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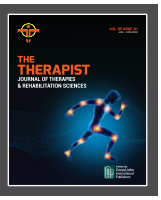

Original Article

Virtual Reality Training Improves Upper Limb Function in Stroke Survivors

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ABSTRACT

Stroke survivors with upper extremity functional limitation are particularly susceptible to problems in performing independent ADLs. Virtual Reality training has a significant contribution to enhancing the independence of stroke survivors. **Objective:** To determine the effect of additional VR training on upper limb gross motor function, gross manual dexterity, and functional activities in hemiplegic stroke survivors. **Methods:** It was a single-group experimental study in which 20 participants were recruited through non-probability convenient sampling. Participants were included in the study if they had any sort of stroke (hemorrhagic or infarct), were between the ages of 30 and 70, had at least one score on the box and block test, and did not have any cognitive deficits or uncontrolled high blood pressure. The intervention was provided three days a week for a total of six weeks. Gross motor function, gross manual dexterity, and functional capacities of the upper limb were measured at baseline, 2nd, 4th and at 6th week of intervention through Fugl-Meyer Assessment, Box and Block Test, and Wolf Motor Assessment Scale respectively. Data were analyzed through within-group inferential analysis using SPSS-21 software. **Results:** The mean age of patients was 49.45 ± 11.02 years. The scores of the Fugl-Mayer Assessment Scale, Box and Block Test and Wolf Motor Assessment Scale were significantly improved from baseline to six weeks ($p<0.05$). **Conclusion:** This study concluded that the hemiplegic stroke survivors who received additional Virtual Reality training using Xbox Kinect showed significant improvement in Gross motor Function, Gross Manual Dexterity and Functional Abilities of the Upper Limb.

INTRODUCTION

Cerebrovascular accident (CVA) is the second main cause of death, and its number is increasing day by day [1]. Stoke has two main types, ischemic 85%, and hemorrhagic 15% later one is more devastating [2, 3]. In Pakistan, it is twofold more than the rest of the world. In developing countries, stroke is the third main reason for mortality and the first main reason for disability [4]. It causes unexpected loss of balance, uncoordinated movements, difficulty in walking, and disequilibrium. CVA-related impairments include motor, sensory, speech and language, cognitive, and emotional dysfunctions. Motor impairments may include the face, upper limb, lower limb or whole side of body. Upper limb is usually more involved as compared to lower limb. Arm and hand functions are mostly impaired by stroke. Upper limb impairments are weakness, inability to perform isolated movements, increase or decrease muscle tone and alterations in superficial and deep sensations [5]. Rehabilitation of CVA survivors makes them free to work as possible and to achieve most ideal personal satisfaction. Techniques used in rehabilitation of stroke includes different concept of exercises e.g., Bobath concept, Perfetti concept, [6, 7] some other simple and single

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isolated concepts such as muscle strengthening exercise, isokinetic muscle strengthening, stretching, bimanual training, force use, constraint-induced movement therapy, mirror neuron and motor imaging technique or mental imaging technique [8-10]. Other adjunct therapies include sensory, and motor electrical stimulations and noninvasive transracial magnetic stimulations [11]. Virtual Reality (VR) is relatively new treatment approach in recovery process that uses technology which enables a person to interrelate with an artificially created environment [8]. It has four types immersive, non-immersive, fish tank, and projected [12]. Benefits of VR rehabilitation include development of interest, person can use this on his own, helps in physical and mental well-being improves cognitive abilities, enthusiasm, understanding by continuously repeating movements, self-assurance through positive support and instant feedback [8]. VR system is cheap, readily available video gaming customize according to need of person. Xbox Kinect is a very common, 3D device for playing video games that recognize user's movement using infrared camera sensors. It can even be used in home practice and can facilitate neuroplasticity [13]. The goal of this study is to investigate the effect of virtual reality-based training in the rehabilitation of stroke patients' upper limb dysfunctions.

METHODS

A six-month quasi-experimental study was conducted at Pakistan Railways General Hospital (1st Jul 2016-1st Jan 2017). IRB approval was taken from IRB&EC of Riphah International University (Reference # 00168). The study is registered in Iranian Registry of Clinical Trials (IRCT registration number: IRCT20191107045358N2). Stroke patients were recruited through non-probability convenient sampling technique. Individuals with hemorrhagic or ischemic stroke, between the ages of 30 and 70, who scored at least one on the box-and-block test were included in the study, but those having cognitive deficits, contractures in upper limb, and not having the ability to sit by their own were excluded. Complete stroke assessment was conducted of each patient and treatment was planned accordingly. Genuine informed consent was taken. Eligible patients followed treatment protocol for three days per week for six weeks. Gross motor function was assessed through Fugl-Meyer Assessment (FMA-UE), gross manual dexterity through Box and Block Test (BBT) and functional capacities of upper limb were measured through Wolf Motor Assessment Scale (WMFT). Participants received a conventional upper limb training regimen that included active and passive range of motion (ROM) exercises, weight bearing for 15-20 minutes, Electric Muscle Stimulation (EMS) for ten minutes, therapeutic stretching, and virtual reality training on an X-Box 360, details are given in table 1. Every movement performed was detected by camera and executed on LCD. Patient positioned either sitting or standing one and half or two meters away from LCD. For treatment purposes different games were selected like Tennis and Bowling from Kinect sport, and 20,000 leaks and Space pop from Kinect Adventures. Data were collected then analyzed on SPSS version 21.0 software. Demographics were analyzed through frequency tables. Within group analysis was done through paired sample t-test for Box and Block Test and Fugl-Meyer Assessment scale as per the normality of the data while Wilcoxen Test was used to determine the within group differences from baseline to Six weeks for Wolf Motor Function Test.

