RESEARCH ARTICLE

VIRTUAL REALITY VERSUS CONVENTIONAL PHYSICAL THERAPY FOR STROKE MANAGEMENT IN IMPROVING ACTIVITY OF DAILY LIVING AND BALANCE: A RANDOMIZED CONTROL

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ABSTRACT

Background: Loss of balance and Activity of daily living commonly compromised in stroke patients. Conventional physical therapy CPT) showed promising result in the rehabilitation of stroke, but these effects are very slow. Virtual reality (VR) technology is an adjunctive therapy that could be applied in neurorehabilitation in conjunction with conventional physical therapy. **Objective:** The aim of the study was to determine the effectiveness of virtual reality and conventional physical therapy (CPT) for stroke management in improving activities of daily living and balance. **Methodology:** A total of n=30 participants with sub-acute ischemic stroke, aged between 45-65 years, were divided into group A and group B. The group A received virtual reality training (VRT) with conventional physical therapy (CPT) for stroke management, while Group B received conventional physical therapy (CPT). The activities of daily living (ADLs) were assessed through Barthel index and balance was assessed through Balance Berg Scale (BBS). The data was collected at baseline, 2nd week, 4th week and after 6th week of intervention. The mixed ANOVA and One way MANCOVA was applied to see the interaction and main effects. The data was analyzed using SPSS 21. **Results:** The mean age of study participants of Group A was 51.533±4.82 years and Group B was 52.53±5.01 years. There is significant interaction effect between interventions and level of assessment in Balance score {F=11.705(1.683, 47.134), p<.001, ηp^2=.295} as well as activity of daily living {F=4.782(2.209, 61.841), p=.010, ηp^2=.146} after 6 week intervention. **Conclusion:** Both groups were effective in improving ADLs and balance but VR was more effective as compared to traditional balance exercises.

Keywords: activities of daily living, acute stroke, balance, physical therapy, virtual reality.

INTRODUCTION

Stroke is defined as a neurological shortage accredited to an acute focal injury of the central nervous system due to a vessel related issue, which includes cerebral infarction, intra-cerebral haemorrhage, and subarachnoid haemorrhage in subarachnoid matter. It is a chief source of disability and death throughout the world[1]. The burden of the disease is more in developing countries, which reported 75.2% of all stroke-related deaths and 81.0% of the associated disabilities after stroke[2]. Prevalence of stroke in males & female population was 1.3% (n=137/10944) & 1.2% (n=134/11556) respectively[3].

Limitation in mobility is a major deficit occurred due to stroke. It affects control of movement on one side of the body, which is present in 80% of stroke patients. Loss of balance during walking is common after stroke and 70% of stroke survivors reported fall and injury. Also, psychological issues including confusion, depression, anxiety is also noted as post-stroke complications[4]. The factors that contribute to reduced walking speed are muscle weakness and loss of voluntary movements which leads to impaired standing balance after stroke. Thus, a key rehabilitation goal is to improve walking and balance in order to enhance activities of daily living[4,5]. The Activities of daily living (ADLs) is majorly compromised in stroke patients. A previous study reported that age, caregivers, history of past illnesses and smoking, and muscle strength may influence the ADLs of stroke patient. The stroke survivors always feel isolated, and over-whelmed due to dependency. Therefore, maintenance of ADLs is important for quality of life of stroke survivors. The primary goal of health care workers is restoration of ADLs such as dressing, bathing and toilet using, moving in and out of bed, mobility, and feeding[6].

Multidisciplinary team is required to deal with the complications and issues after stroke[7]. The rehabilitation team includes physicians, nurses, physical therapists, occupational therapists, speech language pathologists, vocational therapists, and vocational health professionals {Knecht, 2011 #318}. Physical therapy consists of interventional strategies that focus on development, maintenance, restoration of movements, and

functional abilities. Task oriented functional training concomitant to musculoskeletal, cardiopulmonary and sensory interventions appear to be very effective in improving balance and postural stability[9].

