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Original Research Article

Effectiveness of Virtual Rehabilitation on Functional Outcome for Wheel Chair Navigation in Patients with Spinal Cord Injury - A Pilot Study

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ABSTRACT

Spinal cord injury (SCI) is the injury of the spinal cord from the foramen magnum to the cauda equina which occurs as a result of compulsion, incision or contusion. Spinal cord injury patients lead to loss of functional outcome like balance, strength and general mobility because of which may lead to life threatening condition that carries a high risk of morbidity and mortality. Spinal cord injury patients (SCI) should undergo balance rehabilitation to restore the key determinants of ambulation, such as balance, strength, muscle tone, and proprioception. Recently, studies have used virtual reality (VR) as a promising tool for clinical rehabilitation in a variety of neurological disorders.

Purpose: To evaluate the effect of virtual Rehabilitation on Functional Outcome for Wheel chair Navigation In patients with Spinal Cord Injury

Methodology: Eight SCI patients with Cervical and Thoracic level Injury were included in this study. Patients were divided into two groups: Conventional Group (04 patients) and Experimental+conventional Group (04 patients). Both groups underwent the conventional rehabilitation program. An additional training with VR therapy was conducted for 6 weeks with 20 minutes per session and 3 sessions per week. The outcome measures were Modified Functional Reach Test, Range of Motion of Upper Limb and Wheelchair Propulsion Test.

Result: In this study Virtual Rehabilitation Group showed significant improvement in Balance, ROM and Wheelchair Propulsion compared to Conventional group (p <0.01 considered significant).

Conclusion: Virtual Rehabilitation can be considered as adjunctive therapy for improving functional outcome for wheelchair navigation purpose.

Key Words: Spinal Cord Injury, Virtual Rehabilitation, wheelchair navigation.

INTRODUCTION

Spinal cord injury (SCI) is the injury of the spinal cord from the foramen magnum to the cauda equina which occurs as a result of compulsion, incision or contusion. Spinal cord injury (SCI) is a life threatening condition that carries a high risk of morbidity and mortality The most common causes of SCI in the world are traffic accidents, gunshot injuries, knife injuries, falls and sports injuries.[1]

Various epidemiological studies have been carried out in different parts of the world. The incidence of SCI varies from 9.2 to 56.1 per million, which is influenced not only by research methodology but also by social, economic, geographical, demographic and political characteristics of the region. In the Indian setup, as in most developing countries, very little is known about the exact incidence of spinal cord injuries (SCI). Approximate 20,000 new cases of SCI are added every year.[2]

There is a strong relationship between functional status and whether the spinal cord injury is complete or not complete, as well as the level of the injury. A complete

SCI produces total loss of all motor and sensory function below the level of injury. Nearly 50% of all SCIs are complete. Even with a complete SCI, the spinal cord is rarely cut or transected. More commonly, loss of function is caused by a contusion or bruise to the spinal cord or by compromise of blood flow to the injured part of the spinal cord. In an incomplete SCI, some function remains below the primary level of the injury. A person with an incomplete injury may be able to move one arm or leg more than the other or may have more functioning on one side of the body than the other.[3,4]

Spinal cord injury patients (SCI) should undergo balance rehabilitation to restore the key determinants of ambulation, such as balance, strength, muscle tone, and proprioception.[5,6] Additionally, normal postural synergies are lost, and sensory-motor integration of the lower limbs and trunk is impaired. This reduced spatial information contributes to balance dysfunction; therefore, patients should develop strategies using the neck, upper limb.As Static postural stability, while sitting or standing, is important in performing basic activities of daily living. Dynamic balance is the ability to respond to any external stimuli or perturbation by corrective reactions and is required for an independent wheelchair ambulation and gait performance.[7]

For individuals with paraplegia, most functional activities, such as eating, dressing, and transferring, are performed in a seated position. The amount of trunk stability and mobility is directly correlated with the patient’s ability to perform functional tasks. To regain sitting postural control is 1 aim in the rehabilitation of patients with paraplegia Tetraplegia results in impairment of function in the arms as well as typically in the trunk, legs and pelvic organs, *i.e.*, including the four extremities and difficulty in ambulation.[8,9]

