Chapter 9

Virtual Reality and Occupational Therapy

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Additional information is available at the end of the chapter

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Abstract

Virtual reality is three dimensional, interactive and fun way in rehabilitation. Its first known use in rehabilitation published by Max North named as "Virtual Environments and Psychological Disorders" (1994). Virtual reality uses special programmed computers, visual devices and artificial environments for the clients' rehabilitation. Throughout technological improvements, virtual reality devices changed from therapeutic gloves to augmented reality environments. Virtual reality was being used in different rehabilitation professions such as occupational therapy, physical therapy, psychology and so on. In spite of common virtual reality approach of different professions, each profession aims different outcomes in rehabilitation. Virtual reality in occupational therapy generally focuses on hand and upper extremity functioning, cognitive rehabilitation, mental disorders, etc. Positive effects of virtual reality were mentioned in different studies, which are higher motivation than non-simulated environments, active participation of the participants, supporting motor learning, fun environment and risk-free environment. Additionally, virtual reality was told to be used as assessment. This chapter will focus on usage of virtual reality in occupational therapy, history and recent developments, types of virtual reality technologic equipment, pros and cons, usage for pediatric, adult and geriatric people and recent research and articles.

Keywords: virtual reality, rehabilitation, occupational therapy, ICF

1. Introduction

Enhancement of functional ability and the realization of greater participation in community life are the two major goals of rehabilitation science. Improving sensory, motor, cognitive functions and practice in everyday activities and occupations to increase participation with intensive rehabilitation may define these predefined goals [1, 2]. Intervention is based primarily on the different types of purposeful activities and occupations with active participation [3–5]. For many injuries and disabilities, the rehabilitation process is long, and clinicians face the challenge of identifying a variety of appealing, meaningful and motivating intervention tasks that may be adapted and graded to facilitate this process [5].

Occupational therapy (OT), which is one of the rehabilitation professions, is a client-centered profession that helps people who are suffering participation and occupational performance limitations. OT offers a wide range of rehabilitation strategies in different medical and social diagnosis [2]. The common point of all these strategies in rehabilitation is that OT assesses and supports enhancing functional ability and participation throughout participating in meaningful activities in a person's lifespan. To enhance participation, OT, like the rest of the health professions, uses World Health Organization's International Classification of Functioning, Disability and Health (ICF) to understand function in a biopsychosocial manner. In ICF framework, function is defined as the interactions between an individual, their health conditions and the social and personal situations in which they thrive. The complex interactions between these variables define function and disability [1].

ICF classifies health and health-related fields in two groups. These groups are "body functions" and "body structures" and "activity and participation." Sub heading of these groups is considered as body function and structures (physical, physiological etc), activities (daily tasks) and participation (life roles) [1]. When these groups taken into account in rehabilitation, occupational therapists focus on all areas to enhance a client's activity participation, social participation, etc. However, in current literature, there are various rehabilitation approaches that are being used for this aim. Advancements in technology in the twenty-first century create great opportunities for people working in different areas. In particular, in health practices like rehabilitation, technology supports therapists' to rehabilitate their clients in too many different ways like robotics, stimulation devices, assessment tools and virtual reality [6–10].

2. Virtual reality

Virtual rehabilitation is the use of VR and virtual environments (VE) within rehabilitation. VR and VE can be described as a simulation of real world environments through a computer and experienced through a "human-machine interface" [11]. VR rehabilitation, since the 1980s, technology has become widespread with rapid developments in computer technology, and nowadays, many commercial uses have come into play with relatively affordable costs. In addition to its use in the field of health sciences, is used for industrial design, production processes and training purposes [12]. VR rehabilitation can be classified in several ways. The first is the classification method according to the specific patient population. Rehabilitation practices in this class can be classified as musculoskeletal disorders, post-stroke and cognitive and psychological disorders. The second classification method concerns the priority of the applied rehabilitation protocol. VR practice in the rehabilitation protocol can only be used as an adjunct or as the basis of a rehabilitation program to retain the place of classical exercise or activity programs. Therapeutic approaches include education approaches through examples, video games and educational approaches or rehabilitation approaches through "exposure" used in psychological disorders. The training method with examples is frequently used in stroke rehabilitation. For example, a system that perceives the arm movements of a patient reflects arm movements on a computer screen as a motion of an object and is required to control movement of the patient. In the approach used by video games, the client tries to control the objects in the ball with a certain joint or body movement. To apply this method, patients are required to have a higher cognitive level. Finally, VR rehabilitation can be classified according to the proximity or distance of the therapist. Therapist and client are in the same room in VR and in tele-rehabiltation method, in tele-rehabilitation method is participating in a remote location in the rehabilitation process of the patient therapist [3, 11, 12].

