Comparison

Following six weeks of supervised balance training, both groups demonstrated improvements in balance, functional mobility, and confidence during daily activities. Comparison of post-intervention scores showed that participants who trained on unstable surfaces achieved significantly greater improvement in balance than those who trained on a stable surface.

The mean post-intervention **Berg Balance Scale** score was significantly higher in the unstable surface group (**49.93 ± 2.12**) compared with the stable surface group (**46.40 ± 2.87**) ($t = –4.87$, $p < 0.001$),

(ISSN: 0973-7049(P))

indicating superior postural control following unstable surface training.

Both groups demonstrated marked improvement in functional mobility as measured by the **Timed Up and Go Test**. The mean post-intervention TUG score was **21.20 ± 3.05 seconds** in the stable surface group and **21.20 ± 3.01 seconds** in the unstable surface group. No statistically significant difference was observed between the groups (t = 0.00, p = 1.000), indicating that both interventions were equally effective in improving functional mobility.

Fear of falling, measured using the **Falls Efficacy Scale–International (FES-I)**, also improved following the intervention. The mean post-intervention FES-I score was **20.90 ± 1.37** in the stable surface group and **22.55 ± 2.73** in the unstable surface group. The difference between the groups was statistically significant (t = –3.12, p = 0.003). Since the unstable surface group also had significantly higher baseline FES-I scores, this finding should be interpreted with caution.

Table 2. Post-intervention comparison of outcome measures

Outcome Measure	Stable Surface (n = 20) Mean ± SD	Unstable Surface (n = 40) Mean ± SD	t-value	p-value
TUG (seconds)	21.20 ± 3.05	21.20 ± 3.01	0.00	1.000
BBS Score	46.40 ± 2.87	49.93 ± 2.12	-4.87	<0.001
FES-I Score	20.90 ± 1.37	22.55 ± 2.73	-3.12	0.003

Figure 1. Berg Balance Scale (BBS)

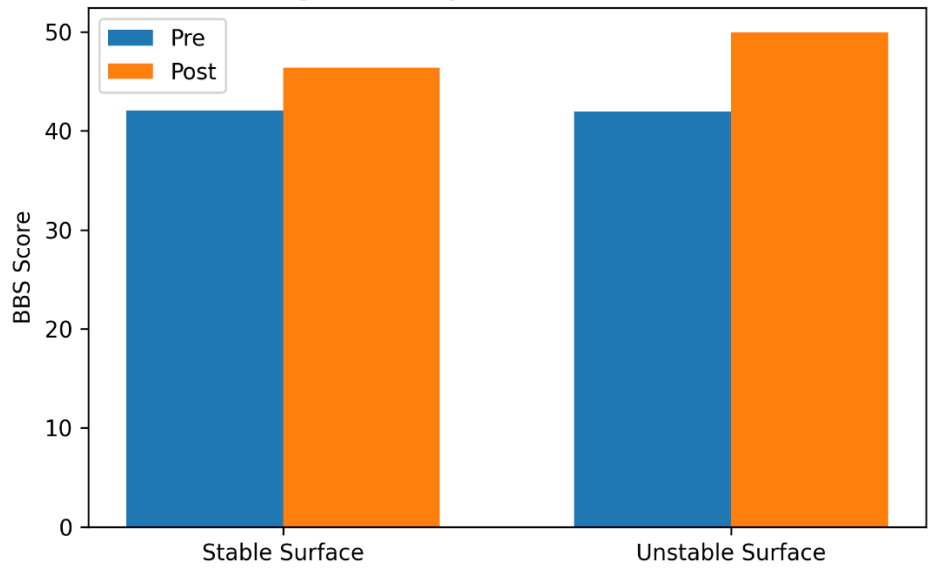


Figure 2. Timed Up and Go (TUG)

