The Effectiveness of Virtual Reality Nintendo Wii Exergaming and Body Supported Treadmill Training in Improving Lower Limb Voluntary Movements, Balance and Gait Among Post-Stroke Patients – A Comparative Pilot Study

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DOI: https://doi.org/10.51244/IJRSI.2026.1306000229

Received: 05 June 2026; Accepted: 10 June 2026; Published: 02 July 2026

ABSTRACT

Objective: To determine the feasibility and preliminary effectiveness of VR Nintendo Wii Exergaming and BWSTT in improving lower limb voluntary movements, balance, and gait among post-stroke patients.

Methods: A randomized pilot study was conducted among 30 post-stroke patients recruited from a tertiary rehabilitation center. Participants were randomly allocated into three groups: Control Group (Conventional Physiotherapy), Experimental Group I (VR Nintendo Wii Exergaming + Conventional Physiotherapy), and Experimental Group II (BWSTT + Conventional Physiotherapy), with 10 participants in each group. Interventions were administered five days per week for eight weeks. Outcome measures included Fugl-Meyer Assessment–Lower Extremity (FMA-LE), Berg Balance Scale (BBS), and Timed Up and Go Test (TUG). Data were analyzed using repeated measures ANOVA and post hoc comparisons.

Results: Significant improvements were observed in all groups ($p<0.05$). Experimental Group I demonstrated the greatest improvement in FMA-LE (18.8±2.4 to 29.6±2.7), BBS (29.4±4.8 to 46.3±4.1), and TUG (31.2±5.1 to 18.4±3.6 seconds). BWSTT also showed significant gains, whereas conventional physiotherapy produced comparatively smaller improvements. Between-group analysis revealed statistically significant superiority of VR Nintendo Wii Exergaming over conventional therapy ($p<0.01$).

Conclusion: The pilot study supports the feasibility and effectiveness of VR Nintendo Wii Exergaming and BWSTT in post-stroke rehabilitation. VR Nintendo Wii Exergaming demonstrated the most favorable outcomes and warrants further investigation in a larger randomized controlled trial.

Keywords: Stroke Rehabilitation, Virtual Reality, Nintendo Wii, Body Weight Supported Treadmill Training, Balance, Gait.

INTRODUCTION

Stroke is one of the leading causes of death and disability worldwide, and it represents an enormous burden for individuals, families, health systems and society. Stroke is defined by the World Health Organization (WHO) as "rapid development of clinical signs of focal or global disturbance of cerebral function, lasting >24 h or leading to death, with no apparent cause other than of vascular origin. Despite improvements in acute stroke management and survival, a large number of stroke survivors still experience persistent neurological deficits that substantially impair their functional independence and quality of life. Motor impairments are one of the most common sequelae of stroke, with around 80% of survivors presenting hemiparesis in the acute stage.

Voluntary control deficits of lower limbs, muscle strength, balance, postural stability and gait are particularly disabling, often limiting mobility and participation in activities of daily living. These impairments result in increased dependence, decreased participation in the community, decreased quality of life, and increased risk of falls. Thus, restoring locomotor function is a primary goal of stroke rehabilitation. A major factor in recovery after stroke is the neuroplasticity of the central nervous system. Neuroplasticity is the ability of the CNS to reorganize and form new neural connections as a result of training and environmental stimuli. Current rehabilitation strategies emphasize intensive, repetitive, task-specific, and goal-directed practice to facilitate motor relearning and functional recovery. Conventional physiotherapy interventions such as range of motion exercises, strengthening exercises, balance training, gait training and functional task practice have been shown to be effective in improving

However, the traditional treatment may be limited by decreased motivation of patients, insufficient training intensity and difficulties in maintaining long-term commitment.

In recent years, technology-assisted rehabilitation has become a promising adjunct to conventional stroke therapy. Virtual Reality (VR) interventions are computer-generated environments that are interactive, allowing patients to perform meaningful tasks with visual and auditory feedback in real time. VR-based rehabilitation promotes motor learning through repetition, active participation, multisensory stimulation, and improved motivation. Among the many VR systems available, Nintendo Wii Exergaming has received a lot of attention because it is affordable and accessible and can simulate functional movements through fun games. The Nintendo Wii system encourages dynamic weight shifting, balance control, lower limb coordination and repetitive task practice, thus it is an appropriate choice for post-stroke rehabilitation. Studies have shown that interventions based on VR can improve balance, motor function, gait performance, and overall functional outcomes in stroke survivors. The interactive component of exergaming increases patient enjoyment and compliance with rehabilitation programs, which can result in greater therapeutic advantages. Moreover, the system provides immediate feedback which helps in correcting the motor and improves the learning process. Despite these benefits, evidence that VR-based interventions are better than other advanced rehabilitation approaches is limited. Another evidence-based intervention that is frequently used in neurological rehabilitation is Body Weight Supported Treadmill Training (BWSTT). BWSTT allows stroke patients to safely and in a controlled manner practice repetitive walking movements and reduces the physical demands of full weight-bearing. It has been shown that repetitive locomotor practice on a treadmill enhances motor recovery mechanisms and activates central pattern generators, leading to improvements in gait speed, endurance, walking symmetry, balance and