As virtual reality in its broad definition can be dated as far as the wall-to-wall frescoes of late Roman Republic era [12], the following text will emphasize the recent technological aspect of the phenomenon and its use in rehabilitation research, which aims to expand the reader's intervention choices in occupational therapy practice. The use of computer systems has become an accepted practice in the clinical setting. VR applications are frequently used in different disease groups for this purpose. VR applications are used in a variety of areas, such as neurological, orthopedic, cognitive function, sensory-perceptual and mental health disorders in basic/instrumental daily life activities [13–16]. Following sections will include these areas.

2.1. Virtual reality in pediatric rehabilitation

VR is defined in pediatric rehabilitation as 'An interactive simulation allowing users to feel experiences similar to real-life environments or objects ones with systems which consist in computer hardware and software, [17]. Virtual reality systems (VRS) are mostly used in pediatric rehabilitation program due to these properties. Pediatric rehabilitation is a concept that covers a wide range of applications and includes treatments for various diagnoses or disorders, such as children with neurological, orthopedic or developmental disabilities.

Children with neurologic or neurocognitive impairments may experience decreased functioning in multiple domains including: physical, psychosocial, cognitive or emotional. Such impairments represent significant obstacles to the child's activities of daily life [18]. Holistic approaches to the treatment of all impairments that children may encounter are implemented through a joint study of many disciplines in rehabilitation program. The use of VR by trained therapists enables to cope with these impairments [19].

Play is described as both the earliest and the most important occupation in the childhood [20, 21]. In order to be defined as play, it must contain these five essential domains: intrinsic motivation, pleasure, free choice, non-literal and active engagement [20, 22]. A few theories have proposed the contributions of play to the developing child. Some of them thought play was a tool for intellectual growth, whereas others thought it was necessary for skills development [23–25]. Children with various disabilities have a more restricted play experience than healthy children [26].

VR potentially offers children with disabilities the opportunity to participate in games otherwise inaccessible. It provides a three-dimensional spatial the degree of the movement between the real world and the computer. Children can also practice intensely and simultaneously receive positive visual, proprioceptive, tactile and auditory sense feedbacks in VR [11, 27]. The use of it in children with disabilities provides motor learning, postural and motor control and improves sensorial-perceptual-motor-cognitive-communication skills. So that children become more independent individuals in their daily lives [28].

2.1.1. The advantages and disadvantages of VR in pediatric rehabilitation

The virtual reality system is separated according to immersion degree and how the users interact with the system [29]. VR systems can be grouped under two main headings such as immersion VR and desktop VR. Immersion VR is a type of application that involves the use of various materials to make the virtual environment feel like it is a real. Specially, users wear a head mounted display that brings them into a 3D virtual environment. Thus, all movements are controlled by head movement. Second type of system is desktop VR. Images appear on a device such as a computer or a television [30]. The users play with the help of various tools such as keyboard, mouse, speaker, glove etc. Systems also connected to the internet (tele-rehabilitation) have the potential to reach out to children who are in distant areas or in their home [11].

VR has many advantages for pediatric rehabilitation. Firstly, VR is a goal-directed method so that it can be used for training and education to increase of skills like sense, perception, motor, cognitive and social in children [31]. Secondly, it was functional, motivational and fun for children [20]. Because of that, it is one of the most preferred treatment methods for therapists and children. Thirdly, VR can be used both in single and in group activity programs that may be included in more than one person. VR applications involving more than one person can be made up of their family members or peer children who can be practiced in the same ergotherapy session. It is also an advantage to promote therapy sessions. Lastly, VR game systems like Nintendo Wii, Wii sport games, Wii fit or Kinect Xbox are common, low, simple and available in both the occupational therapy departments and children's home [32].

VR also has some disadvantages. Technology is rapidly advancing, and the systems and games developed for children are changing day by day. It is not easy to follow and reach for most citizens of the country. Additionally, current virtual reality systems like Interactive Rehabilitation Exercise System (IREX) are also too expensive for the majority of the population [33].

Knowing the advantages and disadvantages of the systems is important in determining appropriate virtual reality systems for clinical use and academic research. For example, all marketed games are not appropriate for all individual, especially for children. Because of their functions, skills, needs or motivations are difference with each other. The games may increase their functional activity, but rather facilitate the appearance of some unwanted symptoms or movement patterns [20]. For this reason, be careful in the preference and use of the game, preferences should be made to the therapist control.

