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A Review of International Experience for Telerehabilitation of Post-stroke Patients with Aphasia and Cognitive Problems

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Abstract
Stroke remains one of the most common reasons of disabilities worldwide. Aphasia, memory and cognitive problems are among common stroke consequences significantly reducing stroke survivors' life quality. To grant access of a large number of stroke survivors to rehabilitation services, and sustain continuous rehabilitation during pandemic, the telerehabilitation can be used.
This article summarizes current approaches on telerehabilitation of post-stroke patients with aphasia, cognitive and memory problems. Authors made a search of research articles and review papers from international medical journals indexed in Scopus, Sciencedirect, and PubMed databases. The results show that the telerehabilitation is feasible providing significant clinical outcomes and can be organized synchronously and asynchronously to meet needs for increasing demand of post-stroke patients. Despite the positive effects of telerehabilitation, there were some limitations. To overcome these limitations, further clinical studies on large groups are needed.
Keywords: telerehabilitation; post-stroke telerehabilitation; cognitive rehabilitation; memory rehabilitation; aphasia; exergames; virtual reality (VR)
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Обзор международного опыта телереабилитации постинсультных пациентов с афазией и когнитивными проблемами

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Резюме
Инсульт остается одной из самых распространенных причин инвалидности во всем мире. Афазию, проблемы с памятью и когнитивными функциями относят к числу распространенных последствий инсульта, которые значительно снижают качество жизни пациентов, перенесших острое нарушение мозгового кровообращения. Чтобы предоставить доступ большому количеству лиц, переживших инсульт, к услугам по реабилитации и обеспечить непрерывную реабилитацию во время пандемии, можно использовать телереабилитацию.
В данной статье обобщены современные подходы к телереабилитации пациентов, перенесших инсульт, с афазией, когнитивными проблемами и проблемами памяти. Авторы провели поиск исследовательских статей и обзоров в международных медицинских журналах, индексируемых в базах данных Scopus, Sciencedirect и PubMed. Результаты показывают, что телереабилитацию возможно осуществить, обеспечивая значительные клинические результаты, она может быть организована в синхронном и асинхронном форматах для удовлетворения возрастающих потребностей пациентов, перенесших инсульт. Несмотря на положительные эффекты телереабилитации, были и некоторые ограничения. Чтобы преодолеть эти ограничения, необходимы дальнейшие клинические исследования на больших группах.
Ключевые слова: телереабилитация; телереабилитация пациентов, перенесших инсульт; когнитивная реабилитация; восстановление памяти; афазия; компьютерные игры; виртуальная реальность (VR).
Источник финансирования: Авторы заявляют об отсутствии финансирования при проведении исследования.

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Introduction

Stroke remains one of the most common reasons of disabilities worldwide [1, 2]. Aphasia, memory and cognitive problems are among typical stroke consequences significantly reducing the quality of life of stroke survivors [3, 4]. This leads to an increase in demand for stroke rehabilitation that is delivered via conventional patients' treatment at medical institutions. However, the traditional rehabilitation services are limited due to non-uniform geographic distribution, lack of equipment and therapists, health status of stroke survivors, and remote location of patients. Moreover, recent pandemic has shown that under lockdown or restriction conditions most post-stroke patients suffer from limited access to rehabilitation services or even stop visiting doctors to prevent infection diseases [5, 6]. To overcome barriers a telerehabilitation can be used. This paper summarizes recent approaches on telerehabilitation of post-stroke patients with aphasia, cognitive and memory problems.

We searched Scopus, PubMed and Sciencedirect databases for research and review articles on cognitive, memory, and aphasia telerehabilitation of post-stroke patients, which were published in peer-reviewed medical journals from 2017 to 2021. After screening the titles and abstracts, excluding conference papers, editorials and books, the remained 16 articles were included in the review.