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue VI June 2026

functional mobility. Both VR Nintendo Wii Exergaming and BWSTT have demonstrated beneficial effects on motor recovery after stroke, but there is limited comparative evidence on their relative effectiveness in improving lower limb voluntary movements, balance and gait. The vast majority of previous studies have looked at these interventions in isolation, which makes it difficult for clinicians to determine the best rehabilitation plan. Pilot studies are important to test feasibility, estimate the effect of the intervention and generate preliminary evidence before large-scale randomized controlled trials.

Therefore, the present pilot study was undertaken to compare the effectiveness of Virtual Reality Nintendo Wii Exergaming combined with Conventional Physiotherapy and Body Weight Supported Treadmill Training combined with Conventional Physiotherapy against Conventional Physiotherapy alone in improving lower limb voluntary movements, balance, and gait among post-stroke patients. The findings of this study may contribute to the development of more effective rehabilitation protocols and provide preliminary evidence for future large-scale clinical trials.

MATERIALS AND METHODS

Study Design:

Randomized Pilot Experimental Study.

Study Setting:

Nandha Medical College Hospital and Nandha College of Physiotherapy.

Sample Size:

30 post-stroke patients.

Sampling Technique:

Simple random allocation.

Group Allocation:

Group A (VR Nintendo Wii Exergaming + Conventional Physiotherapy) (n=10)

Group B (BWSTT + Conventional Physiotherapy) (n=10)

Group C (Control): Conventional Physiotherapy (n=10)

Inclusion Criteria:

• Age 40–75 years

• First-ever ischemic or haemorrhagic stroke

• Ability to follow verbal commands

• Medically stable

Exclusion Criteria:

• Severe cognitive impairment

• Severe cardiac conditions

• Other neurological disorders

Outcome Measures:

1. Fugl-Meyer Assessment Lower Extremity (FMA-LE)

2. Berg Balance Scale (BBS)

3. Timed Up and Go Test (TUG)

Intervention Duration:

5 sessions/week for 8 weeks.

Statistical Analysis

Data were analysed using SPSS Version 26. Descriptive statistics were expressed as mean ± standard deviation. Repeated Measures ANOVA and Bonferroni post hoc tests were used. Statistical significance was set at $p<0.05$.

RESULTS

A total of 30 post-stroke patients participated in this pilot study and were randomly allocated into three groups: Group A (Conventional Physiotherapy), Group B (Virtual Reality Nintendo Wii Exergaming combined with Conventional Physiotherapy), and Group C (Body Weight Supported Treadmill Training combined with Conventional Physiotherapy), with 10 participants in each group. Baseline characteristics were comparable across the three groups. The mean age of participants was 58.4 ± 8.2 years in Group A, 59.1 ± 7.6 years in Group B, and 57.9 ± 8.4 years in Group C. The male-to-female ratio was 6:4, 7:3, and 6:4 in Groups A, B, and C, respectively. The mean duration since stroke was 7.2 ± 2.1 months in Group A, 6.9 ± 2.3 months in Group B, and 7.1 ± 2.0 months in Group C. Statistical analysis showed no significant differences among the groups at baseline ($p > 0.05$), indicating homogeneity of the study population.

Regarding lower limb voluntary movements, assessed using the Fugl-Meyer Assessment Lower Extremity (FMA-LE), all groups demonstrated significant improvements following the 8-week intervention period. Group A improved from 19.1 ± 3.0 to 24.7 ± 2.8, Group B improved from 18.8 ± 2.4 to 29.6 ± 2.7, and Group C improved from 19.3 ± 2.8 to 27.4 ± 2.9. The mean improvements were 5.6, 10.8, and 8.1 points, respectively. Within-group analysis revealed statistically significant improvements in all groups ($p < 0.001$), while between-group analysis demonstrated a significant difference favoring Group B ($F = 12.84$, $p < 0.001$).

Balance performance, measured using the Berg Balance Scale (BBS), also improved significantly in all groups. Group A showed an increase from 30.2 ± 4.5 to 39.8 ± 4.2, Group B improved from 29.4 ± 4.8 to 46.3 ± 4.1, and Group C improved from 30.0 ± 4.3 to 43.1 ± 4.0. The mean improvements were 9.6, 16.9, and 13.1 points, respectively. Statistical analysis demonstrated significant within-group improvements ($p < 0.001$) and significant differences among the groups at post-test assessment ($F = 14.67$, $p < 0.001$), with the Virtual Reality Nintendo Wii Exergaming group achieving the greatest gains.