2.1.2. Studies on VR in pediatric rehabilitation

All studies aimed to improve function or quality of movement in upper and lower limbs in order to increase of social participation and achieve better performance in daily life activities. A great majority of the investigations on this field are children with neurological impairments such as cerebral palsy. Most of the researches showed improvement upper limb functions via VR interventions. For example, Chen et al. showed the benefit of VR use for reaching activity in four children with CP between the ages of 4 and 8. Children were treated with the Sony Eye-Toy system for 4 weeks at 2 hours per week. The quality of reaching was shown to improve after individual training [34]. Jannink et al., in 2007, investigated to evaluate upper extremity training with a Sony Eye-Toy. They randomly included in 12 children with CP. Upper extremity functions were evaluated with Melbourne. The results showed the Eye-Toy to be a motivational education tool that developed upper extremity function in children with CP for 6 weeks at 30 minutes twice a week [35]. Similarly, You et al. investigated in VR-based cortical reorganization and functional motor development with hemiparetic CP. The Bruininks-Oseretsky Test of Motor Proficiency (BOTMP), the Modified Pediatric Motor Activity Log (PMAL) tests and functional magnetic resonance imaging (fMRI) were used pre-/post-measurements. Children treated with IREX for 60 minutes 5 times a week for 1 month.

According to the results, functional motor skills, amount of use in affected upper extremities and the quality of the motion, active movement, control and coordination of upper extremity motor performance were increased. Thus, it might be said that VR applications can be used to enhance motor skills [36].

Reid et al. included in 31 children aged between 8 and 12 years. They randomly divided into two: 19 study (VR) and 12 control group. Treatment for 1.5 hours per week for 8 weeks was implemented for the children. Canadian occupational performance measurement (COPM) and Quality of *Upper Extremity* Skills Test (QUEST) were used to evaluate the effect of VR treatment. All results were improved after the treatment, while there was no significant functional difference was found between the groups. According to the results, there were significantly increased social acceptance and motivation in the study group [37]. These results indicated an important point in rehabilitation which treatment is an extensive concept that has not only physical component but also emotional and social components.

Also, home-based treatment approaches are important to integrate effectiveness of VR intervention in daily life. Winkels et al. included 15 children with CP [Manual ability classification system (MACS) Levels I and II] between the age of 6 and 15 in their study. The children were evaluated with the Melbourne Assessment of Upper Limb Function and ABILHAND-Kids and had upper extremity function training using Wii games. They reported to increase in the performance of daily living activities with VR.

Activities of daily living involve in not only upper but also lower extremity. On the other hand, walking ability or strength is generally researched according to lower extremity activity. Recent studies focused on combination with VR system and robot-assisted gait training (RAGT), and they are emphasized the useful interventions which applies together [38, 39].

The other investigation area in disabilities with children about VR is Down syndrome and autism and attention deficit. These studies were showed to increase of sensorimotor functions and motor proficiency by using VR in these disabilities [27, 40].

As a result, these studies proved that VR systems are motivational, evidenced based and useful for children in pediatric rehabilitation interventions. It can be used for improving upper limb function and proficiency, sensorimotor and cognitive functions, activity of daily living, participation of therapy and motivation level in rehabilitation.

2.2. Virtual reality rehabilitation for adult population

VR is being used in adult rehabilitation by therapists for many years. Groups that being focused most are stroke survivors, Parkinson's disease and geriatric population who needs repetitive rehabilitation approaches with active participation. However, current approaches that were being used had some issues about repetition with fun part. VR had a new perspective to the repetitive rehabilitation approaches after its initial use. Studies showed that VR suggests higher dosage of repetition than traditional approaches [41–43]. Initially, VR was being used with flight simulators, surgery training etc.; within the use in health practices, it spreads its use in the area of post-traumatic stress disorder and body image disorders [3]. VR is advantaged with its goal-oriented tasks and repetition. Repetition, task-oriented movements and fun are needed to achieve neuromotor changes which will lead motor enhancements in client's task. The term goal oriented and repetitive tasks are in a collaboration with neuroplasticity terms which of one is the repetition of the task that is needed to be practice must be trained in rich and fun environments. VR offers a great opportunity for therapist who seeks for these terms in their approaches.

VR offers simulation systems, safe activity training etc for OT. OT comes from real-life situations and lives and develops itself in the community. Being this related to the life, OT needed to adapt itself with the technological developments. Nowadays, mobile phones, internet, phone applications and lots of other software and hardware are common worldwide. OT uses this to involve geriatrics, rehabilitate stroke survivors and other disability causes to rehabilitate.

Daily life activities are being studied for stroke survivors using environments such as driving rehabilitation and market simulations [44]. Akinwuntan et al. [45] used STISIM Drive System (Systems Technology Inc., United States) in their research with people with stroke which had real size computer images, visual angle of 45° and adaptations such as left-sided accelerator and steering wheel spinner. In this study, researchers compared virtual driving rehabilitation with conventional rehabilitation which found to be no different from each other

Barcala et al. [46] used Wiifit (Nintendo, Japan) on balance training with people with stroke. The equipment that is commercially available and serves mainly for entertainment and home exercises could reproduce body movements and give auditory feedback through many display choices such as TVs or projectors. Cho et al. [47] used Interactive Rehabilitation and Exercise System (Vivid Group, Canada) for upper extremity rehabilitation of people with stroke. The system which is specifically aimed to neurorehabilitation programs included video cameras, gloves and virtual games. da Silva Cameirão et al. [48] used Rehabilitation Gaming System (Pompeu Fabra University, Spain) with people with acute stroke. The system uses a motion capturing camera in tandem with motion gloves and has activities (e.g., games) which have gradual difficulties. It aims to functional reorganization of neuronal systems through visual input of virtual extremities on screen combined with task oriented action.