Cognitive and memory rehabilitation

The efficacy of VR rehabilitation to improve cognitive function of post-stroke individuals was evaluated by Torrisi et al. [7]. The study lasted 6 months and involved forty patients, who were randomized into experimental and control groups. At the beginning of the study, the patients from the experimental group participated in VR rehabilitation system-Evo and the control group was treated with a standard cognitive training. After discharge (in the 2nd phase) the experimental group underwent another VR rehabilitation session using the home tablet. The rehabilitation sessions lasted for 50 minutes three times a week. The neuropsychological evaluation was carried out before and after the study and included the following tests: Montreal overall cognitive assessment, attentive matrices, Trail Making Test B, Phonemic Fluency, Semantic Fluency, Rey Auditory Verbal Learning Test I, Hamilton Rating Scale-Anxiety and Hamilton Rating Scale-Depression. Findings indicate that a type of rehabilitation treatment affected their scores, underlining the effectiveness and importance of telerehabilitation.

Bernini et al. in [8] presented a perspective study of using Home Cognitive Rehabilitation software for cognitive telerehabilitation of elderly individuals. It provides the remote telerehabilitation services to the patients who are discharged from the hospital, overcoming a lack of healthcare professionals and supporting continuous recovery. Moreover, the communication technologies and proposed software can be a part of clinical routine protocols. Furthermore, the interface allows a therapist to set requirements of the rehabilitation plan monitoring all the features remotely. The simplicity of patient-therapist interactions by means of telecommunication technologies and software leads to the fulfillment of non-pharmacological therapy telerehabilitation plan at safe home-based environment. The authors concluded that remote communication technologies are considered as potentially effective options to support the cognitive rehabilitation of stroke survivors at their homes and thereby reduce the risk of infection due to COVID-19.

Furthermore, Mantovani et al. in [9] underlined the obstacles of traditional cognitive rehabilitation methods during restrictive measures (COVID-19, etc.) and other social events reducing the accessibility of healthcare and hampering prolonged cognitive rehabilitation. The study suggests that as the healthcare system faces new challenges, telemedicine, VR, and telerehabilitation can mitigate the harmful effects of quarantine and restrictions on delivering cognitive rehabilitation to patients in the future. Technological and methodological improvements seem to result in a healthcare paradigm shift to implement a cost-effective remote delivery healthcare system, meeting the needs of individuals with reduced mobility and providing access to rehabilitation centers and clinics.

However, the limitations of the wide spreading of telemedicine and VR for cognitive telerehabilitation are as follows. Although telemedicine is currently developing, more extensive and wide research on cognitive telerehabilitation is required to prove its safety, reliability, validity, effectiveness and efficiency. Authors claim that VR and telerehabilitation are general measures affecting multiple domains achieving high levels of ecological validity rather than specific outcomes (memory, executive, visuospatial, etc.). In addition, economic reasons must be demonstrated, in case of charging for software and hardware from the patient's account, the healthcare system or tax refund, which is necessary to provide telerehabilitation. Cost reduction can be partially achieved through the use of open source software and wider distribution of hardware.

Furthermore, since most telerehabilitation systems and services require remote connection, it is vital to provide patients and clinicians with high-speed internet, which might be a challenge in rural areas and low-income countries. Other issues include a digital and technical proficiency of delivering and using telerehabilitation and VR for both patients and healthcare professionals, leading to educational needs, clinical training and technical support. A comprehensive approach involving stakeholders (clinicians and managers, stroke survivors

and patient associations, scientific societies) can force the transformation of the healthcare system to deliver sustainable cognitive telerehabilitation services. These results are in line with Maggio et al. [6], emphasizing a pivotal role of cognitive rehabilitation under pandemic conditions, promoting functional recovery of non-COVID neurological patients. However, telerehabilitation is considered an adjustable tool to meet patients' needs, encouraging their acceptance of innovations in the rehabilitation process.