Conventional physical therapy is aiming towards high-intensity, repetitive, and task-specific procedures. This practice is an effective therapy throughout stroke recovery. However conventional physiotherapy is labor and resource-intensive, tiresome and results are often delayed. Along with this, frequency and intensity of the physiotherapy sessions are not sufficient in clinics for maximum recovery of the patients[10,11].

Virtual reality comprises of a simulation of the real environment which is generated by computer software. It is experienced via a human-machine interface. The concept behind using this technology is functional re-arrangement of the damaged motor area of brain that can be stimulated with the facilitation of mirror neurons or through the patient's motor imagery[12]. Virtual reality has provided new visions into the activity of brain areas involved in spatial cognition and navigation, multisensory integration of perceptual stimulation, and societal interaction[13]. It is getting well-known substitute to traditional upper and lower extremity rehabilitation after stroke[14].

Therefore the aim of the study was to determine the effectiveness of VR and traditional stroke management in improving ADLS and balance of acute and sub-acute ischemic stroke patients. VR is an emerging rehabilitation program in Pakistan, thus this study may add little knowledge to scientific literature regarding effective management of stroke cases.

METHODOLOGY

A single-centered, double blinded, randomized control trial was conducted at Haleema Siraj hospital Saidpur road Rawalpindi Pakistan from July 2021-March 2022. The study was initiated after taking approval from Medical Director (Ref #: HSH/2022-06-12/04). The participants with sub-acute ischemic stroke, aged between 45-65 years, who were independent or ambulant classified as level 1 or 2 on Gross Motor Functional Classification System, sufficient cognitive capacity measured through Mini-Mental State Examination (MMSE) score greater than 22-30, and adequate vision and hearing were included in the study. However, exclusion criteria included patients with severe osteoarthritis, asthma, structural deformities, poor cognition level, visual and hearing impairments, neuropathies, hemorrhagic stroke, and Pusher syndrome.

