



## ORIGINAL ARTICLE

### Effect of Nintendo Wii balance board training on postural control and functional mobility in patients with subacute stroke: a randomized controlled trial

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## ABSTRACT

### BACKGROUND

Stroke is a major cause of long-term disability, imposing considerable physiological, psychological, and financial burden worldwide. Postural instability is common after stroke and often persists despite conventional rehabilitation, limiting functional independence and increasing fall risk. The aim of the study is to evaluate the effect of an 8-week multimodal cognitive-sensory balance training programme using the Nintendo Wii balance board on postural control, functional mobility, and cortical activity in patients with subacute stroke.

### METHODS

This randomized controlled trial included 60 participants with subacute stroke (38 male, 22 female) allocated to experimental (n=30) or control (n=30) groups via computer-generated random allocation. The experimental group underwent multimodal cognitive-sensory balance training on the Wii balance board, while the control group received conventional physiotherapy, both for 8 weeks under trained physiotherapists. The Berg Balance Scale, Functional Independence Measure, Centre of Pressure parameters, and functional Electroencephalogram (EEG) were assessed at baseline and after 8 weeks.

### RESULTS

The experimental group showed significantly greater improvement than the control group on the Berg Balance Scale ( $p<0.001$ ), the Functional Independence Measure ( $p<0.001$ ), Centre of Pressure path length ( $p=0.003$ ), and Centre of Pressure velocity ( $p<0.001$ ). No significant between-group difference was observed in functional EEG engagement ( $p=0.615$ ), although both groups improved significantly from baseline.

### CONCLUSION

The findings of the study indicate that multimodal cognitive-sensory balance training delivered through a gaming platform is more effective than conventional physiotherapy in improving postural stability and

functional independence in subacute stroke, and may be considered a useful, low-cost adjunct rehabilitation tool in clinical practice.

**Keywords:** Functional EEG, multimodal training, Nintendo Wii balance board, postural control, rehabilitation, subacute stroke

## INTRODUCTION

Stroke has been broadly known as one of the major sources of long-term handicaps, leading to major physiological limitations, mental and financial burden in most regions of the world.<sup>(1)</sup> The poststroke recovery progresses in a series of phases with the subacute phase being one that goes between one week and three months after the stroke occurring that is the most critical phase toward neurological recovery. At this period, the brain is more prone to reorganization and rehabilitation interventions, and can, therefore, bring significant functional recovery to an individual when implemented in a timely manner.<sup>(2)</sup>

One of the major impairments is a decrease in postural stability, which occurs during the subacute stage. This causes challenges in balance due to disturbed coordination between sensory systems, such as visual, vestibular, and proprioceptive signals and neuromuscular control.<sup>(3)</sup> These impairments limit autonomy and increase the potential of falls thus influencing a general quality of life. Even though the conventional rehabilitation measures can be effective to some degree, they might not always be able to provide the degree of task-specific training, drills, and involvement that could help in fully exploiting the adaptive capabilities of the brain at this stage.<sup>(4)</sup>

Technology-restrained rehabilitation methods have been embraced in reaction to these drawbacks. Interactive gaming platforms involve an enriched therapeutic environment, where movement practice is combined with sensory feedback and cognitive interaction to help in better motor learning.<sup>(5)</sup> One of such systems, which provides a viable and cost-effective method of providing balance training, is the Nintendo Wii balance board. It allows controlled weight-shifting and postural adaptations using real-time visual feedback and interactive activities and is thus an engaging method to increase balance.<sup>(6,7)</sup>

Such interventions need to be integrated into a multidimensional assessment framework to

evaluate their effectiveness, which involves functional performance, and physiological changes.<sup>(8)</sup> The Berg Balance Scale (BBS) is a standardized instrument used to measure balance performance in patients with neurological issues, and assess balance ability.<sup>(9)</sup> The Functional Independence Measure is used to measure functional status and independence in activities of daily living.<sup>(10)</sup> Objective measurement of postural stability is performed with the Centre of Pressure parameters measured with the Nintendo Wii balance board which shows real-time values of body movement and weight load distribution.<sup>(11,12)</sup> In addition, the development of neurophysiological measures has enabled the use of functional electroencephalography (EEG) to monitor brain activity in the process of rehabilitation exercises. Electroencephalography signals processed by EmotivPRO are functional, and can provide real-time data on cortical activity, thus providing meaningful data on cortical changes related to recovery.<sup>(13,14)</sup>

Multimodal interventions of training that incorporate motor, sensory, and cognitive aspects have been suggested to maximize recovery through activation of more than one neural circuit at a time.