The wheelchair is most likely the most important mobility technology, but it is also the device most associated with barriers. According to Post et al there are significant complaints about wheelchairs among subjects with SCI. Manual wheelchairs are often considered heavy and difficult to maneuver. Therefore, it is critical that any wheelchair must match the user’s current expectations, preferences, physical needs, and functional requirements based on his/her interactions with the environment. [10]

Low cervical level can achieve independent level transfers (with or without a sliding board) and some uneven transfers; roll over, come to sitting, and gross movement on a mat or bed without adaptive equipment; and all self-care activities, such as dressing, personal hygiene, eating, drinking, and cooking. All can perform manual wheelchair propulsion on level surfaces with handrims. May be able to navigate minor inclines, uneven terrain, and 2- to 4-inch curbs and can achieve independent living.[10]

Recently, studies have used virtual reality (VR) as a promising tool for clinical rehabilitation in a variety of neurological disorders. Where different types of training and stimulation protocols are commonly used to induce or facilitate processes of neural regeneration and plasticity, which might lead to significant functional recovery after SCI.[11]

Appropriate rehabilitation strategies are highly needed to regain sensorimotor function and reduce symptoms such as spasticity, imbalance, and neuropathic pain. Recently, studies have used virtual reality (VR) as a promising tool for clinical rehabilitation in a variety of neurological disorders.[12]

MATERIALS & METHODS

Present study was conducted at Pravara Rural Hospital and Smt. Sindhutai E.Vikhe Patil Spinal Cord Injury Rehab. Centre, Loni. In this study 08 patients with spinal cord injury were included and divided into two groups. Study design was experimental study (Pre-Post) for duration of 2 years.

Study Group:

Group A (Control Group): Virtual Rehabilitation + Conventional Physiotherapy

Group B (Experimental Group): Conventional Physiotherapy

Participants:

An experimental study was done on 08 patients. Patients with Cervical and Thoracic level Traumatic Spinal Cord Injury, both male and female between age 20 to 60 years were selected. Patients who were having Shoulder pain or injury, Patient with acute case of injury & who need ventilatory assistance or Hemodynamically unstable having any associated neurological condition, Patient having cognitive problems and if having sever hand dysfunction(weakness) were excluded from the study.

Materials:

Data collection sheet, consent forms, Laptop, Neuroforma application, goniometer, inch tape, 10 m distance space, timer, wheel chair.

Procedure:

Permission was taken from the Institutional Ethical Committee of Pravara Institute of Medical Sciences (DU) Loni**.** The aim and methodology of study was explained to them and their consent was taken. The Traumatic Spinal Cord Injury Patients were recruited from Smt. Sindhutai E.Vikhe Patil Spinal Cord Injury Rehabilitation Centre and permission was obtained prior to the study. Demographic data of the subjects were determined. Pre treatment Functional reach test (Modified), Wheelchair propulsion test, ROM were assessed. For Modified functional reach test patient was seated on wheel chair at the side of wall and asked to reach forward as much as possible without losing balance and the distance was measured, wheel chair propulsion test was checked by asking patient to wheeling (Propuling) wheelchair 10m while time was recorded with a stopwatch, and the number of cycles and propulsion methods was recorded by observation, ROM was assessed by Goniometer.

The patients undergone Virtual Rehabilitation exercises program for 6 weeks with 20 minutes per session and 3 sessions per week. These exercises included Virtual based gaming activity for trunk balance and upper limb movement.

While conservative management was given for both groups management was as follows:

Stretching, active range of motion exercises, strengthening for innervated muscles, Aerobic and balance activities. Post treatment functional reach test, wheel chair propulsion test and ROM was assessed and da ta was collected and statistical analysis was done.