Lawson et al. in [10] investigated the rehabilitation of memory using telemedicine. A non-randomized investigation was tailored to analyze effectiveness and feasibility of telehealth using internet videoconferencing and compared it to in-person methods. The compensatory memory rehabilitation program lasted for one and a half months. Twenty-eight stroke participants underwent telehealth rehabilitation, whereas the control group of eighteen individuals was treated with face-to-face rehabilitation. Telemedicine sessions were conducted using Zoom video conferencing with the duration of treatment sessions of 2 hours per week. The sessions consisted of interactive exercises, memory functioning and healthy lifestyle education, internal and external compensatory memory strategies training. In addition, homework tasks were included encouraging daily practice. Findings revealed the feasibility and effectiveness of telerehabilitation providing remote training of compensatory memory skills of post-stroke patients. Although telerehabilitation and face-to-face rehabilitation exhibited similar outcomes in subjective measures improvements, reducing in lapses of prospective memory, the effect of tele rehabilitation on reducing everyday memory lapses was greater than that one of face-to-face rehabilitation. Moreover, a positive effect of booster sessions was observed. The outcomes of booster sessions were measured at a 12-week follow-up. It's noteworthy, the clinicians who delivered the rehabilitation program administrated the booster sessions through videoconferencing and in person. The findings demonstrate that individuals who received a booster session performed greater improvements in memory functioning as compared to participants without the booster session.

Faria et al. [11] carried out a randomized controlled trial with 36 chronic stroke patients in Portugal. They compared cognitive rehabilitation using web-based paper-and-pencil PDF tasks generator (TG) with VR-based interventions consisted of the same paper-and-pencil tasks contextualized in different locations of a virtual city. Moreover, the VR environment allowed patients performing daily living activities in the bank, supermarket, pharmacy, etc. The rehabilitation lasted 1 month. The results showed a positive impact of VR simulations on rehabilitation outcomes and high effectiveness with respect to cognitive domains and self-perceived cognitive deficits in everyday life, while the TG interventions resulted in fewer cognitive improvements for longer.

In 2018, Cogollor et al. [12] overviewed recent practices for cognitive rehabilitation and assessment of stroke patients. Although limitations of smart technologies for the daily living were addressed, the authors emphasized the necessity and importance of information and communication technology for cognitive rehabilitation of stroke patients. The first reason is a large number of post-stroke patients requiring long-term cognitive rehabilitation, the second one relates to reducing the independence of individuals due to consequences of apraxia and action disorganization syndrome and that traditional rehabilitation methods and hospital-based rehabilitation techniques result in a very slow rate of improvements. Finally, it is even more important that the majority of stroke patients suffer from social isolation throughout their lives, since modern rehabilitation methods are not a solution to the problem. Recent studies show the development of systems and platforms for cognitive telerehabilitation. They incorporate task-performance, monitoring, and feedback features, creating a smart environment to attract the post-stroke individuals and personalize their cognitive telerehabilitation plans. Moreover, achieving a successful execution of rehabilitation tasks are in line with improvements in daily live independence, engaging and empowering of active aging and reducing the workload of occupational therapists. The authors summarize that support in the execution of complex daily tasks, automatic error detection, home-based performance, and accessibility are among four principal characteristics that information and communication technologies systems should provide to achieve high efficiency of personalized cognitive rehabilitation. However, only 33% of all European projects considered in the study meet those characteristics, and therefore, the future of health and the intellectual environment requires extensive research and initiatives to obtain excellent platforms and achieve these goals.

Aphasia rehabilitation

Macoir et al. [13] investigated a home-based telerehabilitation among 20 post-stroke aphasia patients. The synchronous rehabilitation was delivered via a video-conferencing, a telerehabilitation platform and software based on the Promoting Aphasics' Communicative Effectiveness approach. During videoconferencing the software displayed images, digital tools for chatting and drawing, a showing a number of metrics, and hints to perform exercises. The hardware included a touchsmart computer, a camera and an omnidirectional microphone.