Previous research has examined the effectiveness of Wii-based exercises in stroke rehabilitation, but results have varied. Lee et al.<sup>(15)</sup> conducted a randomized controlled trial involving stroke patients to compare the effects of virtual reality-based Wii Fit training with task-oriented training on balance. In their study, participants in the Wii group engaged in balance training using interactive games that provided real-time visual feedback, while the control group performed conventional, task-oriented exercises. After the intervention, the Wii group demonstrated significantly greater improvements in balance performance, as measured by standardized scales, suggesting that the combination of task-specific practice and augmented feedback through gaming platforms may enhance recovery.

Conversely, Yatar et al.<sup>(16)</sup> carried out a randomized controlled trial with patients with

chronic stroke, comparing Wii Fit balance training to progressive balance exercises that increased in difficulty over time. Both groups received structured, supervised sessions, but the intervention group utilized the Wii Fit system. The trial's findings indicated no significant differences in balance outcomes or functional mobility between the groups after the intervention period. This study suggests that Wii Fit training may be as effective as conventional progressive balance training, but not necessarily superior in this population. Lee et al.<sup>(15)</sup> showed a clear advantage for Wii-based interventions, while Yatar et al.<sup>(16)</sup> found equivalence between Wii Fit and traditional balance training. These inconsistent results underscore the need for further research using comprehensive outcome measures.

The present study advances the field by simultaneously evaluating clinical, biomechanical, and neurophysiological outcomes in subacute stroke patients, providing a more complete assessment of Wii-based balance training's impact. Thus, the aim of the current research was to evaluate the effect of an 8-week multimodal cognitive-sensory balance training involving the use of the Nintendo Wii Balance Board in postural control, functional mobility, and cortical activity in patients with subacute stroke. It is also supposed that balance, independence in daily activities, postural stability, and functional EEG indicators of cortical activation will improve as a result of this intervention.

## METHODS

### Research design

A prospective randomized controlled trial was conducted in our neurorehabilitation department of the physiotherapy unit of a tertiary care hospital from December 2025 to March 2026.

### Study subjects

Sixty participants with subacute stroke (2 weeks - 3 months following stroke) were recruited through non-probability consecutive sampling procedure due to specific predefined criteria of eligibility. After the baseline assessment, simple randomization was done. A computer-generated randomization sequence was generated and implemented by an independent researcher who was not involved in participant recruitment, assessment, or treatment delivery) to randomize the participants into two groups: the experimental group (30 participants) received multimodal

cognitive-sensory balance training on the Nintendo Wii balance board, while the control group (30 participants) received conventional physiotherapy.

The inclusion criteria were participants having a diagnosis of first-ever unilateral stroke, either ischemic or hemorrhagic, in the subacute period (within 2 weeks to 3 months of stroke onset); being medically stable and able to stand independently or with minimal assistive support; having a moderate level of balance impairment, defined as a BBS score of 21–45; and having sufficient cognitive capacity to follow simple verbal instructions, indicated by a Mini-Mental State Examination score of 24 or above. The Glasgow Coma Scale (GCS) was used at baseline to classify participants' level of consciousness. Only those with mild (GCS 13–15) or moderate (GCS 9–12) impairment were included.

The exclusion criteria were participants having acute musculoskeletal disorders with a possible impact on balance performance (e.g., a recent fracture or severe osteoarthritis); serious visual or vestibular impairment; other neurological conditions such as multiple sclerosis or Parkinson's disease; a Modified Ashworth Scale score exceeding 3; uncontrolled cardiovascular or metabolic disease; or concurrent enrollment in another structured rehabilitation programme during the study period.

### Sample size determination:

G Power software was used to compute the sample size, with an estimate of the effect size of 0.8, based on established guidelines,<sup>(17)</sup> a significance level of 0.05 and a statistical power of 80 and this indicated that at least 27 participants per group (54 total) were required. Taking into account a 10% dropout rate, the sample size was augmented to 30 participants per group (60 total).

