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Comparative effects of weight bearing exercises on mini trampoline and multisensory exercises on balance, proprioception and fatigue among geriatrics: a pilot study

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Abstract: Age-related decline in balance, proprioception, and increased fatigue contribute to functional limitations and fall risk in older adults. Exercise-based interventions targeting sensory integration are commonly used; however, comparative evidence between different approaches remains limited. This randomised pilot study aimed to evaluate the feasibility and preliminary effects of weight-bearing exercises on a mini trampoline and multisensory exercises in the geriatric population. Thirty participants aged ≥65 years were randomly allocated into two groups: Group A (weight-bearing exercises on mini trampoline, *n*=15) and Group B (multisensory exercises, *n*=15). Both groups underwent supervised interventions for 4 weeks (5 sessions/week). Primary outcomes included functional mobility (Timed Up and Go test), proprioception (joint position error), and fatigue (Fatigue Severity Scale). Feasibility outcomes included recruitment, adherence, and safety. Nonparametric analyses were performed, and effect sizes (r) with 95% confidence intervals were reported. Both groups demonstrated significant within-group improvements across all outcomes, with large effect sizes (r=0.81–0.91). Between-group comparisons showed moderate-to-large effect sizes favouring the weight-bearing exercises on the mini trampoline group (r=0.75–0.86). Feasibility outcomes were favourable, with an 88% recruitment rate, 100% adherence, and no adverse events reported. This pilot study suggests that both interventions are feasible and may improve balance, proprioception, and fatigue in older adults. While trends indicate greater improvements with weight-bearing exercises on a mini trampoline, these findings are preliminary and should not be interpreted as evidence of clinical superiority. Larger, adequately powered trials are required to confirm these observations and determine long-term effectiveness.

Keywords: Aging; Fatigue; Health; Postural control; Quality of life

1.0 INTRODUCTION

Ageing is associated with progressive impairments in balance and postural control, increasing the risk of falls and loss of functional independence in older adults (Ferlinc et al., 2019; Wang & Fu, 2022). These impairments are largely driven by age-related declines in sensory integration and neuromuscular function, resulting in reduced postural stability (Sivalingam et al., 2025). In addition to these factors, fatigue has emerged as an important yet under-recognised contributor to fall risk in geriatric individuals. It adversely affects neuromuscular performance, gait stability, and postural control, thereby increasing functional instability (Nam et al., 2013). Fatigue may also impair central processing and sensory integration, particularly under dual-task or challenging conditions, further increasing instability during functional activities (Grobe et al., 2017). Emerging evidence links fatigue to a higher incidence and recurrence of falls in older adults (Pana et al., 2021). Despite its clinical relevance, fatigue is rarely assessed or specifically targeted in routine rehabilitation or clinical decision-making due to the lack of clinically feasible assessment tools and clear guidelines, with current evaluations often relying on inconsistent and subjective reporting (Knoop et al., 2023).

Exercise-based interventions targeting sensory integration are widely used in geriatric rehabilitation. Multisensory exercises, which integrate visual, vestibular, and somatosensory inputs, are commonly used in the early stages of rehabilitation to enhance postural control and coordination (Zhang et al., 2021). In contrast, weight-bearing exercises on a mini trampoline (an unstable surface) place greater proprioceptive and neuromuscular demands and may be more appropriate for progressive dynamic balance training during later stages of rehabilitation (Posch et al., 2019). However, there is limited clinical guidance on selecting and progressing these interventions, particularly regarding fatigue and functional outcomes in older adults.

Despite the widespread use of both approaches, there is a lack of randomised pilot studies directly comparing these rehabilitation interventions within a single framework that evaluates balance, proprioception, and fatigue in older adults. Furthermore, existing research predominantly focuses on balance outcomes, with limited emphasis on fatigue despite its functional relevance in fall risk. This gap limits evidence-based decision-making when selecting and progressing rehabilitation strategies.

Given the growing emphasis on active ageing and the need to maintain functional independence in older adults, it is imperative to explore feasible rehabilitation strategies that address balance impairments while accounting for fatigue as a modifiable risk factor (Dogra et al., 2022; Noto, 2023). Therefore, comparing interventions that differ in sensory and mechanical demands may provide clinically relevant insights for use at different stages of rehabilitation.

