

# Rehabilitation System Using Virtual Reality Techniques and Video Games to Improve Postural Control in People with Acquired Brain Injury

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**Abstract-** Acquired Brain Injury (ABI) is currently one of the largest neurological disorders among medical issues, generating large sequelae and demanding better and more effective intervention programs from an interdisciplinary rehabilitation group. This article suggests a rehabilitation system using virtual reality techniques and commercial video games to improve postural control in people with ABI. By using the system, greater motivation of patients is expected in the rehabilitation process, with changes in postural control movement strategies, that will lower balance disturbances, and avoiding falls in people with sequelae from acquired brain injury.

**Keywords –** Acquired Brain Injury, ABI, video game, virtual reality, telerehabilitation

## I. INTRODUCTION

Acquired Brain Injury (ABI) is currently one of the largest neurological disorders among medical problems, generating large sequelae that demand better and more effective intervention programs from an interdisciplinary rehabilitation group. [1] Experimenting severe brain injury is a critical condition in the life of those who suffer from it, therefore, urgent care and subsequent clinical rehabilitation are vitally important [2].

Under the acquired brain injury concept, countless pathologies that can considerably affect the brain, are framed, causing structural and functional changes. Symptoms from ABI affect the motor, sensory, and neurocognitive levels, requiring a comprehensive physical, psychological and social intervention. Difficulties in walking and balance disturbances are two of the main problems patients identify as more disabling, restraining their autonomy. Regarding balance disturbances, there is a reduction in postural stability, implying an increase in the support base and a limitation in anticipatory balance reactions [3]. There have been elevated levels of mortality and disability in recent years, and most frequent problems include deficiencies in mobility, self-care, domestic activities, learning, knowledge and communication. All this leading to a deterioration in life quality (family, personal and work life).

Advances in technological tools are being increasingly considered in patient rehabilitation. Improvement of technological capabilities, as well as development of more realistic video games inserting patients into a reality, where different sensations and perceptions occur in various rehabilitation sessions, are beginning to become effective. Different research show how virtual reality is used to aid recovery. Authors show that through development of video games that stimulate distinct body parts, including sensory ones, it is possible to obtain better results. There are commercial platforms and video games on the market, primarily designed for entertainment, but with high-quality graphics and scenarios useful in rehabilitation.

Technological tools are diverse (Xbox, Kinect, Nintendo, 3D glasses, sensors, controls, and others) and depending on the rehabilitation requirements, they could be used this way. Even though technological advances have been high in the entertainment sector, very little has been incorporated into treatment protocols in rehabilitation centers, mainly because neither protocols have been generated according to pathologies, nor a robust system, showing management of the patient's recovery, has been proposed.

## II. STATE OF THE ART

Cocaro (2019) carried out a research on the application, feasibility and effectiveness of recent technologies in virtual (VR) and augmented (AR) reality in rehabilitation institutions. It showed that the articles selected for the analysis, combine application of virtual reality and conventional treatments, along with evaluation of variables such as stability/balance, mobility, and pain in patients with neurological pathologies. It established that management in a rehabilitation center, whether public or private, should evaluate cost-benefits of current use of VR and AR, since results as a sole therapy are not promising. Nonetheless, if it is shown that it concatenates well with conventional therapies in which positive effects are found, findings should be considered and the possibility of preparing professionals for the next technological advances should be evaluated [4].

In the research carried out by Cabezuelo (2016), in stroke patients from Jaén, Spain, the main scientific evidence evaluating virtual reality therapy effects was gathered and analyzed. As a result, solid evidence was obtained that virtual reality therapy serves to improve walking and balance in stroke [1].

From another perspective, Silva (2015) researched the effect of a combined VR rehabilitation program with conventional therapy in patients with chronic stroke for improving balance (BERG scale) and functional independence in Rio Grande, Brazil. A quasi-experimental study with a control group not randomized with 10 patients, was carried out including kinesiotherapy exercises, Nintendo Wii, and learning transfer in their sessions. Patients obtained significant improvements in three specific tasks: "dressing lower body," transfers from bathtub and shower, and "locomotion: stairs," as well as a significant increase in balance. For this reason, it was possible to conclude that there is a positive VR influence as a complement to conventional therapy in the rehabilitation of balance and functional capacity after a stroke, and to confirm the feasibility of the proposed combined rehabilitation program [5].