### Intervention

The experimental group received multimodal cognitive-sensory balance training on the Nintendo Wii balance board, while the control group received conventional physiotherapy. Table 1 illustrates the intervention protocols for both groups.

**The Experimental group:** underwent an 8-week multimodal cognitive-sensory balance training programme on the Nintendo Wii balance board comprising 3 sessions per week, 1 hour per session, structured into six components (Table 1):

(i) a warm-up of active range-of-motion and weight-shifting exercises; (ii) static balance training on the Wii balance board with real-time visual feedback under eyes-open and eyes-closed conditions, an approach previously validated against laboratory-grade force platforms for quantifying postural sway.<sup>(11)</sup> (iii) dynamic balance training using Wii Fit games involving weight-shifting and reaching tasks, shown to produce significant gains in dynamic balance in stroke population,<sup>(18)</sup> (iv) task-oriented functional training incorporating Wii-based gait and stepping activities; (v) a cognitive component consisting of game-based dual-task training combining a motor task with a simultaneous cognitive demand, consistent with evidence that exergaming-based dual-task training improves balance outcomes after stroke<sup>(19)</sup> and (vi) a cool-down of stretching exercises.

**The Control group** received a time-matched conventional physiotherapy programme over the same 8-week period comprising 3 sessions per week, 1 hour per session, comprising active range-of-motion warm-up exercises, standing balance practice using parallel bars, weight-shifting and reaching tasks, gait and stepping training, basic dual-task and verbal-cue balance activities, and a stretching cool-down (Table 1), reflecting standard-of-care balance rehabilitation for subacute stroke.

All assessments and interventions were conducted in the presence of trained physiotherapists, and all participants provided written informed consent prior to participation.

### Measurements

Berg Balance Scale (BBS): evaluated on 14 functional balance activities that included

standing, reaching, and turning. The items have a range of 0 to 4, and a cumulative score of 56. A higher score illustrates increased balance and reduced fall risks.<sup>(9)</sup> Functional Independence Measure (FIM): measured by 18 items (18 motor and cognitive items). All items were rated on a 7-point scale and the range of total scores was 18-126. The scores should be higher indicating increased autonomy of activities of daily living.<sup>(10)</sup> Centre of Pressure (COP): measured on Nintendo Wii balance board during standing. Other parameters were measured, including the sway path length and displacement. The smaller the values, the better the control of postural stability and the balance.<sup>(11)</sup>

EEG functional area analyses with the EmotivPRO-EEG recordings were made at the time of performing the task to analyse the cortical activity. An engagement index (0-100 scale) was derived with higher scores indicating more cortical activation and attentional engagement.

### Statistical analysis

SPSS v22.0 was used. Continuous variables were reported as mean  $\pm$  SD; categorical variables as n (%). Baseline comparability was assessed using independent-samples t-tests and chi-square tests. Between-group comparisons post-intervention used independent-samples t-tests. Statistical significance was set at  $p < 0.05$ .

### Ethical approval

This study was approved by the Institutional ethical committee on human experimentation with ISRB No:099/12/2025/ISRB/FGSR/SCPT in accordance with the World Medical Association (WMA) Declaration of Helsinki.

Table 1. Intervention for experimental and control groups

| Component           | Experimental group (Wii-based training) | Control group (Conventional therapy) | Duration  |
|---------------------|-----------------------------------------|--------------------------------------|-----------|
| Warm-up             | Active ROM + weight shifting            | Active ROM exercises                 | 5–10 min  |
| Static balance      | Wii board (visual feedback, EO/EC)      | Standing balance (parallel bars)     | 10 min    |
| Dynamic balance     | Wii games (weight shift, reaching)      | Weight shifting, reaching tasks      | 15–20 min |
| Functional training | Task-oriented Wii activities            | Gait training + stepping tasks       | 10–15 min |
| Cognitive component | Dual-task training (game-based)         | Basic dual-task/verbal cues          | 10 min    |
| Cool-down           | Stretching                              | Stretching                           | 5 min     |