This pilot study aimed to evaluate the feasibility and preliminary effects of weight-bearing exercises on a mini trampoline and multisensory exercises in older adults. The primary objective was to examine the feasibility and effects on balance and functional mobility, while the secondary objective was to explore the effects on proprioception and fatigue. As a hypothesis-generating study, no formal hypothesis was tested. However, improvements in balance, proprioception, and fatigue were anticipated, with potential differences in the magnitude of response between interventions. The findings provide preliminary comparative estimates and feasibility data to inform the design of future randomised controlled trials.

2.0 MATERIALS AND METHODS

2.1 Study setting and design

The present pilot study was conducted in a hospital-based rehabilitation setting. Participants were recruited from the outpatient department after screening according to predefined eligibility criteria. The study was carried out over a period of 4 months (25/05/2025 to 25/09/2025), with no modifications to the protocol after initiation of the study. A parallel-group design was employed to examine the feasibility, safety, and preliminary effects of weight-bearing exercises on a mini trampoline compared with multisensory exercises in older adults. The study was conducted and reported in accordance with CONSORT guidelines for pilot and feasibility trials (**Figure 1**).

2.2 Ethical clearance

Ethical clearance for the study was granted by the Institutional Ethics Committee on Human Experimentation on 09/05/2025 (ISRB No. 018/05/2025/ISRB/PGSR/SCPT). The study was conducted in compliance with the ethical standards outlined in the World Medical Association's Declaration of Helsinki.

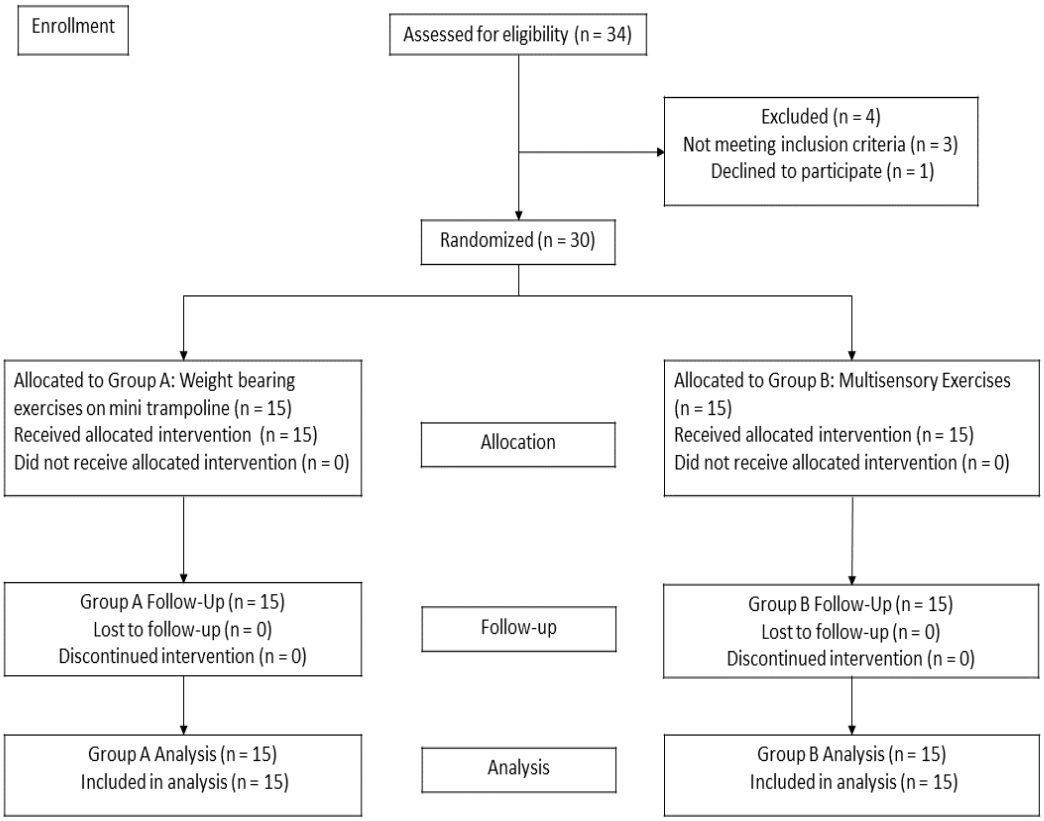

Figure 1. Consort flowchart of participants

2.3 Recruitment and screening procedure

Participants were recruited from the outpatient department during the study period. All individuals were screened for eligibility based on predefined inclusion and exclusion criteria. Screening involved a review of medical history, a physical examination, and a cognitive assessment using the Mini-Mental State Examination (MMSE). Eligible individuals who provided consent were enrolled consecutively in the study until the target pilot sample size of 30 participants was reached.