To prove the virtual reality importance in the physical rehabilitation process, a research is highlighted, purpose of which, was to determine if virtual reality for therapeutic purposes, contributes to improvements in motor function recovery. This was done through a systematic review of the Cochrane Original, Joanna Briggs Connect, Medline/Pubmed, Cinahl, Scopus, Isi Web of Science, and Sport-Discus databases; articles of which, included those published in the last 5 years, in English and/or Spanish, carried out in stroke patients, and using VR to improve motor function. Finally, 4 systematic reviews and 21 randomized controlled trials were selected. Most studies aimed to improve upper limb motor function and improve daily living performance activities. Even, one article aims to improve lower limb motor function to improve gait, as well as improve static-dynamic balance. Results show that there is strong scientific evidence of the beneficial effects of RV on motor recovery of the upper limb in stroke patients [6].

## III. PROPOSED SYSTEM

### *3.1 Definition of Virtual Reality*

Virtual Reality (VR) is a computer simulation that can be physically experienced and interacts with the user's senses to create an alternative reality [7]. To this aim, the system simulates the sensory perceptions that make the user feel immersed in that world and can take those perceptions as real. Therefore, the system must generate perceptions in real time so that it allows the user to interact with the environment through sensory channels. Virtual reality is based on three fundamental principles: immersion, interaction and imagination. It is a technology currently attracting great interest in many companies due to its enormous strategic potential [6].

Virtual reality must allow interaction through input devices, in such a way that virtual environment modification and reception of sensory responses to the user, are made possible. This is achieved by generating immediate responses in the virtual world to user interactions, so that time in the virtual be the same as real time.

### *3.2 Commercial Video Games and Virtual Reality (VR)*

There is a category of commercial video games, aiming to achieve a practical purpose in addition to entertaining, combining sports activities (exergame) with games. Their aim for the user is to carry out physical exercise, fueling his

motivation through the mechanics usually used in games, i.e., through scores, challenges, achievements and others [8]. This is especially useful for people who ought to carry out physical exercise for health reasons.

Use virtual reality games allows people with any type of disability to carry out rehabilitation sessions by playing a game, and this allows the user to carry out the sessions with more motivation and for a longer time. Furthermore, the games allow adaptability to the motor abilities of the player, without causing him excessive effort [9].

### 3.3 Proposed System Using Commercial Video Games

A system called 3DSmartRehab is proposed. It is a comprehensive system that includes the commercial virtual reality platform, managed through web software and making possible to track the telerehabilitation benefits. Figure 1 shows the system, where the virtual workspace is observed, including a 9m<sup>2</sup> space, virtual reality glasses, motion sensors, a computer with a graphics card and processing capacity, and controls to interact in the virtual world. Through the computer, interest data is sent to a web server in charge of recording information on the evolution of patients and behavior of the virtual platform. The system allows to incorporate different rehabilitation protocols, in such a way that it is possible to determine their effectiveness.



Figure 1. Proposed Telerehabilitation System

Regarding the virtual platform, this has an exit interface imposed due to its results in terms of immersion sensation called head-mounted display (HDM), commonly known as a helmet, glasses or virtual reality viewer. HDMs work by placing a high-resolution screen a few inches from the user's eyes and hiding the rest of the user's vision field, so that he can only see the screen. The screen offers each eye an adequate view of the virtual world to generate a feeling of depth like that obtained in the real world. The virtual reality viewer is generally accompanied by a locator that monitors the position and rotation of the helmet so that a precise point of view is shown on the screen, very consistent with the actual position of the user. Figure 2 shows the location of the sensors.