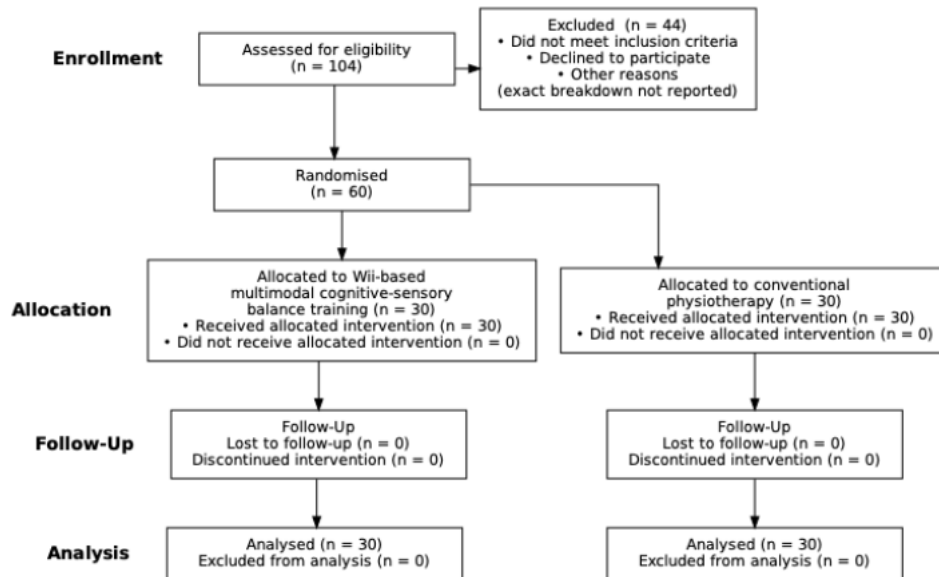


Figure 1. CONSORT flowchart of participants

## RESULTS

### Baseline comparability

A total of 104 participants were assessed for eligibility, with 60 participants ultimately randomised into either the experimental or control group. During the study period of 8 weeks, 49 participants were excluded for not meeting the inclusion criteria and 5 declined to participate, none were lost to follow-up. Thus, 60 subjects

finally completed the intervention and were included in the final analysis (Figure 1). The sample had a mean age of  $57.65 \pm 5.14$  years and a mean BMI of  $24.16 \pm 1.81$  kg/m<sup>2</sup>. The mean time taken after injury was  $5.87 \pm 2.20$  weeks. There was a skew in the gender distribution towards males ( $n=38$ , 63.3%). In terms of clinical severity, 51.7% ( $n=31$ ) of the respondents fell in the mild GCS category and 48.3% ( $n=29$ ) fell in the moderate category (Table 2).

Table 2. General and clinical characteristics of subjects at base-line

| Characteristics            | Wii-based (n=30)   | Conventional (n=30) | p value |
|----------------------------|--------------------|---------------------|---------|
| Age (years)                | $58.2 \pm 4.65$    | $56.9 \pm 5.45$     | 0.324   |
| BMI (kg/m <sup>2</sup> )   | $23.95 \pm 1.61$   | $24.37 \pm 1.79$    | 0.339   |
| Duration of Injury (weeks) | $5.63 \pm 2.09$    | $6.13 \pm 2.11$     | 0.361   |
| Sex                        |                    |                     |         |
| Male                       | 19 (63.3)          | 19 (63.3)           | 1.000   |
| Female                     | 11 (36.7)          | 11 (36.7)           |         |
| GCS severity               |                    |                     |         |
| Mild                       | 14 (46.7)          | 17 (56.7)           | 0.605   |
| Moderate                   | 16 (53.3)          | 13 (43.3)           |         |
| BBS                        | $31.06 \pm 4.50$   | $31.40 \pm 4.66$    | 0.770   |
| FIM                        | $74.05 \pm 10.24$  | $77.79 \pm 9.47$    | 0.147   |
| EEG                        | $51.83 \pm 5.42$   | $51.20 \pm 5.83$    | 0.665   |
| COP Path (mm)              | $252.48 \pm 36.00$ | $255.16 \pm 37.24$  | 0.777   |
| COP Velocity (mm/s)        | $9.31 \pm 2.05$    | $10.06 \pm 1.89$    | 0.148   |

Note : data presented as mean  $\pm$  SD, except sex and GCS severity (n,%); BMI : body mass index; GCS : Glasgow coma scale; BBS: Berg Balance Scale; FIM : Functional Independence Measure EEG : electroencephalography; COP : Centre of Pressure; All  $p>0.05$  for Age, BMI, Duration of Injury (independent t-test), and Sex, GCS Severity (chi-square,  $df=1$ ): the two groups did not differ significantly on any demographic or clinical characteristic, confirming baseline comparability.