2.4 Inclusion and exclusion criteria

The study included participants aged 65 years and older, both male and female. Cognitive status was assessed using the Mini-Mental State Examination (MMSE), and individuals who scored above 24 and were able to ambulate independently, with or without an assistive device, were included. Participants were excluded if they had conditions such as cardiovascular complications (e.g., myocardial infarction, uncontrolled hypertension), vertigo, epilepsy, hernia, spinal cord injury or diabetic neuropathy.

2.5 Sample size determination

The study sample consisted of 30 participants. Since this was designed as a pilot study, a formal sample size calculation was not conducted. The chosen sample size was deemed sufficient to evaluate feasibility and to provide preliminary data for planning future research.

2.6 Randomisation and blinding

Participants were randomly allocated to two groups (1:1 ratio) using a computer-generated block-randomised sequence (block size=4) by an independent statistician. The primary investigator enrolled participants, and group assignment was performed using a sequentially numbered, sealed, opaque envelope method. These envelopes were opened only after participant enrolment, thereby minimising selection bias. Due to the nature of the interventions, participants and treating physiotherapists were not blinded. However, the outcome assessor was blinded to group allocation to reduce measurement bias.

2.7 Intervention

Participants were assigned to Group A (weight-bearing exercises on a mini trampoline) and Group B

(multisensory exercises). Informed consent was obtained from all participants after the study procedure was explained. A physiotherapist supervised all sessions to ensure safety, correct performance, and adherence to the protocol. The intervention was conducted over 4 weeks, with sessions lasting 50 minutes, 5 days per week. Each session included a structured warm-up, a main exercise phase, and a cool-down. Rest intervals of 1-2 minutes were provided between exercises or sets. Session attendance and completion of prescribed exercises were recorded to monitor adherence, and participants were monitored for any adverse events throughout the intervention period. Exercise intensity and progression were guided by participant tolerance, safety considerations, and observed performance, allowing for controlled individualisation. Detailed intervention protocols for both groups are provided in **Tables 1 and 2**.

2.8 Outcome measures

2.8.1 Primary outcome measures

- Timed Up and Go Test: Functional mobility was assessed using the Timed Up and Go (TUG) test. Participants stood up from a chair, walked 3 meters, returned, and sat down. The time to complete the task was recorded in seconds, with lower scores indicating better mobility.
- Joint Position Error (Ankle joint): Joint position error was assessed using the PhysioMaster smartphone application.
  - Joint tested: Ankle joint.
  - Position: Seated with hips and knees at approximately 90°, feet supported, eyes closed
  - Procedure: A target ankle position was demonstrated, after which participants were asked to reproduce the position without visual input
  - Trials: Three repetitions were performed
  - Outcome: The absolute difference between target and reproduced angles was calculated, and the mean of three trials was used for analysis
  - The PhysioMaster application: it has been shown to be valid and reliable for measuring joint angles and range of motion. In this study, it was used to estimate joint position error as an indirect indicator of proprioception function, based on the premise that repositioning accuracy reflects proprioceptive acuity. This approach is consistent with previous clinical studies assessing joint position sense (Hillier et al., 2015). However, as the application has not been specifically validated for proprioception assessment, JPE should be interpreted as a proxy measure rather than a direct assessment of proprioceptive function. Therefore, findings related to proprioception should be interpreted with caution and considered indicative of directional changes rather than precise quantification.
- Fatigue Severity Scale: a self-reported questionnaire that evaluates how fatigue affects various aspects of daily living. Higher scores indicate greater fatigue severity and functional limitation.

