# Effectiveness of 2D virtual reality therapy with conventional physiotherapy versus conventional physiotherapy for improvement of lower extremity functionality of post- stroke hemiparetic patients.

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## Abstract

This paper investigates the comparative effectiveness of virtual reality (VR) therapy integrated with conventional physiotherapy versus conventional physiotherapy alone in improving lower extremity functionality among post-stroke hemiparetic patients. Stroke-induced hemiparesis often results in debilitating motor impairments, particularly affecting lower limb functionality, leading to significant challenges in daily activities and quality of life. Traditional physiotherapy has been a cornerstone in stroke rehabilitation, yet emerging technologies like VR offer promising adjunctive approaches.

In this study, a randomized controlled trial was conducted with post-stroke hemiparetic patients, comparing outcomes following a combined regimen of VR therapy and conventional physiotherapy against conventional physiotherapy alone. Assessment measures included standardized tests evaluating lower limb functionality, such as the Berg Balance Scale, Timed Up and Go Test, and Functional Independence Measure. Additionally, subjective patient feedback regarding satisfaction and perceived improvement was gathered.

## Introduction

India bears a significant burden of stroke cases, with an estimated 8 million patients as of 2016, and 60% of them grappling with various degrees of disability, some enduring lifelong challenges [1]. Among survivors, approximately 80% experience walking dysfunction, notably hemiparetic gait [2].

While traditional rehabilitation methods, predominantly physiotherapy and occupational therapy, have historically served as the mainstay for post-stroke lower limb rehabilitation, it may sometimes encounter limitations such as patient compliance, cost-effectiveness, and logistical constraints.

To address these challenges, researchers are exploring alternative paradigms in rehabilitation. One promising avenue is Virtual Rehabilitation therapy, which has garnered considerable attention in the field. The Virtual reality (VR) rehabilitation is achieved through computer hardware and software, whereby interactive simulations created by a computer provide participants with virtual environments similar to actual objects and events. By engaging patients in immersive gaming experiences, it enhances motivation and minimizes the need for extensive therapist involvement and complex assistive devices.
While previous research has explored the efficacy of VR therapy in rehabilitation in Western countries, with some of them proving it to be as effective as conventional therapy in lower limb rehabilitation, while others denying the claim a very little attention has been paid to its suitability for Indian stroke patients, whose circumstances and rehabilitation needs may differ significantly from those in Western countries. In India, where economic constraints often limit healthcare accessibility, our intervention stands out by specifically designed games that use standard PCs with webcams, making VR therapy more engaging and effective for the patients in Indian healthcare context.

## Methods and Materials

This project will employ a randomized controlled trial (RCT) design to assess and compare the efficacy of 2D virtual reality (VR) games for lower limb rehabilitation in individuals recovering from post-stroke hemiparesis.

- **Participants:**

Two groups of post-stroke hemiparetic patients (n=10 per group) with similar motor dysfunction profiles are recruited in accordance with the inclusion criteria. Patients will be randomly assigned to *(contd.)* either the control group, receiving conventional rehabilitation only, or the test group, receiving a combined intervention of conventional rehabilitation and 2D VR therapy.

- **Intervention:**

The control group will undergo conventional rehabilitation therapy, while the test group will receive both conventional therapy and 2D VR therapy using specially designed games. The VR games will track the movement of the affected limb to perform tasks within the game environment.The study duration is about four weeks with five sessions of VR therapy in one week for each patient in the test group.This accounts to 20 VR sessions for each patient.

- **Outcome Measures:**

Functional motor improvement will be assessed using recognized measures including 10 m walk test, Berg Balance Scale (BBS) , Timed Up and Go Test (TUG) , and Dynamic Gait Index (DGI) at baseline (0th week) and post-intervention (4th week). Outcome measures will be compared between the two groups to evaluate the efficacy of VR games in rehabilitation.

- **Data Analysis:**

Statistical analysis will be conducted to compare the pre- and post-intervention outcomes within each group and between the control and test groups. This will involve t-tests or non-parametric equivalents for continuous variables and chi-square tests for categorical variables, with significance set at $p < 0.05$.