Table 3. Comparison of all outcome measure scores between the intervention groups after eight weeks of intervention

| Outcome (Post)      | Wii-based (n=30)   | Conventional (n=30) | p value |
|---------------------|--------------------|---------------------|---------|
| BBS                 | 46.05 $\pm$ 3.98   | 39.90 $\pm$ 4.54    | <.001   |
| FIM                 | 100.52 $\pm$ 8.42  | 90.47 $\pm$ 10.38   | <.001   |
| EEG                 | 69.47 $\pm$ 5.69   | 68.71 $\pm$ 5.96    | 0.615   |
| COP Path (mm)       | 200.44 $\pm$ 34.72 | 229.18 $\pm$ 36.34  | 0.003   |
| COP Velocity (mm/s) | 6.60 $\pm$ 1.58    | 8.29 $\pm$ 1.87     | <.001   |

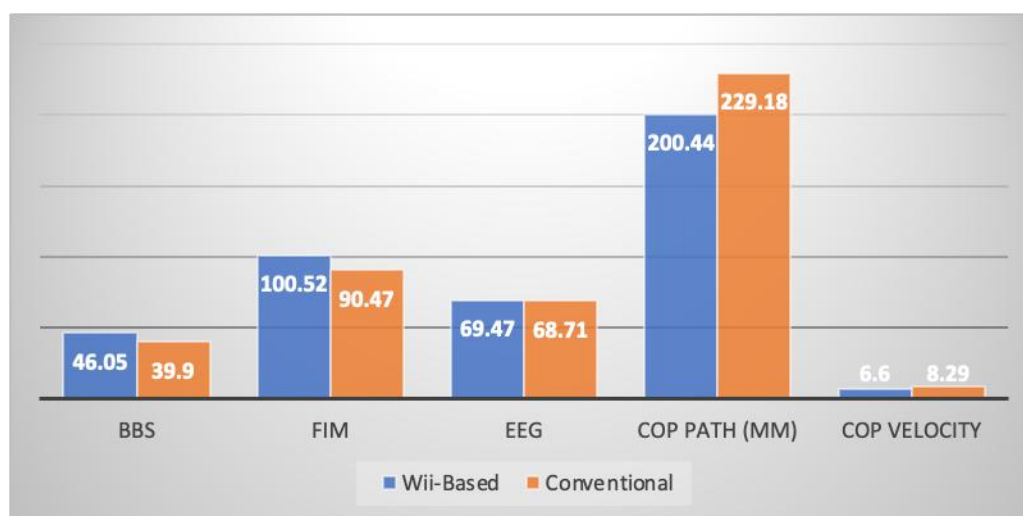
Note: data presented as mean  $\pm$  SD, BBS: Berg Balance Scale; FIM: Functional Independence Measure EEG: electroencephalography; COP: Centre of Pressure

The Shapiro-Wilk test was used to assess data normality. All baseline and post-intervention variables of BBS, FIM, EEG, and COP path were normally distributed ( $p > 0.05$ ); post-intervention COP velocity showed a mild deviation from normality ( $W = 0.956$ , interpreted with appropriate caution. Independent-samples t-tests and chi-square tests showed that the Wii-based and conventional groups did not differ significantly on any baseline demographic or clinical characteristic, including age, BMI, duration of injury, sex, GCS severity, or baseline BBS, FIM, EEG, COP path, and COP velocity scores (all  $p > 0.05$ , Table 2), confirming baseline comparability between groups.

#### Post-intervention between-group comparison

Because the groups were equivalent at baseline, independent-samples t-tests were used to

compare post-intervention outcome scores between groups (Table 3). The Wii-based group showed significantly greater improvement than the conventional group on the Berg Balance Scale (46.05  $\pm$  3.98 vs. 39.90  $\pm$  4.54,  $p < 0.001$ ) and the Functional Independence Measure (100.52  $\pm$  8.42 vs. 90.47  $\pm$  10.38,  $p < 0.001$ ). Significant between-group differences were also found for COP path length (200.44  $\pm$  34.72 vs. 229.18  $\pm$  36.34 mm,  $p = 0.003$ ) and COP velocity (6.60  $\pm$  1.58 vs. 8.29  $\pm$  1.87 mm/s,  $p < 0.001$ ), with lower values in the Wii-based group indicating superior postural stability. In contrast, functional EEG engagement did not differ significantly between groups post-intervention (69.47  $\pm$  5.69 vs. 68.71  $\pm$  5.96,  $p = .615$ ), indicating that cortical engagement improved with rehabilitation overall but was not differentially enhanced by the multimodal Wii-based format.