Table 1: Virtual reality treatment protocol for Upper Limb Training

Week	Activity	Duration
Orientation week	Orientation to exert-gaming and the specific games which will patients perform	15 minutes.
1 week	20,000 leaks	15 minutes (initially)
2 weeks	20,000 leaks (level increase according to patient's progress).	20 minutes
3 weeks	20,000 leak s+ Space Popout	15minutes+10 minutes
4 weeks	Space pop out+ Tennis	15minutes+10minutes
5 & 6 week	Tennis+ Bowling	15minutes + 15 minutes

RESULTS

Number of patients included in study was (n=20), with mean age was 49.45±11.02 years, 15 (75%) among them were male and 5 (25%) were female. Assessment of obtained data revealed that 14 (70%) of the patients had infarction and 6 (30%) of them had hemorrhagic stroke, all of them had Middle Cerebral Artery (MCA) lesions. Patients having HTN as primary risk factor were 12 (60%) and with DM were 5 (25%) individuals having both risk factors along with other risks were 3 (15%). Findings revealed that virtual reality-based training for stroke patients with upper limb dysfunctions has very positive results as significant improvements in scores of all scales used as outcome measures were observed (p-value <0.05). Details are shown in table 2. Assessment of gross motor function in terms of timing was not improved (p-value >0.05).

Table 2: Pre and post interventional analysis of outcome measures

Outcome Measures	Baseline	Week 6	p-Value
Box and Block Test	13.45±12.09	30.35±20.54	<0.001
Fugl Meyer Assessment Scale	32.50±10.75	55.75±8.52	<0.001
Grip Strength	8.30±4.48	14.60±4.59	0.001
Wolf Motor Function Test (Time)	339.93±273.32	89.89±43.80	<0.001
Wolf Motor Function Test (FAS)	42.45±7.53	60.11±12.43	<0.001
Gross motor (FAS)	22.1000 ±2.61	30.4500 ±2.91	0.003
Gross Manual Dexterity (Time)	290.7295 ±272.79	74.9825 ±41.63	<0.001
Gross Manual Dexterity (FAS)	74.9825 ±5.38	29.7152 ±10.87	0.004

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DISCUSSION

Additional VR training of 6 weeks showed marked improvement in upper limb functions, gross manual dexterity that was evaluated through WMFT, BBT and FMA-UE. Findings of present study were supported by an RCT study conducted by Saposnik *et al.*, in which additional VR training on 141 stroke patients for two weeks depicted improvement in WMFT [14]. To enhance neural plasticity any intervention provided for rehabilitation purposes should be well defined, needs lots of repetitive movements, and should be task oriented and it should not demotivate the person. X Box Kinect tool used in this study can make use all these factors for improving upper limb function [15]. In a study conducted by Jang *et al.*, chronic stroke patients were trained for four weeks using the Interactive Rehabilitation and Exercise System (IREX) VR system which was composed of video camera, cyber gloves, virtual objects and sensors. As the results of our study showed that UL functions were significantly improved with VR, results of their study also showed significant improvement in VR training group as compared to control group on Box and Block Test and Fugl Meyer scores [16]. It is observed during the present study that individual's motor recovery was good and fast as improvement was observed after every two weeks of intervention, which is confirmed by an RCT conducted by da Silva *et al.*, who concluded that VR group had rapid recoveries and improvements in values of similar scales used as outcome measures in present study [17]. In accordance with our results that showed VR training has shown improvement in the scores of FMA-UE and WMFT, results of a meta- analysis done in 2011 which included seven observational and five RCT studies revealed that 11 out of 12 studies shown improvement in the score of FMA-UE and WMFT after VR training of four to six weeks. This meta-analysis has supported results of present study, that is additional virtual reality rehabilitation is more effective for improving upper limb function in stroke patients [18]. Another systemic review of seven studies with 205 individuals compared virtual reality training with other treatment options or with no training, results shown that there was significant improvement in scores of assessment tools which are used in our study after VR training [19]. There was marked improvement seen in scoring of Box and Block test after the six weeks of virtual reality intervention. These findings of present study confirmed the results of an earlier study conducted by Sin and Lee reported increased scores of Box and Block Test in 40 Stroke patients with mean onset of seven months for six weeks of VR training [20]. Virtual reality in combination with traditional treatments is more effective than same number of traditional treatments used in rehabilitation for improving function of distal Upper Limb [21].

CONCLUSIONS

The study closes with the fact that hemiplegic stroke survivors who received additional virtual reality training using Xbox Kinect revealed significant improvement in functional abilities of upper limb. This study suggested that use of VR with traditional physical therapy may help treat stroke patients with upper limb dysfunctions. It is recommended that in future studies large sample size should be taken along with increased duration of intervention to get better results that can be generalized to all stroke survivors with hemiplegia.

Authors Contribution

Conceptualization: NS
Methodology: MAR, NA
Formal analysis: NA, MAR
Writing-review and editing: KI, ANM

All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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