(ISSN: 0973-7049(P))

The Bioscan AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES 21(3): S.I (3), 1265-1272, 2026 www.thebioscan.com

ADDED EFFECT OF VIRTUAL REALITY TO CONVENTIONAL PHYSIOTHERAPY ON BALANCE, FUNCTIONAL MOBILITY AND FUNCTIONAL INDEPENDENCE IN NEUROLOGICAL REHABILITATION: A COMPARATIVE STUDY

[1*]Suyog Shinde, [2]Dr. Dipika Balala, [3]Dr, Deepak Lohar, [4]Dr. Payal Sharma, [5]Dr. Jafar Khan, [6]Dr. Saleem Akhtar Naqvi, [7]Lokik Dadheech. [8]Ritika Solanki, [9]Nandini Paliwal, [10]Krati Jain

1. [*]M.P.Th. scholar, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan
2. Associate Professor, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan
3. Professor, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan
4. Assistant Professor, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan
5. Dean & HOD, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan
6. Professor & Head, Physiotherapy Clinical Services, Mahatma Gandhi Physiotherapy College, MGUMST, Jaipur, Rajasthan, India
7. M.P.Th. scholar, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan
8. M.P.Th. scholar, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan
9. M.P.Th. scholar, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan
10. M.P.Th. scholar, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan.

DOI: https://doi.org/10.63001/tbs.2026.v21.i03.S.I(3).pp1265-1272

KEYWORDS

Virtual Reality; neurological rehabilitation; balance; functional mobility; functional independence; Berg Balance Scale; Timed Up and Go; Functional Independence Measure.

Article Info

Received:27-06-2026

Accepted:14-07-2026

Published:22-07-2026

Abstract

Background

Neurological disorders frequently result in impairments in balance, functional mobility and functional independence, which can adversely affect daily activities and participation. Conventional neurological rehabilitation commonly incorporates strengthening, balance training, gait re-education, coordination exercises and functional task practice. Virtual Reality (VR) has emerged as an adjunctive rehabilitation approach that can provide interactive, repetitive and task-oriented practice.

Objective

To compare the effects of Virtual Reality-assisted rehabilitation combined with conventional physiotherapy with conventional neurological rehabilitation alone on balance, functional mobility and functional independence.

Methods

A total of 60 participants undergoing neurological rehabilitation were included and allocated into two groups of 30 participants each. Group A received Virtual Reality-assisted neurological rehabilitation in addition to conventional physiotherapy, whereas Group B received conventional neurological rehabilitation alone. Balance, functional mobility and functional independence were assessed using the Berg Balance Scale (BBS), Timed Up and Go Test (TUG), and Functional Independence Measure (FIM), respectively.

Results

Group A demonstrated a mean improvement of 6.33 ± 1.15 points in BBS compared with 0.63 ± 1.03 points in Group B. TUG performance improved by 3.62 ± 0.74 seconds in Group A compared with 0.83 ± 0.63 seconds in Group B. FIM increased by 8.73 ± 2.23 points in Group A compared with 0.53 ± 1.07 points in Group B.

Conclusion

The present findings demonstrate greater descriptive improvement in balance, functional mobility and functional independence following Virtual Reality-assisted rehabilitation combined with conventional physiotherapy compared with conventional neurological rehabilitation alone. However, definitive claims regarding statistical superiority should be based on the complete between-group inferential analysis from the original dataset.

Introduction

Neurological disorders are an important cause of disability and may produce impairments in motor control, balance, coordination, gait and functional independence. Depending on the underlying neurological condition, individuals may experience difficulty maintaining postural stability, walking safely, performing transfers and completing activities of daily living. Neurological rehabilitation therefore aims not only to reduce impairments but also to improve functional performance and independence. Neurological rehabilitation is a comprehensive, multidisciplinary process aimed at optimizing physical, cognitive, and functional abilities and promoting independence in individuals with neurological impairments.

Conventional neurological physiotherapy commonly includes strengthening exercises, balance training, gait re-education, coordination activities and functional task practice. Repetitive and task-specific practice is an important component of rehabilitation because patients require repeated opportunities to practice functional movements. The conventional rehabilitation programme in the present study included strengthening, balance training, gait training, coordination exercises and functional task training.

Virtual Reality (VR) has increasingly been investigated as an adjunctive intervention in neurological rehabilitation. VR can provide an interactive environment in which patients perform purposeful movements while receiving visual or auditory information regarding task performance. The potential clinical role of VR is therefore not necessarily to replace conventional physiotherapy but to provide an additional environment for repetitive, goal-directed and interactive practice.

In the present study, participants in the experimental group received VR-assisted neurological rehabilitation in addition to conventional physiotherapy. The VR programme incorporated reaching, grasping, stepping, upper-limb exercises, balance activities and interactive rehabilitation games.