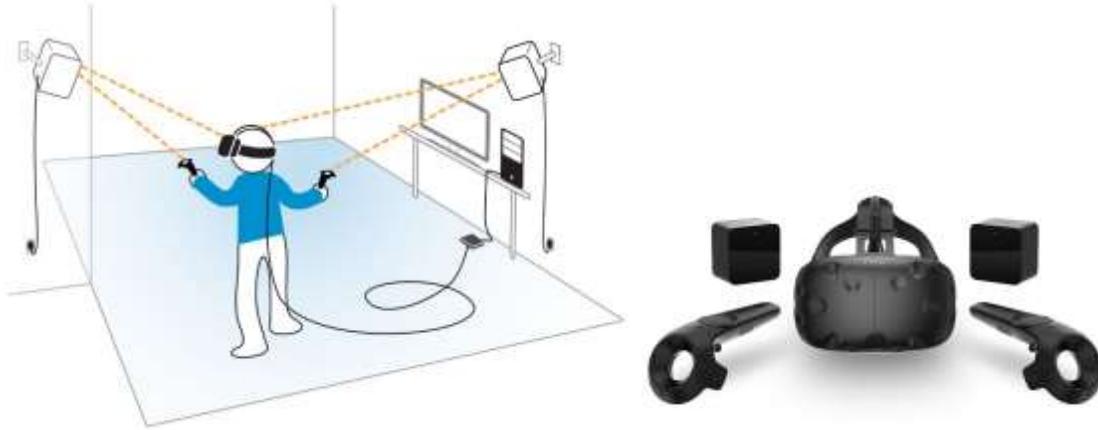


Figure 2. Location of the sensors in the telerehabilitation site

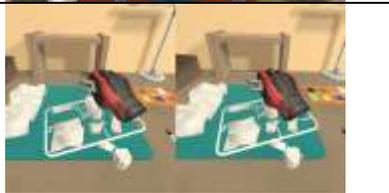
For the system performance, use of the HTC-Vive® device is proposed, developed by the HTC company in collaboration with the Valve company (Steam platform owner) [10]. The device is designed to go even further than the rest in terms of virtual reality perception. Vive offers a laser-based tracking system that not only obtains head rotation but also head position in space within a very wide range (one room). The system is accompanied by two controls, one for each hand, position of which, is also analyzed and used to control the position of the hands of the avatar or objects in the video game. The screen used by this device has a resolution of 2400x1800 pixels, which along with the great position tracking system, produces a virtual reality experience of excellent quality. Nonetheless, the device requires installation of monitoring devices in the room where it will be used, which can be complex for sporadic or not so amateur players.

**3.3 Analysis of Possible Commercial Video Games to Be Used**

Table 1 shows some commercial video games that can be used in telerehabilitation, tested by physical therapists and some patients, identifying with them how they can be incorporated into rehabilitation protocols. Likewise, figure 3 shows use of the rehabilitation system.

Table 1. Possible Commercial Video games to Be Used in Telerehabilitation

Video Games	Features	Image
VR Super Sports [11]	This game is a full body virtual reality experience. Each sport has 3 difficulties for all ages and skill levels. It includes the following games: <ul style="list-style-type: none"> <li>• Bowling</li> <li>• Homerun Derby</li> <li>• Soccer</li> <li>• Basketball</li> <li>• Japanese Archery</li> <li>• Clay Shooting:</li> <li>• Boxing</li> <li>• Kart</li> </ul>	
Beat Saber [12]	Beat Saber is an immersive rhythm experience. It has levels made by hand through musical rhythms, surrounded by a futuristic world. It allows exercise while dancing and cutting the rhythms. It works through campaigns to improve every day while completing goals and challenges.	

<p>Job Simulator [13]</p>	<p>The game shows a world where robots have replaced all human jobs. It allows to use hands to stack, manipulate, throw and crush physics objects in an inexplicably satisfying way.</p>	
<p>Model Kit Simulator VR [14]</p>	<p>The game allows for a casual simulation where players can assemble and paint simple model kits. Ideal for people looking for a virtual reality leisure experience.</p>	
<p>Gadgeteer [15]</p>	<p>It's a physics-based virtual reality puzzle game in which chain reaction machines are built to solve fun and intricate puzzles. Their machines use devices to launch, hit, and spin around, creating chain reactions that can even end up shattering the space-time structure.</p>	



(a) (b)  
 Figure 3. Use of the Virtual Reality Kit with (a) Beat Saber and (b) VR Super Sports games.

IV.CONCLUSION

Technological advances can be incorporated into physical rehabilitation processes of patients with mobility impairments. Patients with Acquired Brain Injury (ABI) can benefit from incorporating virtual reality and video games into their treatments, so that they get motivated to autonomously perform their exercises, and thus, allowing reduction of balance disturbances and avoiding risk of falls. Commercial video games are a good option to be applied in treatments, since they have scenarios to advance in the rehabilitation protocols.

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