Table 1. Group A: Weight-bearing mini trampoline training protocol

Component	Exercise	Sets/Repetition/Time	Progression
Warm-up	General weight-bearing movement	5-10 minutes	
Static Balance	Bipedal stance (feet apart)	3 sets x 20-30 seconds	Progress to feet together
	Feet together stance	3 sets x 20-30 seconds	Progress to semi-tandem
	Semi-tandem stance	3 sets x 15-20 seconds	Progress to tandem stance
	Tandem stance	3 sets x 10-20 seconds	Eyes closed
Sensory Training	Eyes open to eyes closed	Integrated within exercise program	Increase duration
Dynamic Balance	Forward reaching	2 sets x 10-15 repetitions	Increase distance
	Lateral reaching	2 sets x 10-15 repetitions	Increase speed
	Marching in place	3 sets x 15-20 repetitions	Increase speed
Strength	Heel raises	2 sets x 12-15 repetitions	Reduce support
	Toe raises	2 sets x 12-15 repetitions	Dual task activities
Dual task activities	Cognitive + balance tasks	2 sets x 2-3 minutes	Increase complexity
Advanced	Hopping activities	2 sets x 8-10 repetitions	Increase repetitions
Cool-down	Stretching and relaxation	5 minutes	

Table 2. Group B: Multisensory training protocol

Component	Exercise	Sets/Repetition/Time	Progression
Warm-up	Mobility and stretching exercises	5 minutes	
Gait training	Walking (forward/ backward/lateral)	10 feet x 2-3 rounds each	Increase speed and vary surfaces (firm → foam → uneven surfaces)
Surface training	Walking on different surfaces	2-3 rounds x 2 minutes	Progress to varied surfaces
Sensory challenge	Eyes open and eyes closed	Integrated	Increased duration and perform on varied surfaces
Dynamic Task	Obstacle walking	2-3 sets x 2-3 minutes	Vary across surface conditions
Static Balance	Bipedal stance	3 sets x 60-90 seconds	Progress to unipedal stance and varied surfaces
	Unipedal stance	3 sets x 30 seconds	Increase duration and perform on varied surfaces
Dynamic Balance	Tandem walking	2-3 rounds 30-40 seconds	Add a dual task on varied surfaces
Dual-task	Cognitive and motor tasks	2-3 sets x 2-3 minutes	Increase task difficulty and surface challenge
Cool-down	Stretching	5-10 minutes	

2.8.2 Secondary outcome measures

Feasibility outcome measures included participant recruitment, adherence to the intervention and study completion rates. Progression to a future definitive trial will be considered contingent upon satisfactory recruitment, adherence, and completion rates, as well as the absence of serious adverse events

2.9 Statistical analysis

Data were analysed using IBM SPSS Statistics version 27.0. Normality of the data distribution was assessed using the Shapiro–Wilk test. Because the data were not normally distributed, nonparametric statistical methods were used. Within-group changes between pre and post-intervention were analysed using the Wilcoxon signed-rank test. Between-group comparisons at 4 weeks were conducted using the Mann-Whitney U test. Statistical significance was set at $p<0.05$; however, given the exploratory nature of this pilot study, p-values were interpreted cautiously. Effect sizes were calculated using the formula $r=Z / \sqrt{N}$ to estimate the magnitude of observed differences and were interpreted according to Cohen's criteria (small (0.1), moderate (0.3), and large (≥0.5)). No adjustments for multiple comparisons were performed, consistent with the exploratory design. No missing data were observed, and all participants completed the intervention; therefore, a complete-case analysis was conducted. The variability estimates and effect sizes obtained in this study may serve as preliminary parameters to inform formal sample size calculations for future adequately powered randomised controlled trials. No adjustment for baseline values was performed due to the study's pilot nature.

3.0 RESULTS

A total of 34 participants were screened for eligibility; 30 met the inclusion criteria and were randomised into two groups ($n=15$ per group). All participants completed the 4-week intervention, with no dropouts or adverse events, resulting in a 100% retention rate. The recruitment rate was 88%, and adherence to the intervention protocol was 100%, indicating high

Table 3. Baseline characteristics of participants in the study group

Characteristics	Group A (Mean ± SD)	Group B (Mean ± SD)
Age (years)	68.00 ± 1.65	68.27± 2.3
Males n (%)	7 (46.7 %)	8(53.3%)
Females n (%)	8(53.3 %)	7(46.7%)

Values are presented as mean ± standard deviation (SD), number of participants (n), and percentage (%). Both groups were comparable at baseline.

feasibility, safety, and acceptability of both exercise interventions in older adults. Baseline demographic characteristics were comparable between the groups, with no statistically significant differences observed in age or gender distribution (p>0.05), confirming successful randomisation and baseline homogeneity (**Table 3**). The trial was completed as per the predefined sample size and study duration, with no early stopping or termination.