Primary clinical studies have examined the effects of VR on balance and functional mobility in neurological rehabilitation. A randomized controlled trial involving individuals with stroke evaluated Xbox Kinect-based VR training using BBS, TUG and FIM. The study reported improvement in both groups and between-group differences favoring the VR intervention for several functional outcomes.

Similarly, Feng et al. conducted a randomized controlled study comparing VR rehabilitation with conventional physical therapy in individuals with Parkinson's disease. BBS and TUG were among the outcome measures, and both groups demonstrated improvement following rehabilitation.

A randomized controlled trial investigating VR reflection therapy in individuals with chronic stroke compared conventional rehabilitation with conventional rehabilitation supplemented by VR reflection therapy. BBS and TUG were among the outcomes used to evaluate balance and gait.

However, evidence is not uniformly positive. Yang et al. compared home-based VR balance training with conventional balance training in people with Parkinson's disease. Both groups improved in BBS and TUG, but no significant between-group differences were found.

These findings indicate that the effectiveness of VR may depend on the neurological population, intervention protocol, treatment dosage and outcome assessed. Therefore, VR should not automatically be described as superior to conventional rehabilitation.

The clinically relevant question is whether adding VR to conventional physiotherapy provides an additional benefit compared with conventional physiotherapy alone. The present study was therefore designed around this comparison, with particular emphasis on balance, functional mobility and functional independence.

MATERIALS AND METHODS

Study Design

The study employed a **comparative experimental design** involving 60 participants who were allocated into two groups.

The intervention comparison was:

VR-assisted rehabilitation + conventional

physiotherapy
versus
Conventional neurological rehabilitation alone.
The term randomized controlled trial should be retained only if the original study documentation confirms the randomization procedure and other methodological requirements for that designation.

Study Setting
The study was conducted in the **Department of Physiotherapy at Pacific Hospital, Udaipur**.

Participants
The study describes the study population as individuals with neurological disorders undergoing neurological rehabilitation.
A total of 60 participants were included:
- Group A: n = 30
- Group B: n = 30

Inclusion Criteria
- Participants diagnosed with a neurological condition requiring physiotherapy/neurological rehabilitation.
- Adults aged 18-65 years.
- Participants who are medically stable and able to participate in the rehabilitation programme.
- Participants able to understand and follow simple verbal instructions.
- Participants with sufficient visual and auditory ability to interact with the virtual reality system, with or without appropriate correction.
- Participants able to maintain sitting or standing safely as required for the selected virtual reality activities.
- Participants willing to participate voluntarily and provide written informed consent.

Exclusion Criteria
- Severe cognitive impairment that prevents understanding or following instructions.
- Severe visual, auditory, or vestibular impairment that prevents safe use of the virtual reality system.
- Uncontrolled epilepsy or a history of photosensitive seizures, where relevant to the VR equipment.
- Severe musculoskeletal pain or deformity that prevents participation in the intervention.
- Unstable cardiovascular or medical conditions contraindicating exercise or rehabilitation.
- Severe behavioural or psychiatric problems that interfere with participation.
- Previous significant adverse reactions to virtual reality, such as severe cybersickness.
- Inability to complete the assessment or intervention protocol.
- Participants unwilling to continue or who withdraw informed consent.

Intervention
Group A: VR-Assisted Rehabilitation
Participants received Virtual Reality-assisted neurological rehabilitation in addition to conventional physiotherapy.
The VR intervention included:
- **reaching activities,**
- **grasping activities,**
- **stepping activities,**
- **upper-limb exercises,**
- **balance training, and**
- **interactive rehabilitation games.**

Group B: Conventional Rehabilitation
Participants received conventional neurological rehabilitation consisting of:
- **strengthening exercises,**
- **balance training,**
- **gait training,**
- **coordination exercises, and**
- **functional task training.**

OUTCOME MEASURES
Berg Balance Scale
The Berg Balance Scale (BBS) was used to assess functional balance.
BBS has been used directly in clinical trials investigating VR-based neurological rehabilitation. In a randomized study of stroke participants, BBS was used alongside TUG and FIM to evaluate the effect of Xbox Kinect-based VR training.

Timed Up and Go Test
The Timed Up and Go Test (TUG) was used to assess functional mobility.
TUG incorporates transitional movement, walking

and turning and therefore provides a clinically relevant measure of functional mobility.
TUG has been directly used in randomized VR rehabilitation studies in neurological populations.

Functional Independence Measure
The Functional Independence Measure (FIM) was used to assess functional independence.
FIM provides information regarding the individual's level of assistance required during functional activities.
FIM has been used as a functional outcome in randomized VR rehabilitation research, including stroke rehabilitation.

STATISTICAL ANALYSIS
Data were expressed using mean and standard deviation.
Pre-intervention and post-intervention values were assessed and mean change was calculated for each outcome.