**Figure 2.** Comparison of post-intervention outcomes between the Wii-based and conventional groups across the Berg Balance Scale (BBS), Functional Independence Measure (FIM), functional EEG engagement, and Centre of Pressure (COP) path length and velocity. The Wii-based group showed significantly greater improvement on BBS, FIM, and both COP parameters, with no significant between-group difference in EEG engagement.

Figure 2 illustrates the comparative magnitude of post-intervention improvement across all outcome measures. The Wii-based group shows visibly greater gains than the conventional group for the Berg Balance Scale, Functional Independence Measure, and both Centre of Pressure parameters (path length and velocity), while the functional EEG engagement bars remain closely matched between groups, visually reinforcing the pattern of superior clinical and biomechanical improvement in the Wii-based group without a corresponding differential change in cortical engagement.

## DISCUSSION

The current study showed that an 8-week multimodal cognitive-sensory balance training programme using the Nintendo Wii balance board produced significantly greater improvements in balance, functional independence, and postural stability than conventional physiotherapy in patients with subacute stroke. Both groups improved from baseline, but the Wii-based group's gains were significantly larger on every clinical and biomechanical measure, indicating that technology-based, feedback-driven training can enhance recovery beyond what conventional therapy alone achieves and that this advantage held even though the two groups began the study statistically equivalent on every baseline characteristic, strengthening confidence that the difference reflects a true intervention effect rather than pre-existing imbalance.

The marked improvement in BBS scores in the experimental group indicates superior gains in both static and dynamic postural control. This finding is consistent with reports that Wii-based virtual reality exercises significantly improved balance and motor recovery in stroke patients, attributing these gains to task-specific training combined with augmented visual feedback.<sup>(20)</sup> Our results also align with a systematic review that found virtual reality-based interventions effective for improving balance outcomes, particularly as an adjunct to standard rehabilitation.<sup>(21)</sup> The present study extends these findings to the subacute stage specifically, a period of heightened neuroplasticity in which patients may be especially responsive to enriched training.

The significant between-group difference in FIM scores suggests that these balance gains translated into meaningfully greater independence in daily activities, arguably the outcome of

greatest relevance to patients and clinicians. This is consistent with findings that virtual reality-based gait and balance training improves functional mobility through repetitive, goal-oriented practice,<sup>(22)</sup> and with evidence emphasizing that task-specific, intensive rehabilitation improves independence in daily activities.<sup>(23)</sup> The dual-task and functional components embedded in the Wii-based protocol likely aided transfer of trained motor skills to real-life activities, contributing to this outcome.

The significantly greater reduction in COP path length and velocity in the experimental group further supports improved neuromuscular control of postural sway. Centre of pressure measures have similarly been found to be sensitive indicators of postural control change following rehabilitation.<sup>(11)</sup> The larger reduction in COP parameters observed here suggests that the multimodal, feedback-rich format of Wii-based training may engage sensorimotor integration more effectively than conventional exercises alone.

A notable finding was that functional EEG engagement did not differ significantly between groups, despite the clear between-group advantage on every clinical and biomechanical measure. This dissociation suggests that cortical engagement, as captured by surface EEG, improved with rehabilitation in general rather than being specifically enhanced by the multimodal, technology-based format. This contrasts with reports of a significant effect of virtual reality-based rehabilitation on cortical activity and neuroplasticity in stroke survivors.<sup>(24)</sup> One plausible explanation is a neural efficiency effect, whereby the experimental group achieved superior functional gains without a proportionally greater increase in global cortical effort. It is also possible that postural control improvements are substantially mediated by subcortical structures including the cerebellum and brainstem whose activity is not well captured by surface EEG, meaning the true neural substrate of the observed balance gains may lie below the resolution of this measurement technique.