Statistical Analysis:

Data were analysed with InStat software. Intragroup pre-post data analysed using paired t test and Inter group data compared using unpaired t test and $p<0.05$ considered as significant**.**

RESULTS

The Modified Functional Reach Test (MFRT) of Group B improved from 7.5±2.0 to 10.7±0.9 as compared to Group A from 6.7± 2.2 to 7.5 ± 2.5 **(Table.1,Figure.1).**On inter Group comparison of Group B showed significant improvement in MFRT 0.75±0.5 to 3.25±1.5 respectively $p<0.019$ **(Table.2, Figure.6).** For Wheelchair Propulsion Test all components (in relation with distance ,time, cycles) were assessed and data was analysed with Graphical presentation which showed significant improvement in group B within the group post intervention. Result of wheelchair propulsion test in relation with distance was 737.5 ±188.7 to 887.5 ±103 as compared to Group A 700 ±182.5 to 725 ±184.8 **(Table.1,Figure.2).**On inter Group comparison Group B showed significant improvement compared to Group A 25 ±28.8 to 150 ±91.2 respectively $p<0.04$ **(Table.2,Figure.7).** Result for propulsion test in relation with Time showed improvement in Group B 11.25 ±2.2 to 15.7 ±2.9 as compared to Group A 14 ±1.8 to 14.25±2.2 **(Table.1, Figure.3).** On inter group comparison Group B showed significant improvement in wheelchair propulsion test in relation with time 0.25 ±0.5 to 2±0.8 respectively p<0.010 **(Table.2, Figure.8)**. Result for propulsion test in relation with cycles showed improvement in Group B 15.25 ±3.3 to 21.7 ±2.5 as compared to Group A 20.25 ±2.9 to 21.25 ±3.5 **(Table.1,Figure.4).**On inter group comparison Group B showed significant improvement in wheelchair propulsion test in relation with cycles 2 ±2.1 to 6.5±1.2 respectively p<0.011 **(Table.2,Figure.9).** Range of Motion was compared with in the group pre and post showed significant improvement in Group B 107.5±13.2 to 121.2±10.3 **(Table.1, Figure.5).** On inter Group comparison Group B showed significant improvement compared to Group A 3.75±4.1 to 13.7 ±4.7 respectively p<0.019 **(Table.2,Figure.10).**

Table 1: Details of Modified Functional Reach test, Wheelchair Propulsion Test and ROM Pre and Post Intervention

OUTCOME MEASURES		Group A Mean ±SD	Group B Mean ±SD
MFRT	PRE	6.7 ±2.2	7.5 ±2.0
	POST	7.5±2.5	10.75±0.9
	p Value	0.02	0.05
WPT (Distance)	PRE	700±182.5	737±188.7
	POST	725±184.8	887±103.0
	p Value	0.18	0.04
WPT (Time)	PRE	14±1.8	11.25±2.2
	POST	14.2±2.2	15.75±2.9
	p Value	0.39	0.02
WPT (Cycles)	PRE	20.25±2.9	15.25±3.3
	POST	21.25±3.5	21.7±2.5
	p Value	0.09	0.008
ROM	PRE	104±12.1	107±13.2
	POST	108±9.9	121±10.3
	p Value	0.16	0.01

GRAPHICAL PRESENTATION

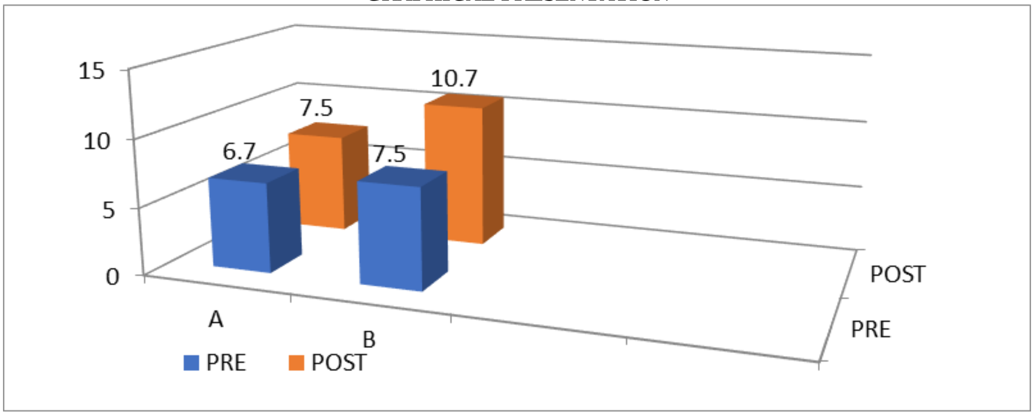

Figure 1: Comparison of Modified functional Reach test Pre and Post intervention with in both groups