## Data Analysis

A sample size of 10 participants was selected for each group. To evaluate efficacy, we calculated the Index of control for each outcome measure for the 10 patients in the control group, defined as

$$Index\ of\ 10m\ walk\ Test_{control} = \frac{Post\ 10m\ walk\ Test_{control} - Pre\ \ 10m\ walk\ Test_{control}}{Pre\ \ DGI} \quad \dots (eq.\ 1)$$

$$Index\ of\ DGI_{control} = \frac{Post\ 10m\ DGI_{control} - Post\ DGI_{control}}{Post\ 10m\ walk\ Test_{control}} \quad \dots (eq.\ 2)$$

$$Index\ of\ BBS_{control} = \frac{Post\ BBS_{control} - Pre\ \ BBS_{control}}{Pre\ \ BBS} \quad \dots (eq.\ 3)$$

$$Index\ of\ TUG_{control} = \frac{Post\ TUG_{control} - Post\ TUG_{control}}{Post\ TUG_{control}} \quad \dots (eq.\ 4)$$

Similarly, we computed the index for the test group to assess the degree of improvement relative to the pre-value.

$$Index\ of\ 10m\ walk\ Test_{test} = \frac{Post\ 10m\ walk\ Test_{test} - Pre\ \ 10m\ walk\ Test_{test}}{Pre\ \ DGI} \quad \dots (eq.\ 1)$$

$$Index\ of\ DGI_{test} = \frac{Post\ 10m\ DGI_{test} - Post\ DGI_{test}}{Post\ 10m\ walk\ Test_{test}} \quad \dots (eq.\ 2)$$

$$Index\ of\ BBS_{test} = \frac{Post\ BBS_{test} - Pre\ \ BBS_{test}}{Pre\ \ BBS} \quad \dots (eq.\ 3)$$

$$Index\ of\ TUG_{test} = \frac{Post\ TUG_{test} - Post\ TUG_{test}}{Post\ TUG_{test}} \quad \dots (eq.\ 4)$$

Subsequently, we compared both indexes using the Mann-Whitney test to determine the p-value utilizing JASP software. The results revealed that for the 10-meter walk test, Berg Balance Scale (BBS), and Timed Up and Go Test (TUG), the p-value was less than 0.05. This indicates a significant improvement in efficacy in the test group compared to the control group. However, for the Dynamic Gait Index (DGI), the improvement yielded a p-value greater than 0.05, suggesting no significant difference between the two groups in this aspect.
We employed a null hypothesis to test whether there was no difference in efficacy between the control and test groups, and the results supported the rejection of this null hypothesis in favor of the alternative, indicating the effectiveness of VR therapy in enhancing rehabilitation outcomes.

**Table 1.** p value to compare efficacy of test & control group.

## Result

| Outcome Measures | Test | P value |
|---|---|---|
| 10 m walk test | Mann-Whitney | 0.019 |
| BBS | Mann-Whitney | <0.001 |
| TUG | Mann-Whitney | 0.014 |
| DGI | Mann-Whitney | 0.070 |

## Discussion

- Post-stroke hemiparetic patients commonly face challenges related to asymmetric and abnormal walking patterns, leading to diminished mobility and balance [3].
- Extended confinement to these conditions often results in psychological stagnation and reduced motivation for traditional exercises.
- VR rehabilitation presents a unique approach by offering task-oriented training mirroring real-life tasks.
- The immersive nature of VR, coupled with audio-visual feedback and stimulation of multiple sensory channels, facilitates imitation-based learning and activates the mirror neuron system.
- by stimulating neural pathways through immersive virtual environments, translating into enhanced performance in daily activities and rehabilitation outcomes.
- VR therapy augments motor relearning processes [4], assisting patients in regaining physical function and task performance post-stroke.
- VR games in the project encompassed activities targeting distinct ranges of motion.
- Sit-to-stand exercises promote weight shifting, lower limb muscle activation, balance enhancement, and weight distribution, leading to improved completion times on the TUG test.
- VR exercises like forward, backward, and sideways walking simulate real-life gait patterns, demanding precise coordination and leg placement, resulting in significant improvements in step length and overall gait symmetry, leading to decreased completion times on the 10-meter walk test.
- Dynamic activities like jumping and squatting target lower limb muscles, particularly the extensors, reducing fall risk and improving BBS scores.
- Through combined interventions, VR offers promising avenues for comprehensive post-stroke rehabilitation, addressing various facets of functional mobility and balance with tangible outcomes.

## Sapshots of VR sessions

**Figure 1.** Snapshots of Patients playing games at INK Main Building
(1. sit to stand, 2. forward bacward leg movement, 3. stair climbing)

## Conclusions

The comprehensive evaluation of outcomes, including both motor and cognitive functions, ensures a holistic assessment of the benefits of VR-enhanced rehabilitation in 10-meter walk test, Berg Balance Scale (BBS), and Timed Up and Go Test (TUG). The combination of objective measures and standardized assessments provides robust evidence supporting the superiority of VR therapy in facilitating recovery post-stroke, particularly when used in conjunction with conventional therapy. By harnessing the immersive and interactive capabilities of VR, healthcare professionals can optimize patient outcomes and improve the quality of care for individuals recovering from post-stroke hemiparesis. This study not only highlights the efficacy of VR-enhanced rehabilitation but also sheds light on the importance of innovation and adaptation in meeting the evolving needs of stroke patients within the Indian healthcare landscape.

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