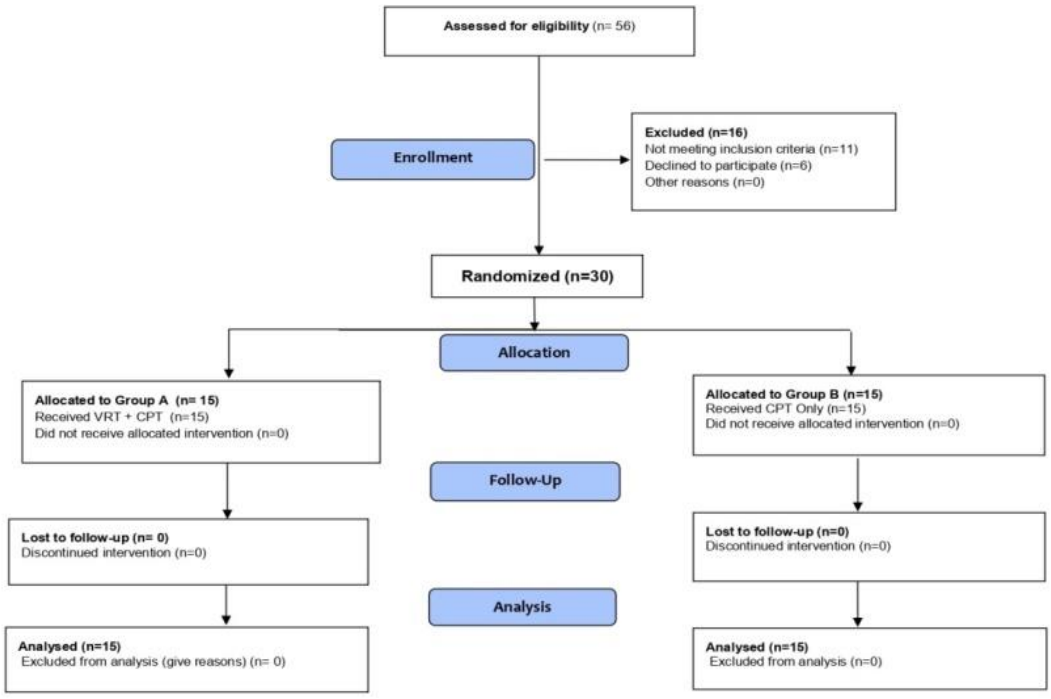

Figure 1: CONSORT diagram

The written informed consent, according to the Deceleration of Helsinki, was obtained from all the study participants prior to the study. A total of n=56 stroke subjects were evaluated for eligibility criteria, n=11 subjects did not fulfil the inclusion criteria and n=6 subjects decline to participate in the study due to accessibility issue. A total of n=30 participants were randomly allocated into two study groups, n=15 participants in each group through the computer generated numbers, and were written on the cards and placed in thick and sealed envelopes. When the patient came, physiotherapist opened the envelope and gave the assigned treatment. Each patient was given an allocated treatment written on the envelope. Group A (n=15) received virtual reality intervention while Group B (n=15) received traditional stroke management. (Figure 1)

The virtual reality games included bucket ball, balance it, and reflex ridge. While playing games patient has to move forward/backward, right/left side, and also move the upper the upper extremity to complete the tasks of the game. The games have different activities, including balance the object on virtual bar or collect the balls using bilateral arms and then move to the opposite direction to put in a bucket, and moving in different directions to avoid obstacle and using upper limb to collect bonus points. The participants were encouraged by providing feedback to complete the task. The game became more challenging with each passing level, which actively involves the patients. Before starting intervention, the trial session was given to each participant for better understanding of the game. The VR session was conducted in a separate room to avoid distractions and held under the supervision of physiotherapist. The duration of intervention was 40 minutes; 15 minutes VR games and 25 minutes of traditional stroke management.

The traditional management included exercises for balance with strengthening included stretching, range of motion, weight bearing, bed side activities, turning from affected to sound side, sitting, bed to chair transferring, sitting to standing, and parallel bar activities, and strengthening activities. The duration of intervention was 40 minutes.

The frequency of traditional protocol is 10 repetitions of each exercise depending on the endurance of patients. Each exercise was performed after 5 seconds of relaxation with 10 seconds of holding. A total of 18 sessions were given to the study participants for 6 weeks - 3 sessions in a week.

The outcome measures were Barthel Index and Balance Berg Scale (BBS). Barthel index has established validity and reliability and was used to determine the activities of daily living[15]. Balance Berg Scale was used to determine balance and is a valid and reliable tool[16]. The demographic data in terms of age, gender, BMI, gender, occupation, sitting and standing duration was obtained at baseline. The data of outcome measures was collected at baseline, 2nd week, 4th week and 6th week. The Mixed ANOVA was applied to determine the interaction effects between the intervention and level of assessments. After significant interaction effects main effects were measured through RM-ANOVA for within group analysis test was used. The MACOVA was applied to compare the groups while controlling the baseline differences. The level of significance was set at $p<0.05$ and the data were analyzed through SPSS version 21.

RESULTS

The mean age of Group A was 51.533±4.82 years and Group B was 52.53±5.01 years. The mean of mini mental status examination score of Group A was 25.33±2.22 and Group B was 24.86±1.68 which depicts no significant cognitive impairments in subjects. The detail of other demographic characteristics of study participants is shown in table 1.

Mauchly's Test of Sphericity indicated that the assumption of sphericity had been violated, the Greenhouse-Geisser values showed that there is significant interaction effect between interventions and level of assessment in Balance score {$F=11.705(1.683, 47.134)$, $p<.001$, $\eta p^2=.295$} as well as activity of daily living {$F=4.782(2.209, 61.841)$, $p=.010$, $\eta p^2=.146$} after 6 week intervention. (Figure 2) The main effects also showed significant within group improvement ($p<0.05$) in both Group A (VRT) and Group B (CPT) regarding activity of daily living and balance. (Table 2)