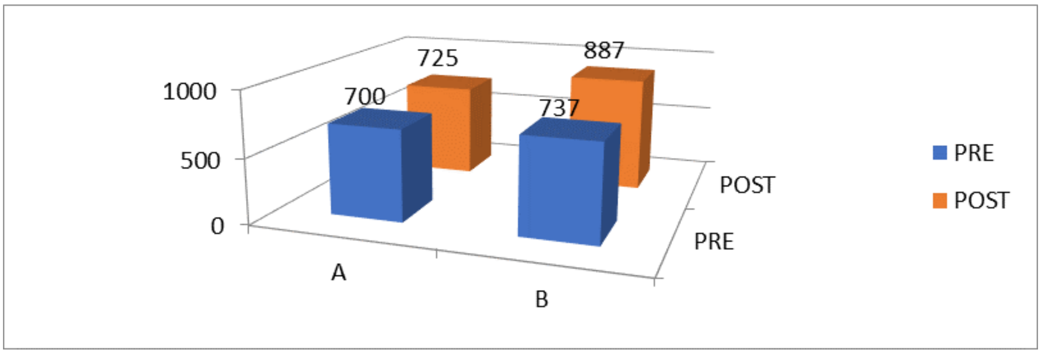

Figure 2: Comparison of Wheelchair Propulsion Test in relation with distance Pre and Post intervention with in both groups

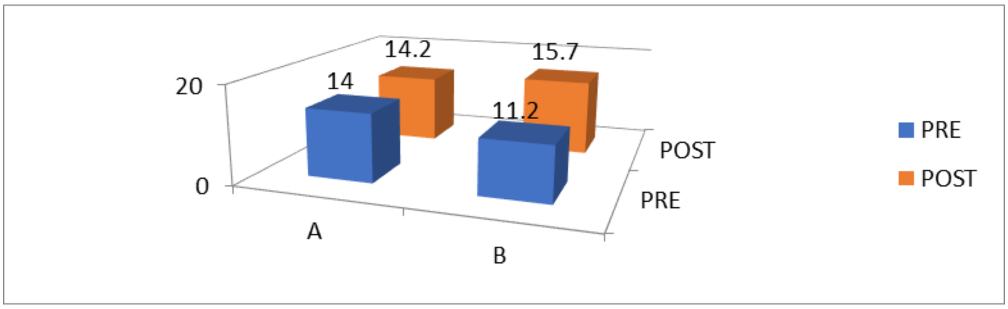

Figure 3: Comparison of Wheelchair Propulsion Test in relation with Time required to complete the distance Pre and Post intervention

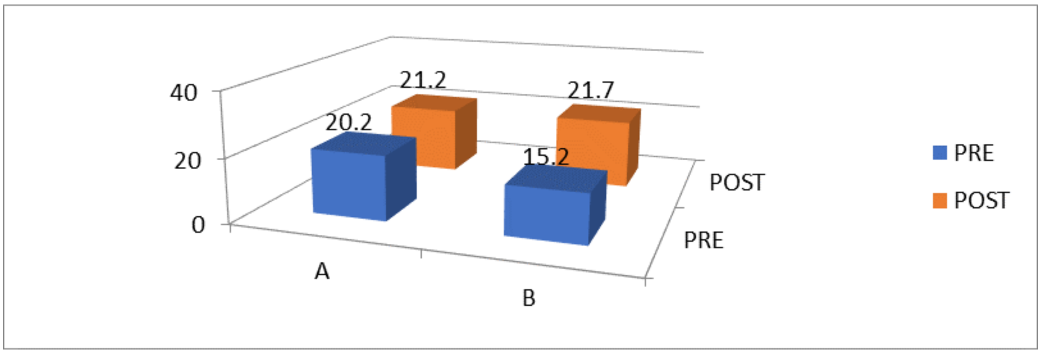

Figure 4: Comparison of Wheelchair Propulsion Test in relation with push cycles Pre and Post intervention

