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Use of the Robots, Virtual Reality and Other Technological Devices in Rehabilitation

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Abstract

Robotic systems, virtual reality, transcranial magnetic stimulation and telecommunication technologies have been safely used in rehabilitation of traumatic brain-spinal injuries, stroke, motor neuron diseases, fibromyalgia, Parkinson's disease, and balance disorders. Their benefits from the point of view of scientific studies include the properties of a reliable test environment, gradual exposure to stimuli, simultaneous performance reporting, stimulus and response modifications, independent application chance, stimulus control and consistency, distraction or enhancement of the patient's attention, and patient motivation. It would be inevitable to benefit from these technologies, which are economical, and for which access to rehabilitation is facilitated as a result of further worldwide increase in the elderly population and it would be useful technologies such as include robotics, virtual reality and magnetic stimulation used in rehabilitation of health professionals in their education programs.

Keywords: Robotic, rehabilitation, virtual reality, magnetic stimulation

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INTRODUCTION

Technological innovations used in the field of rehabilitation have increasingly taken place in the last few decades. Transcranial magnetic stimulation (TMS), robotic systems, virtual reality (VR), and telecommunication technologies, which have spread and developed in this electronic and information age in association with scientific developments, are also used in the field of rehabilitation in the developed and developing countries (1-4).

Robotic rehabilitation (RR) systems, including computer-based electromechanical devices are used in rehabilitation, particularly in neuro-rehabilitation because they are intensive, repetitive, interactive, and sustainable which is therapist-independent. Hemiplegia, stroke, and upper extremity motor diseases are the main disease groups with the possibility of rehabilitation (1, 3, 4). Although this rehabilitation programs are increasingly used in developed countries having appropriate infrastructure, difficulties in accessing these systems by developing countries and the lack of more scientific studies on this rehabilitation programs became obstacle for wide spreade of this rehabilitation programs (4, 5).

Today, three-dimensional systems have been developed so that we can perceive the real-world sections through visual, auditory, and tactile by means of glasses or closed platforms. They are used in healthcare as well as in civil and military education and for recreational purposes. They have a key importance in rehabilitation by providing patient adaptation to exercises, repeatability, and objective measurement of the effort by creating alternative visual environments that can be reached in a more economical manner (6, 7).

Transcranial magnetic stimulation was first used for major depression treatment subsequently it found a place in the field of rehabilitation. TMS acts by creating depolarization, neural plasticity, and evokes responses on the brain parenchymal neurons with electrical stimulation created by electromagnetic field. TMS therapy is used in cases, such as fibromyalgia syndrome, neuropathic pain, and Parkinson's disease, in which a response cannot be achieved with classical therapies (8-10).

Increased telecommunication technologies are beneficial for patients with transportation problems or with fewer mobilization opportunities, and for the sustainability of treatment after discharge. Thus, the patient can be followed without the physician's presence, and treatment options can be provided (2, 4, 5). Many inventions, such as wireless brain and extremity implants with artificial intelligence, smart watches, smart wearable items, musculoskeletal tracking devices, smart prostheses, stem-cell implants, and package cardiac rehabilitation systems have been developed to enhance rehabilitation practices (4, 5, 10).

With the increasing elderly population worldwide, it would be inevitable to use economical technologies, for which access to rehabilitation is facilitated (5, 10, 11).

Robotic Rehabilitation

Since the last quarter of the twentieth century, robotic technologies have increasingly started to take place in the sectoral basis. They are also used as an auxiliary method in the field of rehabilitation. RR is especially utilized in patients who need intensive support in neurorehabilitation. Because the force and resistance parameters can be programmed in RR, it supports the rehabilitation techniques applied to the patient, decreases the physical efforts of the therapist, and provides accurate feedback. It facilitates patient compliance with the therapist to increase the number of movements. It allows patients to perform their movements with gradual autonomy (1, 3, 4). Although it reduces the number of therapists needed, it helps in increasing the number of patients that are given therapy and the duration of therapy. It provides active participation in treatment by increasing the motivation of patients under objective feedback data.

In the computer-assisted RR, the treatment protocol stored in the memory can be applied to the patient by the robotic mechanism, after the first movement of the therapist. Duration, the number of repetitions, and speed can be altered by the therapist from outside. It is also possible to motivate the patient to perform movements by showing a target with visual objects (1-4, 10, 11). Besides regulating the rehabilitation process and improving therapeutic outcomes, robotic technologies have the potential to support clinical evaluation, to completely control therapy, to measure, and to apply new forms of mechanical manipulation by therapists. The well-known robotic platforms are hand-arm-shoulder, robotic bed-wheelchair, walking, and isokinetic exercise systems (Cybex II). All these systems can be programmed and adjusted according to the pathology of the muscle and joint movements of the patient (4, 5, 10).

According to their usage areas, they are classically handled as lower and upper extremity robots. RR was first used on the lower extremities. However, the success rates of upper extremity applications are higher. In upper extremity applications, the success rates for hand, wrist, and finger movements are lower than those for the other components of upper extremity. For example, the wrist pronation and supination, and elbow flexion and extension in the upper extremity provide a new approach for strength and movement improvement in assisted physiotherapy. Passive, active, and assisted exercise programs can be applied. Moreover, feedback on proprioceptive state and force information is obtained. In patients with hemiplegia and cerebral palsy, it recreates a situation that is as similar as possible to a real walking pattern for the lower extremity, and encourages patients to control different movements related to walking.

