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Review article

INFLUENCE OF NEW TECHNOLOGIES ON POST-STROKE REHABILITATION

Petya Kasnakova[1,2], Biyanka Tornyova[1,2], Tanya Paskaleva[2], Georgi Gelov[3]
1)Department of Health Care Management, Faculty of Public Health, Medical University - Plovdiv, Bulgaria
2)Department of Healthcare, Branch of Haskovo, Trakia University, Stara Zagora, Bulgaria
3)General Surgery Department, MHAT "Haskovo "- Haskovo, Bulgaria.

ABSTRACT:

The rapid development of new technologies contributes to the improvement of telemedicine and telerehabilitation. Telepractices in modern rehabilitation have a positive impact on functional, motor, and cognitive recovery.

The aim of the present study is to investigate and analyze the possibilities of new technologies for functional recovery and cognitive functions in rehabilitation after a stroke.

Material and Methods: A systematic search of the PubMed, Embase, and Google Scholar databases was performed. The search was conducted from March to August 2024 using the keyword "telerehabilitation", "E-rehabilitation ", "occupational therapy ", and "stroke ".

Results: Stroke recovery is a complex and lengthy process. The functional telerehabilitation system facilitates therapeutic intervention by using interactive virtual environments and biomedical technologies. Applied rehabilitation training programs with new technologies have a positive effect and significantly restore the functional level after a stroke in self-care, motor abilities of the upper limbs (dexterity of movements, grip strength, kinematics), cognitive abilities (attention, memory, visual-spatial abilities), and locomotion.

Conclusion: Modern telerehabilitation is a relatively new approach with unlimited applications. Telepractice facilitates the access of stroke patients to health services and supports the recovery of impaired function to the maximum extent, permanently improving independence and quality of life.

Keywords: telerehabilitation, recovery, occupational therapy, stroke, technologies,

INDUCTION

Rehabilitation is a multidisciplinary field that encompasses a wide range of services aimed at improving the functional capacity, independence, and quality of life of individuals who have experienced disability or health problems. The World Health Organization (WHO) defines rehabilitation as "a set of interventions designed to optimize functioning and reduce disability in persons with health problems in interaction with their environment" [1]. Each rehabilitation program is tailored to the specific needs and goals of the individual, following a holistic approach [2]. Rehabilitation is a dynamic field that is constantly evolving in response to advances in technology, changing demographics, and a growing understanding of human health [3].

The rapid development of artificial intelligence (AI) has led to the emergence of new opportunities in the field of rehabilitation medicine. Telerehabilitation (Telerehab or TR) is part of the modern face of rehabilitation, which is developing rapidly and becoming an important segment of telemedicine and electronic health care [4].

De Araujo FMA, et al. (2019) [5] and Ciajlo I, et al. (2017) [6] indicated that in recent years, telerehabilitation has expanded due to technological advances, increased telecommunications speed, and reduced costs of computer hardware and software.

Robotic neurorehabilitation, in combination with conventional physical therapy, uses high-tech and telecommunications technologies to implement rehabilitation services. Telerehabilitation (TR) can be divided into three main categories: image-based telerehabilitation, sensor-based telerehabilitation, and virtual technology-based telerehabilitation [7].

Studies by Levac DE, et al. (2019) and Quadrado VH, et al. (2019) demonstrate that virtual environment therapies promote motor learning, retention of learned skills, and transfer of skills to real-world situations [8, 9]. Telerehabilitation (TR) offers several advantages, such as reduced treatment expenses, time savings, improved access, and continued care for clients with infectious diseases [10].

The nature of the rehabilitation process determines the type of telecommunications technology and information infrastructure used to implement the rehabilitation services. In the recovery process, continuous monitoring of the patient's functional indicators is necessary to track the impact of the administered therapy and adapt to the improvement of the patient's condition. Long-distance communication can be easily achieved through video conferencing, text and voice messaging, virtual reality, and more.

Innovative virtual reality (VR) technologies are successfully used as a tool for TR and limit [11]. According to several authors (Barrios M, et al., 2019; Ferencik N, et al., 2019), VR technology is applied more often in pathologies of neurological origin (stroke, craniocerebral and spinal cord injuries, Parkinson's disease, childhood cerebral palsy, and others), achieving improved results in patient intervention and motivation to achieve a significant level of functionality [12, 13].

The aim of the present study is to investigate and analyze the possibilities of new technologies for functional recovery and cognitive functions in rehabilitation after a stroke.

MATERIAL AND METHODS

A systematic search was performed mainly in the PubMed, Embase, and Google Scholar databases. The search was conducted from March to August 2024 using the keywords "telerehabilitation", "E-rehabilitation ", "occupational therapy ", and "stroke ".

RESULTS AND DISCUSSION

Stroke is a type of cerebrovascular disease of great health and social importance due to its high frequency and prevalence. Projections show that by 2030, the number of people aged over 60 who have had a stroke in Europe is expected to increase by 23% [14]. It is a leading cause of acquired disability in the elderly in developed countries and has negative consequences for the lives of patients and their families [15].

Stroke causes neurological deficits in different areas of the brain: motor, sensory/perceptual, visual, language, cognitive, intellectual, and emotional [16]. Rehabilitation of stroke patients is a complex and long-term process aimed at improving the quality of life restoring impaired motor function, self-care, and walking. Access to timely rehabilitation can reduce morbidity and help patients return to their normal lives. Stroke rehabilitation programs are characterized by an interdisciplinary team working cohesively and closely to provide a comprehensive rehabilitation program for each patient [17].