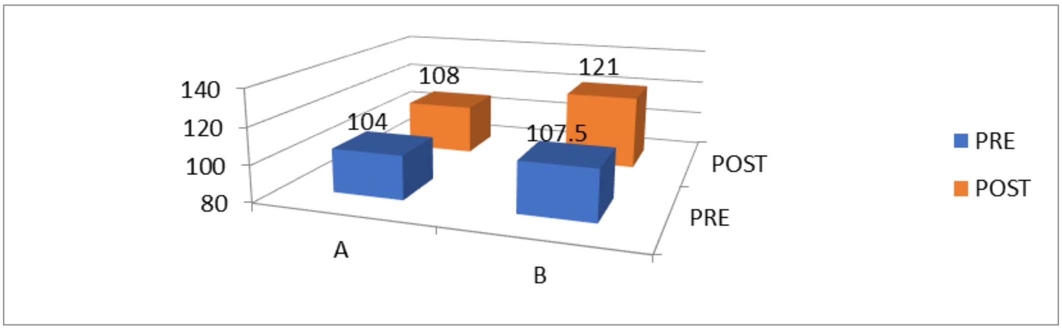

Figure 5: Comparison of Range of Motion of Upper Limb Pre and Post intervention

Table 2: Inter Group Comparison of Modified Functional Reach test, Wheelchair Propulsion Test and ROM

OUTCOME MEASURES	Group A Mean Diff ±SD	Group B Mean Diff±SD	P Value
MFRT	0.75 ±0.50	3.25 ±1.50	0.01
WPT (Distance)	25±28.8	150±91.2	0.04
WPT (Time)	0.25±0.5	2±0.8	0.01
WPT (Cycles)	2±2.1	6.5±1.2	0.01
ROM	3.75±4.1	13.75±4.7	0.01

INTER GROUP COMPAIRISON

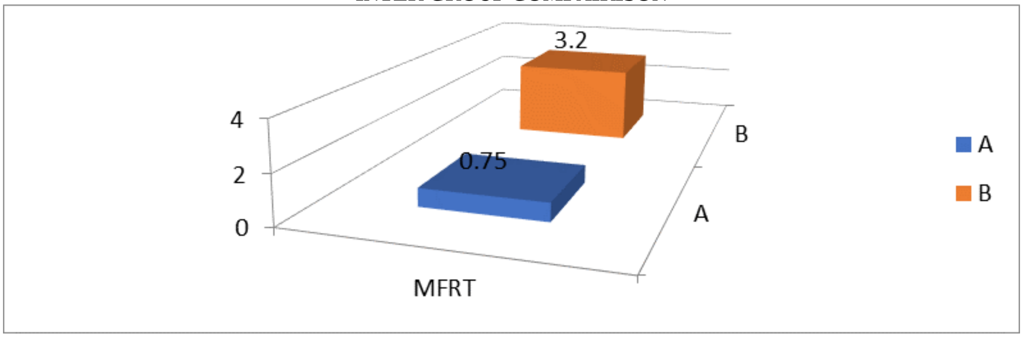

Figure 6: Inter Group comparison of Modified Functional Reach Test

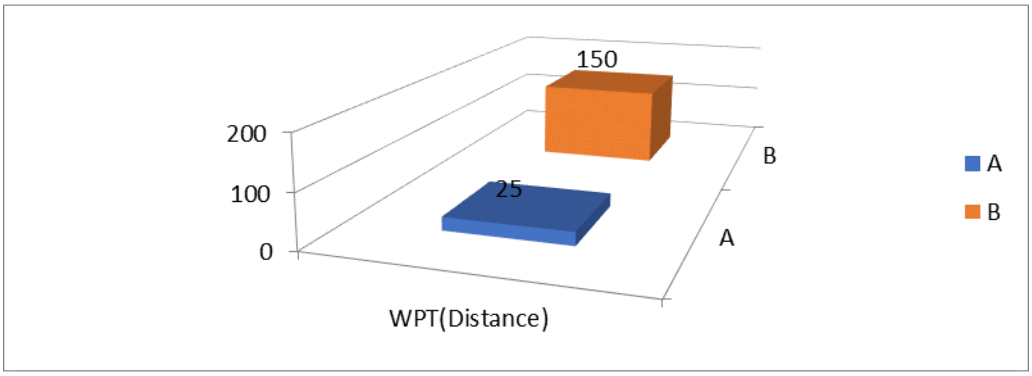

Figure 7: Inter Group comparison of Wheelchair Propulsion Test in relation with Distance