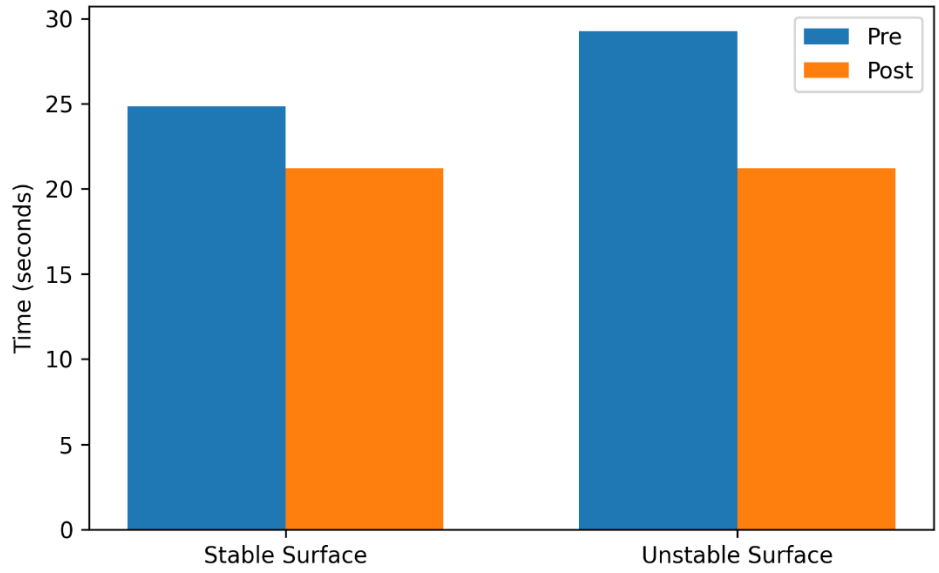
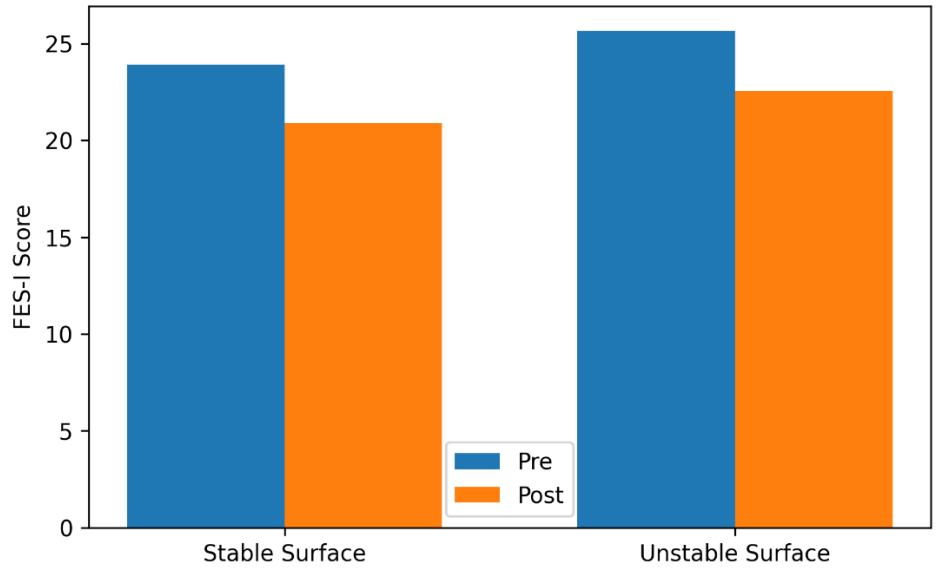


Figure 3. Falls Efficacy Scale-International (FES-I)



Overall Findings

The findings of the present study indicate that both stable and unstable surface balance training programmes were effective in improving balance, functional mobility, and reducing fear of falling among older adults after six weeks of intervention. Participants in both groups demonstrated clinically meaningful improvements across all outcome measures.

Comparison between the two training approaches revealed that unstable surface balance training produced significantly greater improvements in balance performance, as demonstrated by higher post-intervention BBS scores. In contrast, improvements in functional mobility, assessed using the Timed Up and Go Test, were comparable between the two groups. Although a statistically significant difference was observed in post-intervention FES-I scores, the unstable

surface group had higher baseline fear-of-falling scores, which should be considered while interpreting this finding.

Overall, these results suggest that while conventional balance exercises performed on a stable surface are beneficial, training on unstable surfaces provides additional advantages for enhancing postural control in older adults, making it a valuable component of geriatric balance rehabilitation programmes.

DISCUSSION

The present study compared the effectiveness of stable and unstable surface balance training on postural control, functional mobility, and fear of falling among community-dwelling older adults. This secondary analysis was performed using data from a randomized controlled trial in which participants originally received balance training on a firm, foam, or dynamic surface. For the current analysis, the foam and dynamic surface groups were combined to represent unstable surface training and compared with participants who trained on a firm surface.

The findings showed that both stable and unstable surface balance training were effective in improving balance, functional mobility, and confidence after six weeks of intervention. However, participants who trained on unstable surfaces demonstrated significantly better balance performance than those who trained on a stable surface, as reflected by higher post-intervention Berg Balance Scale (BBS) scores. In contrast, no significant difference was found between the two groups in Timed Up and Go (TUG) performance after the intervention, indicating that both types of training were equally effective in improving functional mobility. Although a significant difference was observed in Falls Efficacy Scale–International (FES-I) scores, this finding should be interpreted carefully because the unstable surface group had higher baseline fear-of-falling scores before the intervention.