Table 1: Distribution of demographic features in Group A and Group B group

	Categories	Group A n (%)	Group B n (%)	Total
Age (Cat)	20-40 years	10(33.33 %)	12(40%)	22(73.3%)
	41-60 years	5(16.66%)	3(15%)	8(26.7%)
Gender	Male	6(40%)	6(40%)	12(40%)
	Female	9(60%)	9(60%)	18(60%)
BMI (Cat)	Normal	5(33.3%)	5(33.3%)	10(33.3%)
	Over weight	5(33.3%)	6(40%)	11(36.7%)
	Obese	5(33.3%)	4(26.7%)	9(30%)
Sitting duration (hr/day)	<4	4(26.7%)	6(40%)	10(33.3%)
	4 - 6	2(13.3%)	4(26.7%)	6(20%)
	6 - 8	9(60%)	5(33.3%)	14(46.7%)
Standing duration (hr/day)	<4	10(66.7%)	9(60%)	19(63.3%)
	4 - 6	-	4(26.7%)	4(13.3%)
	6 - 8	5(33.3%)	2(13.3%)	7(23.3%)

Significance Level: p<0.05, p<0.01**, p<0.001****

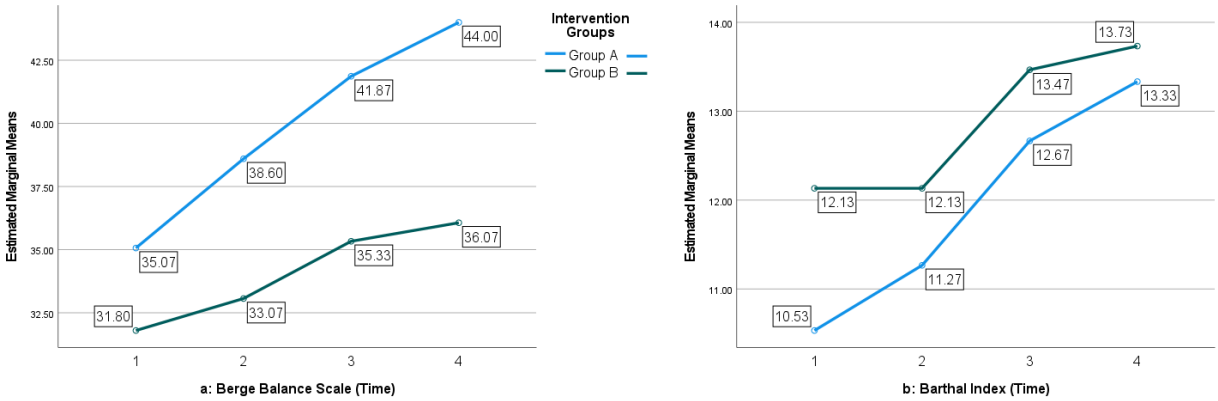

Figure 2: Interaction effect between intervention and level of assessment

Table 2: Within the Group Changes in Both Groups

		Group A (VRT)				Group B (CPT)			
		Mean	SD	MD/F(df)	p-value	Mean	SD	MD/F(df)	p-value
Barthal Index	Baseline	10.53	.83	-.733*	.01[a]*	12.13	.51	.000	.
	2nd Week	11.26	.96	-1.400*	0.00[b]***	12.13	.51	-1.333*	.001**
	4th Week	12.66	1.29	-.667	.074[c]	13.46	1.24	-.267	.986
	6th Week	13.33	1.17	58.06(3,42)	0.00[d]***	13.73	1.09	30.21(3,42)	0.00[d]***
Berg Balance Scale	Baseline	35.26	2.40	-3.533	.002**	31.80	2.88	-1.267*	.020*
	2nd Week	38.73	2.25	-3.267	<.001***	33.13	2.13	-2.267*	0.00***
	4th Week	41.86	2.94	-2.133	.009**	35.13	2.03	-.733*	.037
	6th Week	44.06	2.15	66.30(1.55,21.82)	0.00[d]***	35.93	2.05	39.22(1.46,20.54)	0.00[d]***

[a]baseline to 2nd week, [b] 2nd week to 4th week, [c]4th week to 6th week, [d]baseline to 6th week
Significance level: p<0.05, p<0.01**, p<0.001****

The MANCOVA test was applied to compare both groups for controlling the baseline differences, the result indicated that group A was significantly improved as compared to group B {13.33±1. ver. 13.73±1.09, F=5.251(1.26), p=.030, ηp^2=.168} regarding activity of daily living after 6th week.