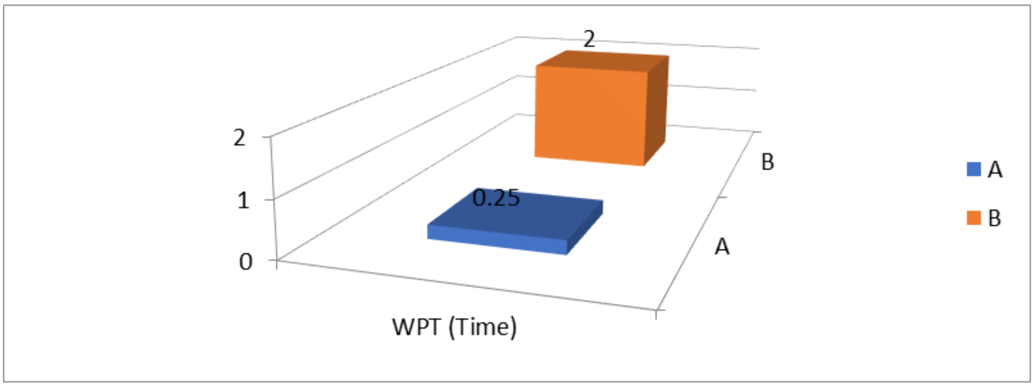

Figure 8: Inter Group comparison of Wheelchair Propulsion Test in relation with Time

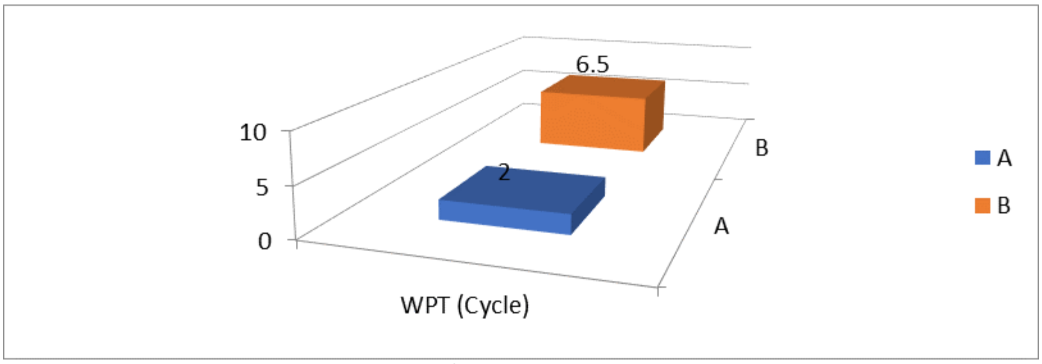

Figure 9: Inter Group comparison of Wheelchair Propulsion Test in relation with cycles