The greater improvement in balance observed in the unstable surface group may be explained by the additional challenge provided by unstable training surfaces. Exercises performed on foam pads or dynamic balance devices reduce the stability of the supporting surface, forcing the body to make continuous postural adjustments to maintain balance. This increases the demand on the proprioceptive system and encourages greater activation of the muscles around the ankle, knee, hip, and trunk. Repeated exposure to these challenges improves sensory integration, neuromuscular coordination, and postural reactions, which may explain the superior improvements in BBS scores observed in the present study.

Our findings are consistent with previous studies reporting that unstable surface training produces greater improvements in balance than conventional balance exercises performed on firm surfaces. Earlier randomized controlled trials have shown that exercises performed on foam pads, wobble boards, and other unstable devices enhance proprioceptive input and improve postural stability in older adults. Likewise, systematic reviews investigating exercise-based fall prevention programmes have concluded that balance training involving progressively challenging tasks can significantly improve balance performance and reduce fall risk. The present study supports these findings by demonstrating that unstable surface training provides additional benefits for postural control when compared with conventional firm-surface exercises.

Functional mobility also improved in both groups following the intervention.

Participants in both the stable and unstable surface groups completed the Timed Up and Go test more quickly after six weeks of balance training, suggesting that regular balance exercises contribute to better movement efficiency and mobility. However, no significant difference was found between the two groups after the intervention. This finding indicates that although unstable surfaces provide greater balance challenges, improvements in functional mobility may be influenced by several factors in addition to balance, including lower-limb muscle strength, walking ability, joint mobility, endurance, and confidence during movement. Since both groups performed the same exercise programme with only the training surface differing, it is likely that these shared components contributed equally to improvements in TUG performance.

Fear of falling also improved after the intervention in both groups. As participants became more familiar with balance exercises and successfully performed progressively challenging activities under supervision, their confidence during daily functional tasks increased. This improvement is reflected by the reduction in FES-I scores observed after training. Nevertheless, because participants in the unstable surface group reported greater fear of falling before the intervention, direct comparison of post-intervention scores should be interpreted cautiously. Future studies should consider analysing change scores or using statistical methods such as analysis of covariance to account for baseline differences between groups.

The findings of this study also support current concepts of motor learning and balance rehabilitation. Repeated practice under unstable conditions encourages the nervous system to adapt by improving the coordination of sensory input and motor output. Such adaptations become particularly important in older adults, where age-related declines in proprioception, muscle strength, reaction time, and sensory processing often compromise balance. Training in a more challenging environment may therefore prepare older adults to respond more effectively to balance disturbances encountered during everyday activities.

From a clinical perspective, the results suggest that unstable surface training can be incorporated as a progression in balance rehabilitation programmes for older adults. Once individuals are able to safely perform exercises on a firm surface, physiotherapists may gradually introduce foam pads or dynamic balance equipment to increase the difficulty of training. This progressive approach may further improve postural control while maintaining patient safety through close supervision. At the same time, stable surface exercises remain an essential part of rehabilitation, particularly for individuals with severe balance impairment or those who require a safer environment during the early stages of treatment.

One of the strengths of this study is that it is based on data obtained from a randomized controlled trial, providing a strong methodological foundation for the secondary analysis. The use of validated outcome measures, including the Berg Balance Scale, Timed Up and Go Test, and Falls Efficacy Scale–International, also strengthens the reliability of the findings. In addition, combining the foam and dynamic surface groups allowed the overall effectiveness of unstable surface training to be evaluated, providing information that is directly relevant to clinical practice.

Despite these strengths, certain limitations should be acknowledged. This was a secondary analysis with unequal group

sizes, which resulted in 20 participants in the stable surface group and 40 participants in the unstable surface group. Significant baseline differences in TUG and FES-I scores may have influenced comparisons between the groups. Furthermore, the study was conducted at a single centre with a relatively small sample size, which may limit the generalizability of the findings. Since outcomes were assessed only immediately after completion of the intervention, the long-term effects of the training programme remain unknown.

Future research should include larger multicentre randomized controlled trials with balanced group allocation and longer follow-up periods to determine whether improvements in balance are maintained over time. Future studies should also include objective biomechanical assessments, gait analysis, muscle strength measurements, and quality-of-life outcomes to better understand the mechanisms underlying improvements following unstable surface training. In addition, comparing different unstable surfaces individually may help identify the most effective training method for improving balance in older adults.

Overall, the findings of the present study suggest that both stable and unstable surface balance training are effective interventions for improving balance, functional mobility, and confidence among older adults. However, unstable surface training appears to provide additional benefits for postural control, making it a valuable progression in balance rehabilitation programmes. Incorporating progressively challenging balance exercises into routine physiotherapy practice may help reduce fall risk, improve functional independence, and support healthy ageing.

CONCLUSION

The findings of the present study indicate that both stable and unstable surface balance training are effective in improving balance, functional mobility, and confidence among community-dwelling older adults. After six weeks of intervention, participants in both groups demonstrated noticeable improvements across all outcome measures, highlighting the importance of regular balance training in geriatric rehabilitation.