While no significant difference (p≥0.05) found at 2nd and 4th week. The balance was significantly improved (p<0.05) in group A as compared to group B at 2nd week, 4th week and 6th week with large effect size. (Table 3)

Table 3: Between the Group Comparison (Group A & Group B)

		Group A (VRT)		Group B (CPT)		F(I,26)	p-value	ηp^2
		Mean	SD	Mean	SD			
Barthal Index	Baseline	10.53	.83	12.13	.51	-	-	-
	2nd Week	11.26	.96	12.13	.51	1.089	.306	.040
	4th Week	12.66	1.29	13.46	1.24	1.456	.238	.053
	6th Week	13.33	1.17	13.73	1.09	5.251	.030*	.168
Berg Balance Scale	Baseline	35.26	2.40	31.80	2.88	-	-	-
	2nd Week	38.73	2.25	33.13	2.13	14.318	0.00***	.355
	4th Week	41.86	2.94	35.13	2.03	12.069	.002**	.317
	6th Week	44.06	2.15	35.93	2.05	43.648	0.00***	.627

Significance level: p<0.05, p<0.01**, p<0.001****

DISCUSSION

The purpose of the study was to determine the effectiveness of balance exercises in ischemic stroke patients. It was hypothesized that virtual reality is more effective in improving balance and ADLs. The results of the study showed significant improvement in both groups but Group A showed more significant improvement.

According to the results of the study, VR games showed significant improvement in ADLs. The result supported previous study in which VR significantly improve daily life activities of stroke patients[17]. Previous studies reported that stroke patients have reduced ADLs due to stress, anxiety, dependency, sense of self-deprivation, and avoidance of using affected side[18], however VR games improves performance, satisfaction, and sense of achievement that leads to the improvement in daily activities[17]. Similarly, it was observed in a recent study that patients of VR group are more self-motivated to complete the tasks, which may also leads to the improvement in performance of ADLs.

The results of the recent study showed significant improvement in balance after VR intervention which corresponded with the previous study. A previous literature found VR games significantly improve balance of stroke patients[19,20]. It may be due to the improvement in spatial orientation capacity of patients through cerebral cortex activation in VR training, which improves balance and motor function[21]. The other possible reasons of improvement are repetitive task practice, which is supported by literature that repetitive task training improves motor function[22]. VR facilitates neural plasticity through incorporation of motor learning principles such as implicit learning, real-time feedback and focus of attention[23]. These factors may contribute to the improvement in balance.

Furthermore, traditional balancing exercises along with strengthening significantly improved activities of daily living and balance, which is supported by the previous literature balance along muscle strength is important for performing ADLs[24]. A previous literature suggests that functional training such as balancing exercises along strengthening significantly improve balance and thus function and daily life activities[25].

Between the groups analysis showed significant difference between Group A and Group B group. According to the results of this study, Group A showed significant improvement in ADLs and balance. The results of this study is in coherence with the previous study in which VR training is more effective as compared to the traditional therapy[26]. The possible reason of improvement in VR could be the neuroplasticity (which is at peak during acute and sub-acute stage), repetitive movement, task-oriented approach, feedback, implicit and explicit learning, which in return self-motivates the patient and leads to improvement in ADLs and balance. Brain-derived neurotrophic factor (BDNF) has appeared as a key facilitator of neuro-plasticity involved in motor re-learning. Firstly, learning-related plasticity encompasses the strengthening of current, in addition to the formation of new, neuronal networks that support learned actions. It is followed by focusing of neural connections as skill and preferential pathways[27]. However in traditional physical therapy, outcomes mostly rely on the ability and prior training of physical therapist. Moreover, the repetitions and intensity of traditional physical therapy is not sufficient to reach the plasticity-based optimal motor recover[26]. Therefore, the VR training augments the effects of traditional stroke management.

The limitation of the study was small sample size and short duration of intervention. The data was collected from single clinical setting. Only short term efficacy of intervention was investigated. These factors limit the generalizability of the results.

CONCLUSION

In this study both groups showed statistically significant results but clinically the group treated with VR showed more marked improvement in balance and ADLs. Future studies should be incorporated on a larger sample size, and multicentre. The study duration should be large to determine the long-terms effects of VR.

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