Walking, balance and mobility problems of VR application are made in people with Parkinson's disease. Significant improvements are observed in the individuals in these studies [49]. In addition, studies on motor learning, retention-transfer and cognitive functions are being studied with VR applications in Parkinsonian individuals [50]. VR applications are utilized to improve functional balance, mobility, static-dynamic postural control, and dual-task reaction times [51]. VR technologies are utilized in the treatment of loss of cognitive function skills in geriatric people. In individual attention, alertness, reaction time and the short-/long-term memory due to the stimulation of VR applications are preferred [52, 53]. VR technology is also used in mental health treatment in geriatric people. VR technology can be used as a treatment tool for agoraphobia, social phobia, fear of death, depression, anxiety, posttraumatic stress syndrome, attention deficit, dementia and schizophrenia treatment [54]. One of VR performed on geriatric people, and the most important applications are the study of the fall and after the growing fear of falling. These studies provide postural stability, strengthening of activity muscles, ground sensing, proprioceptive and vestibular sensory training [55].

Lee et al. [56] used K-Pop Dance Festival (Nintendo Inc., Japan) software for Nintendo Wii platform for the rehabilitation program of participants with Parkinson's disease. The handheld motion controller of the platform was strapped to the participants' hands as a compensation strategy. The software includes songs, and the success of the activity depends on dance movements that match the songs' rhythms. The researchers found that independence in activities of daily living and decrease in depressive symptoms were acquired by VR rehabilitation.

Pichierri et al. [57] used TX 6000 Metal DDR Platinum Pro metal dance pads (Mayflash Limited, China) in tandem with Stepmania Software, a free dance and rhythm game (https://www.stepmania.com). Participants were asked to match the direction of arrows on screen that appear in sync with musical rhythm by stepping on the corresponding arrows on the dance pad. By this approach, participants were asked to participate dual task activities. Researchers suggested that cognitive-motor intervention was appropriate to use to increase strength and balance in elderly. Hoffman et al. [58] used Oculus Rift VR goggles (Facebook Inc., United States) during occupational therapy of a young burn patient. Researchers used SnowWorld (University of Washington, United States), a software developed specifically for pain management of burn patients, with Oculus Rift which showed slightly pain decrease of the client. The goggles can be worn head mounted or worn with an arm mounted apparatus. Faber et al. [59] used Cybermind Hi-Res900$_{ST}$ (Jasandre Pty. Ltd, Australia), a head mounted VR goggles during the treatment of burn patients in tandem with SnowWorld software (University of Washington, United States). Researchers measured pain levels of the participants after every session of the treatment. Yoon et al. [60] used Interactive Rehabilitation and Exercise System (Vivid Group, Canada) along with traditional occupational therapy in their research on patients with brain tumor. Researchers used Birds and Balls, Conveyor, Drums, Juggler, Coconuts, and Soccer VR programs of the system. Jahn et al. [61] used Nintendo Wii (Nintendo, Japan) in their research with inpatient adults with cancer. Participants were able to choose either Wii Sports, Family Trainer, Sports Island or Family Ski and Snowboard programs for each single session. Rohani et al. [62] used Kinect (Microsoft, United States) along with a virtual classroom software. The classroom software had two different tasks, and children were asked to accomplish the tasks, while distractions were presented (e.g., a construction worker entering the classroom).

3. Discussion

VR in rehabilitation is a common approach in current rehabilitation era. The repetition enhancement, moving client away from one's diagnosis/disability, enabling and active participation in rehabilitation, enriched environments and making rehabilitation fun are the greatest motives to use VR for rehabilitation. Lots of studies showed the benefits of using VR in different rehabilitation settings. A therapist with VR access may feel confident to use VR.

Both pediatrics and adult population had fun with their VR rehabilitation, which removes the boring role of rehabilitation. In particular, in pediatrics, using VR opens a wide perspective for the therapists. However, technological improvements must consider rehabilitation-based games or applications to achieve fully adaptable and client-special rehabilitation patterns. Commercially, sold games and applications still have low awareness of disability. Additionally, new coded software are needed to be adaptable for each participant and one's current motor/cognitive/social status related to the disability. Also game types that may used for VR may be gender depended as the children or older participants may not be willing to participate VR session.

As the technology improves, more opportunities are likely to occur; as rehabilitation specialists, we must keep our contact with these developments and develop ourselves according to our client's needs.

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