When the two approaches were compared, unstable surface training produced greater improvements in postural control, as reflected by significantly higher Berg Balance Scale scores. This suggests that exercises performed on unstable surfaces provide an additional challenge to the balance system, encouraging better neuromuscular control and postural adaptation. However, improvements in functional mobility were comparable between the two groups, indicating that both stable and unstable surface training can effectively enhance mobility in older adults. Fear of falling also decreased following the intervention, although the observed between-group difference should be interpreted with caution because the unstable surface group had higher baseline FES-I scores.

From a clinical perspective, the findings support the use of unstable surface exercises as a progression in balance rehabilitation programmes. Once older adults are able to perform exercises safely on a firm surface, introducing foam pads or other unstable surfaces may provide additional benefits in improving postural stability and reducing fall risk. Nevertheless, stable surface training continues to play an important role, particularly during the early stages of

rehabilitation and for individuals with poor balance.

Overall, the present study suggests that incorporating progressively challenging balance exercises into routine physiotherapy programmes may help improve postural control, maintain functional independence, and contribute to healthier ageing in older adults. Further well-designed studies with larger sample sizes and long-term follow-up are recommended to confirm these findings and establish the most effective balance training protocols for the geriatric population.

CLINICAL IMPLICATIONS

The findings of the present study have important implications for physiotherapy practice in geriatric rehabilitation. Both stable and unstable surface balance training were effective in improving balance, functional mobility, and confidence among older adults. However, the greater improvement in postural control observed following unstable surface training suggests that progressively challenging balance exercises should be incorporated into rehabilitation programmes whenever appropriate.

Unstable surfaces such as foam pads and dynamic balance devices may be introduced after patients develop adequate stability on firm surfaces. This progressive approach can provide greater proprioceptive stimulation, improve neuromuscular coordination, and enhance postural control while maintaining patient safety through appropriate supervision. Such interventions may contribute to reducing fall risk and improving functional independence in community-dwelling older adults.

STRENGTHS OF THE STUDY

- The study was based on data obtained from a randomized controlled trial, providing a strong methodological foundation.
- Standardized balance training protocols were followed throughout the intervention.
- Valid and reliable outcome measures (BBS, TUG, and FES-I) were used to assess treatment outcomes.
- The study evaluated the overall effect of unstable surface training by combining foam and dynamic surface interventions, making the findings more clinically applicable.
- The results provide practical evidence that can assist physiotherapists in selecting appropriate balance training strategies for older adults.

LIMITATIONS OF THE STUDY

- This was a secondary analysis of an existing randomized controlled trial.
- Unequal group sizes (20 participants in the stable surface group and 40 participants in the unstable surface group) may have influenced between-group comparisons.
- Baseline differences were observed in TUG and FES-I scores, which should be considered while interpreting the findings.
- The study was conducted at a single centre with a relatively small sample size, limiting the generalizability of the results.

- Long-term follow-up was not performed; therefore, the sustainability of the observed improvements remains unknown.

FUTURE RECOMMENDATIONS

Future studies should include larger multicentre randomized controlled trials with balanced group allocation to improve the generalizability of the findings. Long-term follow-up is needed to determine whether improvements in balance and mobility are maintained over time. Future research should also incorporate objective biomechanical assessments, gait analysis, muscle strength measurements, and quality-of-life outcomes to better understand the mechanisms underlying balance improvement. In addition, comparative studies evaluating different unstable training surfaces individually may help identify the most effective rehabilitation strategy for older adults.

DECLARATIONS

Ethical Approval

The original randomized controlled trial was approved by the Institutional Ethics Committee of Pacific Medical University, Udaipur, Rajasthan, India. The present study is a secondary analysis of data obtained from that approved trial and was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki.

Informed Consent

Written informed consent was obtained from all participants before their enrolment in the original study. Participants were informed about the purpose, procedures, potential benefits, and possible risks of the study, and their confidentiality was maintained throughout the research.

Conflict of Interest

The authors declare that there are no conflicts of interest related to this study.

Funding

The authors received no financial support from any funding agency, commercial organization, or not-for-profit institution for the conduct of this study.

Author Contributions

Simran Chhaperwal contributed to the study design, data collection, data analysis, interpretation of findings, manuscript preparation, and final approval of the manuscript.

Dr. Dipika Balala supervised the research work, contributed to the study design, critically reviewed the manuscript, provided academic guidance throughout the study, and approved the final version of the manuscript.

Acknowledgements

The authors sincerely thank all the older adults who voluntarily participated in this study. The authors also express their gratitude to the Department of Physiotherapy, Pacific College of Physiotherapy, Pacific Medical University, Udaipur, for providing the necessary facilities, resources, and academic support to successfully complete this research.

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