It can create synergy not only in the individual movements of the lower extremity joints but also in the upper body, and it provides an appropriate posture. Studies have reported that passive and active movements that can be programmed in robotic systems are beneficial in the treatment of hemiplegia or motor diseases by regulating resistance to movements (1, 3, 11). Besides that, these systems can be applied together with conventional methods right from the beginning of treatment (2, 4, 10).

Virtual Reality

Since their introduction by J. Lanier in the late 1980s, computers have begun to produce realistic, more detailed, and fast three-dimensional images. The VR technology gives us the opportunity to revive the complex physical state of the real world in a controlled environment of the laboratory. It has the potential to measure and adjust complex movements on request in natural environments. The VR products are available in different designs from head-mounted visual data devices to cabinet designs. Basically, they work with the same logic, but in practice they are different.

In some of the glass-type VR devices, communication with the outside world is interrupted, and the visuals produced by the computers are seen. In some of them, the modellings produced by the computers are created as projections on real environments. In the cabinet designs, the image generated by the computers is reflected on a surface in front of the cabinet and the simulation is performed. In this application, the field of view is limited according to the glasses-type systems. Another platform is projection-based systems. They create a three-dimensional image by projecting the produced image onto a surface or screen in cinema-like environments. These systems generally have a wide field of view and can be used by reflecting on multiple surfaces (2, 4, 11).

The introduction of all these technologies in rehabilitation dates back to the early 1990s. Scientific studies are being published with increasing momentum. Accessing the environments, which have high economic cost and which we cannot easily reach in real life, by the help of computers and low cost has paved a way for VR applications in rehabilitation (2, 4, 11, 12). What are the advantages of VR applications for health practitioners? VR applications have many advantages for health practitioners such as being independently applicable, reliable test environment, graded and controled exposure to stimuli, concurrent performance reporting, ability to do modifications on stimulus and response also it provides advantages that are reported in the literature, such as distracting or enhancing patient motivation. (11-13). Using virtual environments and reality, it offers the opportunity to work on motor rehabilitation and, wherever possible, compare them to the results obtained in controlled real-world applications (13, 14). Particularly traumatic cerebrospinal injuries and stroke rehabilitation are used in orthopedic rehabilitation of patients with Parkinson's disease and rehabilitation of balance disorders. Studies suggest that it facilitates rehabilitation adjustment problems in pediatrics (2, 4, 5, 11-13).

Transcranial Magnetic Stimulation

Transcranial magnetic stimulation is a non-invasive neurophysiological application. It is based on the principles of electromagnetic stimulation defined in the last quarter of the twentieth century and developed over time. Earlier, repetitive TMS (rTMS) application was used for treating patients with resistant major depression, and it later became widespread after Food and Drug Administration approval. In the later years, it has also been used in chronic pain, tinnitus, movement disorders, and obsessive compulsive disorders. This technique is performed by stimulating the cortical areas of the brain by electrical stimuli placed on the scalp. With the help of electrical coil, electromagnetic field is created with fast and variable frequencies. With the help of electrodes from a short distance, this area is expected to act on the brain parenchyma by converting to electrical stimulation.

The magnetic field itself does not directly stimulate the tissue, but the amplitude of the induced current generates action potential leading to depolarization in the nerve membrane if the spatial characteristics and duration are sufficient. TMS acts by depolarizing neurons, providing neural plasticity, or generating stimulated responses. It can be used for diagnostic, prognostic, and therapeutic purposes. In diagnostic use, the findings determined by TMS are not disease specific and should be evaluated with other clinical information. In therapeutic applications, the cortical excitability reduces in low-frequency and increases in high-frequency applications of repetitive rTMS (8, 9, 15).

Transcranial magnetic stimulation is used in fibromyalgia syndrome, stroke, neuropathic pain, multiple sclerosis, and Parkinson's disease. It also activates the motor units of the related muscle groups by acting on the affected area of the brain parenchyma after stroke. It has an impact on motor cortex by displaying functional increase in Parkinson's disease. In neuropathic pain, TMS is suggested to provide a regulatory effect on the central and peripheral neural pathways. In addition to the potential beneficial effects, TMS has been reported to affect the intact parenchyma of the brain and have temporary central side effects, such as epilepsy, headache, and hearing loss (8, 9, 15).

Telecommunications Technologies

They are technologies facilitating the follow-up of discharged patients, who underwent rehabilitation at home. They facilitate the access of the patient groups who have difficulty in reaching rehabilitation centers and the patients in elderly care centers to have access to rehabilitation (2, 4, 5, 10).

CONCLUSION

The introduction of robotic-device-based techniques in physical rehabilitation and TMS and VR applications has been shown to contribute to treatment and increase in patient compliance. Since it is envisaged that these approaches will be more widespread in parallel with technological developments, especially in the areas of neurorehabilitation and stroke rehabilitation, it would be useful if the trainings of health professionals are accordingly planned.

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