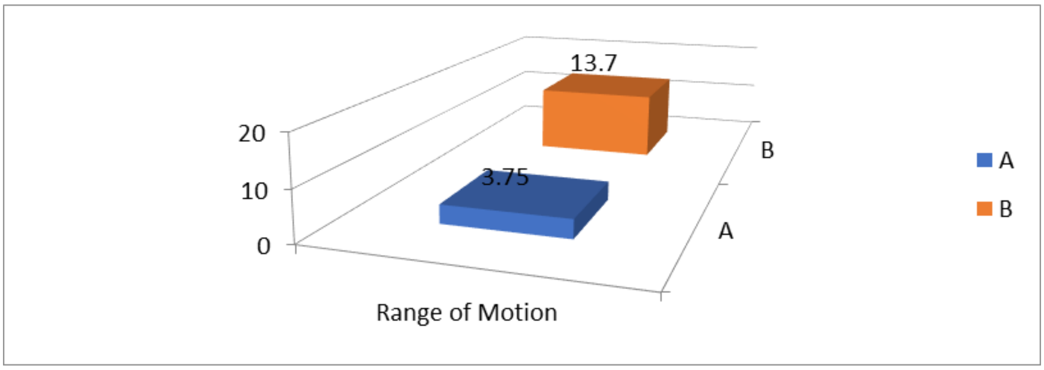

Figure 10: Inter Group comparison of Range of Motion

DISCUSSION

Virtual reality (VR) is a computer-based technology that constructs a virtual environment simulating a real-world scenario and provides multimodal cues to the participants where users interact with or manipulate the virtual objects, they receive instant visual, audio, or haptic feedback of their performances.[13] In spinal cord injury patients postural synergies are lost, and sensory-motor integration of the lower limbs and trunk is impaired This reduced spatial information which contributes to balance dysfunction; therefore, patients should develop strategies using the neck, upper limb and postural Muscles.[14,15]

The purpose of the study was to see the effect of virtual rehabilitation on Functional outcome for wheel chair navigation in patients with spinal cord injury. Where patients were assessed for balance, Range of motion of Upper limb and Wheelchair propulsion. The present study showed significant improvement in balance on Modified functional reach test. With respect of reaching distance where largest change was found in Virtual Rehabilitation group compared to conventional group. Horlings and coworkers confirmed that virtual reality balance training could provide more realistic proprioceptive and visual input, and improved the patient's reaction time, postural stability, balance and walking function effectively (Bisson, 2007; Horlings et al., 2009; Singhet al., 2012). Therefore, virtual reality balance games can be used as a potential and useful tool to train adults with balance dysfunction (Schwesig et al., 2011).[16]

Winstein C et.al(2006) in his study found virtual stimuli, especially at the higher levels of difficulty, facilitated therapy for diverse equilibrium reactions rather than being limited to the simple transfer of weight, which is usually the focus of conventional treatment. The most effective means for improving neuroplasticity and subsequent recovery of motor function following injury or disease to the nervous system is through intense skillful practice. Whereas in VR games, training can be progressed by gradually increasing the complexity of the tasks.[17,18,19]

Meetika Khuranaet.al concluded in her study that VR game-based balance training showed better improvement on outcome measures as compared to participants who received real-world task-specific balance training where conventional rehabilitation was given to the Spinal cord injury patients.[20]

In our study we also found that the wheelchair propulsion was also improved in Spinal cord injury patients supported by study conducted by Jean-Francois Lam et.al (2018) performed systematic Review on Use of Virtual Technology as an Intervention for Wheelchair Skills Training where he concluded that Virtual Training may indeed be a solution that can help to alleviate barrier to wheelchair skills training and subsequently improve wheelchair users skill.[21]

Present study also showed significant improvement in Upper limb function in Experimental Group (Virtual Rehabilitation with conventional Physiotherapy) supported by study conducted by Halton J. et al Nintendo Wii in combination with conventional therapy could be equivalent to conventional rehabilitation for improving upper extremity motor functions. Researches have shown that neuroplasticity is enhanced by repetitive, high-intensity, task-specific activities. [21,22]

Witmer BG et.al observed in VR environment training, participants used to respond
with enthusiasm to goal-directed movements. Same as in our study, participants showed great interest during VR training sessions, but we did not objectively measure the motivational level of the participants.

However, the limitations of our study deserve comment. This was a pilot study with a small sample size. Because most of the patients in this study were incomplete, a group of patients with complete cervical SCI should be included in future studies to determine the influence of the injury in the effectiveness of VR treatments. Moreover, only traumatic cases of SCI were included in the study.

CONCLUSION

It is concluded that Virtual Rehabilitation with conventional exercises showed significant improvement in Overall

Functional Outcome like balance, Wheelchair propulsion and Upper limb Range of motion in Spinal cord injury patients.

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Ethical Approval: Ethical Registration No.: PIMS/DR/COPT/2020/334

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