The pattern of improvement observed is consistent with core principles of neuroplasticity. Neuroplastic change is driven by intensity, repetition, and task specificity,<sup>(25)</sup> thus the interactive, game-based nature of the Wii intervention likely provided a greater number of meaningful repetitions with immediate feedback, thereby supporting motor learning. Patient

engagement may also have played a role: enriched, feedback-oriented rehabilitation environments have been found to enhance patient engagement and outcomes,<sup>(26)</sup> and the gamified nature of the Wii balance board plausibly improved adherence and effort during training. Additionally, the multisensory demands of the balance board engaging visual, vestibular, and somatosensory systems simultaneously align with an account of sensory reweighting as a mechanism underlying improved postural strategy.<sup>(27)</sup>

Clinically, these findings support the Nintendo Wii balance board as a practical, low-cost rehabilitation adjunct. This is consistent with evidence demonstrating that accessible virtual reality platforms can produce functional gains comparable to higher-cost rehabilitation technologies,<sup>(28)</sup> making such systems attractive for wide-scale implementation across varied clinical settings. The limitation of the study was that a 8-week intervention period precludes conclusions about the long-term durability of the observed gains. The use of a portable EEG system (EmotivPRO) rather than laboratory-grade neuroimaging may have limited spatial resolution and the ability to detect subtler or deeper cortical changes. Factors such as participant motivation, therapist interaction, and individual recovery trajectories were not controlled and may have influenced outcomes. The absence of participant and assessor blinding also raises the possibility of performance bias. Future studies should incorporate longer follow-up, multicenter designs, and higher-resolution neurophysiological assessment to build on these findings.

These findings carry several practical implications. Clinically, incorporating multimodal, technology-assisted balance training such as the Nintendo Wii balance board into subacute stroke rehabilitation may accelerate gains in balance and functional independence beyond those achieved with conventional physiotherapy alone, particularly when introduced during the window of heightened neuroplasticity that characterizes the subacute phase. From a health-systems perspective, because the Wii balance board is low-cost, portable, and widely available, comparable programmes may be feasible to implement in resource-limited or community-based rehabilitation settings, potentially widening access to enriched, feedback-based therapy. The dissociation between the robust clinical and biomechanical gains and the absence of a differential surface-EEG effect

further suggests that clinicians should not rely on cortical engagement indices alone to judge the success of a balance intervention, and that combining functional, biomechanical, and neurophysiological outcome measures gives a more complete picture of recovery than any single domain in isolation.

Future studies should investigate the long-term effects of Wii-based balance training to determine whether the functional and postural improvements observed are maintained over time and lead to lasting benefits in daily life. Additionally, research utilizing advanced neuroimaging techniques such as functional MRI or high-density EEG would provide deeper insight into the specific neuroplastic changes and brain network adaptations that occur as a result of this intervention. Furthermore, exploring the potential of home-based or remotely supervised virtual reality training could help to make effective rehabilitation more accessible for a broader population of stroke patients, especially those who face barriers attending in-person therapy. Such research could also inform the development of personalized, technology-driven rehabilitation programs tailored to individual patient needs.

## CONCLUSION

This 8-week multimodal cognitive-sensory balance training programme using the Nintendo Wii balance board produced significantly greater improvements in balance, functional independence, and postural stability than conventional physiotherapy in subacute stroke, with no differential effect on functional EEG engagement. These findings support incorporating low-cost, technology-assisted balance training into subacute stroke rehabilitation to enhance recovery, particularly in resource-constrained settings where its affordability, availability, and capacity to engage patients make it a practical adjunct to standard care.

## Conflict of Interest

Competing interests: No relevant disclosure.

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### Authors' Contributions

All authors will take public responsibility for the content of the manuscript submitted to *Universa Medicina*. AP: Conceptualization, methodology, investigation, data curation, formal analysis, writing – original draft. PM, LP and DP: conceptualization, methodology, supervision, validation, writing– review & editing. PS and BM: Clinical evaluation and diagnosis, supervision, writing – review & editing. All authors have read and approved the final version of the manuscript.

### Data Availability Statement

The data of the study will be available from the corresponding author upon reasonable request.

### Declaration of AI Usage in Scientific Writing

AI was used only for minor grammatical corrections. All data presented in this study are original.

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