Similarly, gait performance assessed using the Timed Up and Go (TUG) test showed significant reductions in completion time across all groups, indicating improved functional mobility. Group A improved from 30.8 ± 5.4 seconds to 24.6 ± 4.3 seconds, Group B improved from 31.2 ± 5.1 seconds to 18.4 ± 3.6 seconds, and Group C improved from 30.7 ± 4.8 seconds to 20.9 ± 3.9 seconds. The mean reductions in TUG time were 6.2 seconds, 12.8 seconds, and 9.8 seconds for Groups A, B, and C, respectively. These improvements were statistically significant within each group ($p < 0.001$). Between-group comparison revealed a significant advantage for Group B over the other groups ($F = 16.21$, $p < 0.001$).

Overall, the findings of this pilot study indicate that all three intervention approaches were effective in improving lower limb voluntary movements, balance, and gait among post-stroke patients. However, Virtual Reality Nintendo Wii Exergaming combined with Conventional Physiotherapy produced the greatest improvements across all outcome measures, followed by Body Weight Supported Treadmill Training combined with

Conventional Physiotherapy, while Conventional Physiotherapy alone demonstrated comparatively smaller but significant improvements. These preliminary findings support the feasibility and potential superiority of Virtual Reality-based rehabilitation for enhancing functional recovery following stroke.

Variable	Group A (Conventional Physiotherapy) (n=10)	Group B (VR Wii + Conventional Physiotherapy) (n=10)	Group C (BWSTT + Conventional Physiotherapy) (n=10)	p-value
Age (years), Mean ± SD	58.4 ± 8.2	59.1 ± 7.6	57.9 ± 8.4	0.931
Male/Female, n	6/4	7/3	6/4	0.874
Duration of Stroke (months), Mean ± SD	7.2 ± 2.1	6.9 ± 2.3	7.1 ± 2.0	0.954

Table 1. Baseline Characteristics

Group	Pre-test Mean ± SD	Post-test Mean ± SD	Mean Difference	p-value
Group A	19.1 ± 3.0	24.7 ± 2.8	5.6	<0.001*
Group B	18.8 ± 2.4	29.6 ± 2.7	10.8	<0.001*
Group C	19.3 ± 2.8	27.4 ± 2.9	8.1	<0.001*

Table 2. FMA-LE Scores

Group	Pre-test Mean ± SD	Post-test Mean ± SD	Mean Difference	p-value
Group A	30.2 ± 4.5	39.8 ± 4.2	9.6	<0.001*
Group B	29.4 ± 4.8	46.3 ± 4.1	16.9	<0.001*
Group C	30.0 ± 4.3	43.1 ± 4.0	13.1	<0.001*

Table 3. BBS Scores

Group	Pre-test Mean ± SD	Post-test Mean ± SD	Mean Difference	p-value
Group A	30.8 ± 5.4	24.6 ± 4.3	-6.2	<0.001*
Group B	31.2 ± 5.1	18.4 ± 3.6	-12.8	<0.001*
Group C	30.7 ± 4.8	20.9 ± 3.9	-9.8	<0.001*

Table 4. TUG Scores (seconds)

DISCUSSION

The findings demonstrated significant improvements across all intervention groups. However, participants receiving VR Nintendo Wii Exergaming exhibited superior gains in lower limb motor recovery, balance, and gait performance. The immersive environment and real-time visual feedback likely enhanced motor learning and patient engagement. BWSTT also produced substantial improvements by facilitating repetitive gait practice and promoting neuroplasticity. The results support previous evidence indicating that technology-assisted rehabilitation can complement conventional physiotherapy and improve functional outcomes after stroke.

Limitations

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XIII Issue VI June 2026

The pilot study involved a relatively small sample size and short-term follow-up. Long-term retention of treatment effects was not evaluated. Future studies with larger samples and multicenter recruitment are recommended.

CONCLUSION

VR Nintendo Wii Exergaming and BWSTT are feasible and effective interventions for post-stroke rehabilitation. VR Nintendo Wii Exergaming demonstrated the greatest improvements in lower limb voluntary movements, balance, and gait. These findings support progression to a full-scale randomized controlled trial.

Ethical Approval

Ethical approval was obtained from the Institutional Ethics Committee of Meenakshi Academy of Higher Education and Research, Chennai.

Conflict Of Interest

The authors declare no conflict of interest.

Source Of Funding

This study received no external funding and was conducted as part of the PhD research work of the principal investigator.

Data Availability

The datasets generated during the current pilot study are available from the corresponding author upon reasonable request.

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