Given the non-normal distribution of the data, all outcome measures are presented as medians (interquartile ranges). At baseline, the mini-trampoline group demonstrated TUG 15.30 (0.20), JPE 6.80 (0.10), and FSS 5.10 (0.10), while the multisensory group showed TUG 15.10 (0.60), JPE 7.00 (0.30), and FSS 5.10 (0.10). Following the intervention, the mini-trampoline group improved to TUG 10.40 (0.40), JPE 3.00 (1.20), and FSS 3.20 (0.20), whereas the multisensory group demonstrated post-intervention values of TUG 14.00 (0.60), JPE 5.20 (0.30), and FSS 4.80 (0.20) (**Tables 4-6**).

Within-group analysis using the Wilcoxon signed-rank test (**Tables 4-6**) demonstrated large effect sizes across all outcomes in both groups (r=0.81–0.91; 95% CI: 0.52–0.97), indicating meaningful within-group changes, though interpretation remains exploratory. Between-group comparisons performed using the Mann–Whitney U test (**Table 7**) showed moderate-to-large effect sizes in favour of the mini-trampoline group (r=0.75–0.86; 95% CI: 0.54–0.93).

Overall, this pilot study emphasises estimation, with effect size and confidence interval reporting suggesting meaningful intervention responsiveness. Findings should be interpreted cautiously, not as evidence of clinical superiority, but rather as preliminary data to inform future adequately powered trials. The observed effect sizes (r=0.75-0.86) and variability estimates (interquartile ranges) from this pilot study may serve as preliminary parameters for future sample size calculations.

Table 4. Within-group analysis for Timed Up and Go (TUG)

Groups	Pre Median (IQR) value	Post Median (IQR) value	Z value	*p*-value	Effect size(r)	95% CI
Mini trampoline (*n*=15)	15.30 (0.20)	10.40 (0.40)	-3.450	0.001	0.89	0.73–0.96
Multisensory (*n*=15)	15.10 (0.60)	14.00 (0.60)	-3.530	0.001	0.91	0.77–0.97

Data are presented as median (IQR) in line with nonparametric distribution characteristics. CI: confidence interval, IQR: interquartile range

Table 5. Within-group analysis for Joint Position Error (JPE)

Groups	Pre Median (IQR) value	Post Median (IQR) value	Z value	*p*-value	Effect size(r)	95% CI
Mini trampoline (*n*=15)	6.80 (0.10)	3.00 (1.20)	-3.408	0.001	0.88	0.70–0.95
Multisensory (*n*=15)	7.00 (0.30)	5.20 (0.30)	-3.502	<0.001	0.90	0.76–0.96

Data are presented as median (IQR) in line with nonparametric distribution characteristics. CI: confidence interval, IQR: interquartile range

Table 6. Within group analysis for Fatigue Severity Scale (FSS)

Groups	Pre Median (IQR) value	Post Median (IQR) value	Z value	*p*-value	Effect size(r)	95% CI
Mini trampoline (*n*=15)	5.10 (0.10)	3.20 (0.20)	-3.437	<0.001	0.89	0.72–0.96
Multisensory (*n*=15)	5.10 (0.10)	4.80 (0.20)	3.156	0.002	0.81	0.56–0.93

Data are presented as median (IQR) in line with nonparametric distribution characteristics. CI: confidence interval, IQR: interquartile range

Table 7. Between group analysis across outcome measure

Outcomes	U-value	Z-value	*p*-value	Effect Size (r)	95% CI
TUG	0.000	-4.670	<0.001	0.85	0.72–0.93
JPE	14.000	-4.092	<0.001	0.75	0.54–0.87
FSS	0.000	-4.702	<0.001	0.86	0.73–0.93

CI: confidence interval, TUG: Timed up and go, JPE: Joint position error, FSS: Fatigue severity scale

4.0 DISCUSSION

This pilot study compared the effects of weight-bearing mini-trampoline exercises and multisensory exercises on balance, proprioception, and fatigue in the geriatric population. Both intervention groups demonstrated statistically significant within-group improvements across all outcome measures, with large effect sizes. These findings suggest potential improvements in sensorimotor outcomes and overall quality of life. However, given the pilot nature of the study, these results should be considered preliminary and hypothesis-generating rather than confirmatory evidence of treatment effectiveness.

Although statistically significant changes were observed, the clinical relevance of these findings should be interpreted with caution, as minimal clinically important differences (MCID) for the selected outcome measures were not established within this study. Previous literature suggests that a reduction of approximately 2-3 seconds in the Timed Up and Go test may be associated with meaningful improvements in functional mobility and reduced fall risk in older adults (Beauchamp et al., 2021; Low et al., 2022). The changes observed in the present study appear to fall within this range, suggesting potential functional relevance; however, this requires confirmation in adequately powered trials.