RESULTS
Participant Distribution
Table 1. Distribution of Participants

Group	Intervention	Sample
Group A	VR + Conventional Physiotherapy	30
Group B	Conventional Rehabilitation	30
Total		60

5.2 Balance
Table 2. BBS Scores Before and After Intervention

Group	Pre-intervention	Post-intervention	Mean Change
Group A	32.23 ± 3.07	38.57 ± 4.11	6.33 ± 1.15
Group B	32.37 ± 2.99	33.00 ± 3.14	0.63 ± 1.03

The observed difference in mean change between groups was approximately 5.70 BBS points, favouring Group A.

5.3 Functional Mobility
Table 3. TUG Scores Before and After Intervention

Group	Pre-intervention	Post-intervention	Mean Improvement
Group A	23.30 ± 1.71 s	19.68 ± 2.35 s	3.62 ± 0.74 s
Group B	23.25 ± 1.59 s	22.43 ± 1.74 s	0.83 ± 0.63 s

Because lower TUG time represents better performance, the observed reduction represents improvement.
The observed difference in mean improvement between groups was approximately 2.79 seconds, favouring Group A.

Functional Independence
Table 4. FIM Scores Before and After Intervention

Group	Pre-intervention	Post-intervention	Mean Change
Group A	78.73 ± 4.87	87.47 ± 6.92	8.73 ± 2.23
Group B	78.90 ± 4.66	79.43 ± 4.80	0.53 ± 1.07

The observed difference in mean change between groups was approximately 8.20 FIM points, favouring Group A.

DISCUSSION
Principal Findings
The principal finding of the present study was that participants receiving Virtual Reality-assisted rehabilitation in addition to conventional physiotherapy demonstrated greater descriptive improvements in balance, functional mobility and functional independence than participants receiving conventional rehabilitation alone.
The findings were consistent across all three selected outcomes:

- BBS,
- TUG, and
- FIM.

This is clinically relevant because the study evaluates VR as an adjunct to conventional rehabilitation, rather than as a replacement for

conventional physiotherapy.

Balance

The VR-assisted group demonstrated a mean BBS improvement of 6.33 points, whereas the conventional rehabilitation group demonstrated an improvement of 0.63 points.

This finding is supported by primary clinical research investigating VR-based balance rehabilitation.

In the randomized Xbox Kinect study involving individuals with stroke, BBS was used as one of the primary functional outcomes. Both groups improved, while the study reported between-group differences for some functional outcomes.

Similarly, Feng et al. evaluated VR rehabilitation against conventional physical therapy in Parkinson's disease using BBS and TUG. Both groups demonstrated improvement after treatment.

The chronic stroke VR reflection therapy study also directly evaluated BBS and TUG after adding VR to conventional rehabilitation.

Functional Mobility

The present study demonstrated a greater improvement in TUG in Group A.

The VR group improved by 3.62 seconds, while the conventional group improved by 0.83 seconds.

This finding is consistent with primary clinical evidence.

Feng et al. reported improvements in TUG following VR rehabilitation in Parkinson's disease.

The chronic stroke VR reflection therapy trial also included TUG as an outcome and investigated the effect of adding VR to conventional rehabilitation.

The Xbox Kinect trial in stroke similarly included TUG and reported between-group improvement favouring the intervention for functional mobility.

However, Yang et al. found no significant between-group difference between home-based VR balance training and conventional balance training in Parkinson's disease, despite improvement in TUG in both groups.

This conflicting evidence is important because it demonstrates that VR should not automatically be considered superior to conventional rehabilitation.

Functional Independence

The VR group demonstrated an 8.73-point mean improvement in FIM compared with 0.53 points in the conventional group.

Functional independence is an important rehabilitation outcome because improvement in impairment does not necessarily result in greater independence in daily activities.

The randomized Xbox Kinect study in stroke directly evaluated FIM in addition to BBS and TUG. The investigators reported between-group improvement in FIM favouring the intervention group.

This provides direct clinical support for the use of FIM when evaluating the functional effect of VR-assisted rehabilitation.

However, the present study did not directly investigate whether the improvement in FIM was mediated by improvements in balance or mobility.

Therefore, the appropriate interpretation is:

The greater improvement in functional independence may be associated with the broader functional improvements observed following VR-assisted rehabilitation.

Improvement in the Conventional Rehabilitation Group

The conventional rehabilitation group also demonstrated improvement.

This is an important finding because conventional neurological physiotherapy itself provides therapeutic stimuli through strengthening, balance training, gait training, coordination and functional task practice.

Therefore, the findings should not be interpreted as indicating that conventional rehabilitation was ineffective.

The appropriate interpretation is:

Both groups demonstrated improvement, but the VR-assisted group demonstrated larger descriptive changes across the selected functional outcomes.