Stroke patients need continuous rehabilitation, but many of them miss it. There are many barriers for these individuals—access to usual face-to-face care, time constraints, resource constraints, geographic isolation, compliance with rehabilitation, and lack of awareness. Telerehabilitation may be one way to address these barriers [18]. Patients can receive services through computers or other mobile devices, even in remote areas. Telerehabilitation has a positive impact on motor function. Interventions such as movement therapy, moving platform training, resistance, and balance training in patients with chronic stroke lead to improvements in motor function [19]. Through remote rehabilitation programs, personalized tasks that correspond to the patient's cognitive and physical disabilities are set through design in a virtual environment. Recovery is a process that combines spontaneous and learning-dependent processes, including retrieval (restoring the functionality of damaged neural tissue), replacement (reorganization of partially removed neural pathways to restore lost functions), and compensation (improving the mismatch between the patient's impaired skills and environmental requirements) [20].

Physical and occupational therapy provided through telerehabilitation includes motor learning exercises, goal setting, virtual reality, robotic therapy, and community therapy. Motor training exercises are the most commonly applied modality. In motor training exercises, the provider guides the patient through various movements and activities to restore strength and function.

Motor training and early occupational therapy intervention through telerehabilitation yield equivalent functional results and have a positive effect on the patient's functional independence. It can, therefore, lead to improvements in sensory-motor, perceptual-cognitive, and communication skills, as well as the quality of life and levels of anxiety and depression [21].

Almasi S. and Ahmadi H. (2022) and Adomavièienë A. and Daunoravièienë K. (2019) state that telerehabilitation results in increased patient satisfaction and improvement in goal-setting activities of daily living. Virtual reality therapy involves the use of sensors to detect motion and a virtual environment displayed either on a screen or on a headset. Patients perform therapeutic movements that correspond to tasks in the virtual environment. This provides an immersive environment for the patient and allows computer monitoring of the patient's progress. Studies comparing virtual reality with motor training exercises have shown results equal to or better than virtual reality [22, 23].

Robotic therapy typically involves the use of arm and leg strengthening robots that provide resistance training and assist the patient in performing movements. Robotic devices can also obtain accurate data on patient movements and usage statistics and transmit them to providers for evaluation. Robotic therapy has even been combined with virtual reality telerehabilitation to create a virtual environment that responds to robotic movements. Robotic telerehabilitation studies have shown improvement in patients from baseline but equivalent functional outcomes compared to motor training exercises [19, 22].

One of the most effective ways to improve body posture in patients with neurological diseases is by using the popular Nintendo Wii Fit board and virtual reality application, which serves as an adjunct to balance training and sensory integration [24]. A study conducted by Casanova M, et al. (2015) recommended a system for

the physical rehabilitation of patients with multiple pathologies by performing motor tasks with video games, where the patients' movements were analyzed using specific software [25].

For cognitive problems, the best rehabilitation for stroke patients is brain stimulation with adequate interactions with the environment. Approaches to neurological telerehabilitation are not clearly defined and lack specific theoretical foundations [26]. According to recent research, the most effective approach is virtual reality, which consists of simulations through specialized machines such as personal computers with specific graphic characteristics of a real environment. The machine connects to devices such as robotic arms, legs, data gloves, and smart glasses. Such smart devices can be used in 3D environment simulation and allow for a greater sense of immersion in the virtual environment. Another telerehabilitation system is the Rehab @ Home framework, which is used for home-based rehabilitation for stroke patients [27]. The framework consists of instrumented insoles connected wirelessly to a third-generation tablet, a server, and a graphical web interface for medical experts. Rehabilitation progress is analyzed automatically after performing assessment tests on the tablet computer [22, 27].

Studies conducted by Laver KE, et al. [28] (2017) and Laver KE, et al. [29] (2020) state that virtual reality can be beneficial for improving upper extremity function (dexterity of movements, grip strength, kinematics) and activities of daily living when used as an adjunct to usual care (to increase total time for therapy) [28]. The authors recommend the use of telerehabilitation as the speed and sophistication of communication technologies improve. However, it is currently unclear how effective this delivery model is compared to face-to-face rehabilitation or when added to usual care [29]. Information and communication technology (ICT) is perceived as important to integrate into stroke rehabilitation for assessment, training, and compensation for remaining deficits [30].

The authors (Leong SC, et al. [31] and Chen J, et al. [32] 2022) confirm that telepractice in neurorehabilitation is an effective therapeutic approach to improve the quality of life of stroke patients. Special attention is required for the rehabilitation of the upper extremity, especially fine movements, activities of daily living, and locomotion [31, 32].

The central figure in any rehabilitation process is the patient and the resumption of good quality of life [33]. The various physical activities provided by telerehabilitation can include personal kinesitherapeutic programs with specific goals, tasks, and methodical recommendations [34]. Physiotherapy-related telemedicine is broad and encompasses a myriad of telerehabilitation elements, including digital monitoring tools, patient healthcare devices, and real-time applications.

CONCLUSIONS

Telerehabilitation for stroke patients, carried out in a virtual environment and introduced as a full complement to conventional therapy, offers strategies in an engaging, motivating, and accessible approach. Early initiation of therapy and inclusion of work activities and elements of daily life are essential to achieve good rehabilitation results and improve self-care. Telerehabilitation is rapidly gaining supporters and is becoming increasingly popular and preferred by healthcare professionals and stroke patients, accelerating their return to independent quality living and social activity.

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Address for correspondence:
Petya Kasnakova, PhD
Department of Health Care Management, Faculty of Public Health, Medical University – Plovdiv;
15A Vasil Aprilov Blv., Plovdiv, Bulgaria.
E-mail: petya.kasnakova@mu-plovdiv.bg,