Between-group comparisons suggested a trend toward greater improvement in the weight-bearing mini trampoline group. However, the study was not powered to detect between-group differences; therefore, these findings should not be interpreted as evidence of clinical superiority. Instead, they should be considered exploratory observations that require confirmation in larger randomised controlled trials.

With respect to functional mobility, the weight-bearing mini trampoline group demonstrated numerically greater improvements in the Timed Up and Go test, suggesting benefits for dynamic balance performance. While task-specific or surface-related demands may have contributed to these findings, such factors were not directly measured in the present study. Previous studies have reported improvements in functional mobility following mini-trampoline training in older populations, findings broadly consistent with the present observations (De Oliveira et al., 2014).

Proprioceptive function improved in both groups, with numerically greater changes observed in the weight-bearing mini trampoline group. Proprioceptive training has been associated with enhanced motor control and reduced reliance on visual inputs, thereby supporting improved postural control (Carey & Matyas, 2011; Winter et al., 2022). However, as no MCID has been established for ankle joint position error in older adults, these findings should be interpreted as indicative of directional improvements rather than definitive clinical change (Kalirathinam et al., 2018; Al Dahas et al., 2024).

Both interventions were associated with reductions in fatigue levels. Fatigue is common among older adults, particularly in those with sleep disturbances, and may negatively impact functional capacity and quality of life (Gnanadurai and Kasimariyappan, 2024). Exercise interventions, particularly low-impact activities, may improve aerobic capacity and muscular endurance, which could influence fatigue perception (Luawo et al., 2024; Liu et al., 2023). However, fatigue is a multidimensional construct influenced by both physiological and psychological factors, and minimal important differences vary across populations (Nordin et al., 2016). Psychological factors may also contribute to variations in fatigue perception (Satapathy et al., 2025). As the present study did not assess underlying mechanisms, the observed reductions should be interpreted cautiously.

4.1 Clinical implications

The findings of this pilot study suggest that both weight-bearing exercises on a mini trampoline and multisensory exercises may be considered for inclusion in geriatric rehabilitation programs aimed at improving balance, proprioception, and fatigue. However, given the exploratory nature of the study, these results should not be interpreted as evidence of the superiority of one

intervention over the other. In clinical practice, intervention selection should be individualised based on patient characteristics, safety considerations, and rehabilitation goals. Both approaches remain valuable components of comprehensive geriatric rehabilitation programs.

4.2 Limitations and future recommendations

This study has several limitations. The small sample size limits statistical power and generalizability. The 4-week intervention duration may not be sufficient to assess long-term effects or retention of improvements. As a pilot study, the primary objective was to assess feasibility and generate preliminary effect estimates rather than test formal hypotheses; therefore, the findings should be interpreted as exploratory, and the observed effect sizes should be considered as estimates to guide future research. Further studies should include larger, adequately powered randomised controlled trials with longer follow-up periods to evaluate the sustainability of interventions.

The relatively short duration was appropriate for assessing feasibility within a clinical setting; however, longer intervention periods are typically associated with greater improvements in balance and functional outcomes. Previous studies have demonstrated that balance and proprioceptive training programs conducted over longer durations (typically 6-12 weeks) yield more substantial and sustained benefits (Martínez-Amat et al., 2013). Therefore, future studies with extended intervention durations and follow-up periods are required to evaluate the clinical effectiveness of these exercise protocols. Future research should also involve large randomised controlled trials and explore the underlying neural adaptations using neurophysiological assessments such as electromyography and posturography.

4.3 Study contribution and novelty

The present study contributes preliminary comparative evidence between two established rehabilitation approaches using a randomised pilot design. While both interventions are commonly used in geriatric rehabilitation, this study provides exploratory effect estimates, feasibility data, and comparative trends that can guide the design of future definitive trials.

5.0 CONCLUSIONS

Both weight-bearing exercises on a mini trampoline and multisensory exercises were associated with improvements in balance, proprioception, and fatigue in the geriatric population. Although differences in the magnitude of change were observed between the interventions, these findings are preliminary and provide a foundation for future trials aimed at evaluating long-term effectiveness and optimising rehabilitation strategies in geriatric care.

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Conflicts of Interest: The authors declare no conflict of interest.

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