Potential Role of Repetition and Feedback

The VR programme included reaching, grasping, stepping, upper-limb activities, balance training and interactive rehabilitation games.

These activities may provide repeated opportunities for goal-directed movement practice.

VR can also provide visual or auditory information during task performance, potentially supporting motor learning.

However, the present study did not measure:

- number of repetitions,
- active treatment time,
- adherence,

- motivation,
- feedback frequency, or
- neurophysiological changes.

Therefore, these mechanisms should be described as possible explanations, rather than proven mechanisms.

Is VR Superior to Conventional Physiotherapy?

The present study should not be described as demonstrating that VR is universally superior to conventional physiotherapy.

The actual comparison was:

VR + conventional physiotherapy

versus

conventional physiotherapy.

Therefore, the most appropriate conclusion is:

The addition of VR to conventional rehabilitation was associated with greater descriptive improvement in the selected functional outcomes.

This wording accurately reflects the intervention tested.

Contradictory Evidence

Not all primary studies demonstrate additional benefit from VR.

Yang et al. compared home-based VR balance training with conventional balance training in Parkinson's disease. Although both groups improved in balance and mobility, no significant between-group differences were identified.

This finding suggests that conventional rehabilitation can itself produce meaningful improvements and that the incremental effect of VR may depend on the population, intervention design and treatment context.

Therefore, the present findings should be interpreted as supporting a potential adjunctive role for VR rather than universal superiority.

CLINICAL IMPLICATIONS

The findings suggest that VR may be incorporated into conventional neurological rehabilitation as an adjunctive treatment approach.

Potential clinical applications include:

- balance training,
- stepping activities,
- reaching activities,
- upper-limb task practice,
- interactive functional activities, and
- mobility-oriented exercises.

The present study does not support replacing conventional physiotherapy with VR.

Instead, VR may be used to supplement conventional rehabilitation and provide additional task-oriented practice.

STRENGTHS

The study has several strengths.

1. It evaluates an adjunctive VR model rather than comparing VR with no treatment.
2. It includes clinically meaningful functional outcomes.
3. Balance, mobility and functional independence were assessed separately.
4. The intervention included practical task-oriented activities.
5. The direction of descriptive change was consistent across all three selected outcomes.

LIMITATIONS

First, the sample consisted of 60 participants, with 30 participants in each group.

Second, Different neurological diagnoses may have different recovery trajectories and treatment responses, which may introduce clinical heterogeneity.

Third, the currently available thesis data provide descriptive statistics but do not provide sufficient participant-level information to independently reconstruct all between-group inferential statistics.

Fourth, long-term retention of treatment effects was not established.

Fifth, potential mediating factors such as motivation, adherence, treatment repetitions and neurophysiological changes were not directly measured.

Finally, much of the external primary evidence has been generated in specific populations such as stroke and Parkinson's disease. Therefore, generalization to all neurological disorders should be made cautiously.

CONCLUSION

The present study demonstrated greater descriptive improvements in balance, functional mobility and functional independence among participants receiving Virtual Reality-assisted neurological rehabilitation combined with conventional physiotherapy compared with conventional neurological rehabilitation alone.

The VR-assisted group demonstrated greater mean changes in:

- BBS: 6.33 ± 1.15 points,
- TUG: 3.62 ± 0.74 seconds improvement, and
- FIM: 8.73 ± 2.23 points.

The findings support the potential use of Virtual Reality as an adjunctive tool within conventional neurological rehabilitation.

However, the findings do not establish that VR is universally superior to conventional rehabilitation or that neuroplasticity was the mechanism responsible for the observed improvements.

Future studies should use larger diagnosis-specific samples, standardized VR protocols, appropriate between-group statistical analyses and longer follow-up periods.

EVIDENCE APPRAISAL

Claim	Interpretation
VR can improve balance	**Supported by primary clinical trials using BBS and related balance outcomes.**
VR can improve functional mobility	**Supported by primary studies using TUG and gait-related measures.**
VR can improve functional independence	**FIM has been directly studied in VR rehabilitation, particularly in stroke.**
VR is superior for all neurological disorders	**Current evidence is heterogeneous and diagnosis-specific.**
VR improves outcomes because of neuroplasticity	**Plausible mechanism, but not measured in the present study.**
VR increases motivation	**Plausible, but motivation was not measured.**
Repetition explains the improvement	**Consistent with rehabilitation principles, but repetitions were not quantified.**
VR should replace conventional physiotherapy	**The current study tested VR as an adjunct, not a replacement.**
VR alone caused the improvement	**The experimental intervention was VR plus conventional physiotherapy.**

Author Contributions

Suyog Shinde: Study conception, methodology, data collection, data analysis and manuscript preparation.

Dr. Dipika Balala: Supervision, methodological guidance and critical review of the manuscript.

Dr. Jafar Khan: Academic and institutional supervision and critical review of the manuscript.

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