The participants and clinicians used audio and visual aids communicating to guess the image which was displayed on the other party screen. Moreover, the attempt of exercises was counted if patients transmitted information. Interestingly, three therapists participated in the treatments sessions to mitigate habituation. Additionally, a family caregiver presented during the therapy sessions in patient's home. The findings showed improvements in functional communication among aphasia patients who underwent the telerehabilitation. Although the study showed positive effects of the telerehabilitation, further clinical trials are required to determine the optimal dose of therapy with respect to their health status and impairments severity. Also, the authors underline the need for equipment availability and technical support during telerehabilitation.

Maresca et al. in [14] examined a VR rehabilitation of aphasia patients by means of a touch-screen tablet. Thirty post-stroke patients (mean age 51.2±11.3 years) with aphasia acquired from either hemorrhagic or ischemic stroke were involved in a two-phase 6-month rehabilitation program. Each participant performed 50 minutes training sessions five days a week. The performance of the participants was assessed by means of neuropsychological evaluation at baseline, after 12 weeks of study, and finally at the end of the protocol (12 weeks later). Half of the patients underwent traditional speech rehabilitation services since another 15 individuals participated in VR rehabilitation. In the first phase, an experimental group

was treated with experimental linguistic training using a VR rehabilitation system, more specifically, the exercises were tailored and personalized according to the needs and abilities of the patients (reaction time, number of variable stimuli). The control group experienced the same exercises but through traditional linguistic training and used paper-pencil tools.

Notably, that second phase included different trajectories of training for experimental and control groups. The patients from the experimental group were equipped with touch-screen tablets with the inbuilt protocol of linguistic exercises that were modulated with respect to the capability of each patient. They carried out VR training in their homes, moreover, the exercises were performed either online or offline. The offline VR training was recorded and then the data were transmitted to the control panel just after the tablet was connected to the internet. Furthermore, online sessions between patients and a neuropsychologist were organized two times a week to monitor the process of rehabilitation discussing the performance and feasibility of individuals. The control group underwent conventional speech therapy at territorial services. The patients who underwent traditional rehabilitation improved only in comprehension, depression, and quality of life whereas the individuals from the VR-rehabilitation group showed significant improvements in all areas except writing.

Study revealed that the VR system is effective for telerehabilitation of aphasia patients, positively affecting linguistic functions, mood, and perception of their health state. Apparently, VR-rehabilitation improves engagement and provides motivation to the patients encouraging them to explore new horizons in a positive way supporting treatment adherence. Moreover, VR-rehabilitation provides instant feedback of their performance and knowledge of the results, enhancing neuroplasticity and motor learning.

Gerber et al. in [15] investigated a multimodal telerehabilitation system (Bern Aphasia App) to treat stroke patients with aphasia. The study involved 15 post-stroke patients with moderate to severe aphasia having a stroke on average 444 days before the study and 11 experienced language and speech therapists. The participants were recruited from the University Hospital of Bern (Switzerland) and the research was carried out in its general ward. The participants were provided with tablets (iPad) which were programmed in Object-C. In general, the rehabilitation system was consisted of the patient and therapist interfaces allowing training, assigning exercises, creating new patient accounts, and supervising the rehabilitation process of post-stroke patients. Moreover, secured databases were used to store the exercises and patients' data, images and video records of the exercises.

Patients performed speech-related training by means of the tablets with a variety of exercise types and difficulty levels which were adjusted remotely by the therapist. Then the results of the training were sent to the database and feedback was provided automatically to all of the patients. Online monitoring of the progress allowed the therapist to correct or change the training plan depending on the progress and needs of the participants. The findings demonstrated the simplicity of the system and its acceptability by patients and therapists. Apparently, the system is beneficial for post-stroke patients with aphasia as it provides supplementary training with individualized dose and intensity in their own homes in an easy and enjoyable way.

These observations are consistent with Kurland et al. [16] who conducted research at the University of Massachusetts Amherst (USA) in which an unsupervised tablet-based home practice program with a weekly telepractice support for post-stroke aphasia rehabilitation was examined. The findings showed improvements in the naming of objects and actions for participants who underwent individualized home training using iBooks. The observations found applicability of the system among individuals with chronic severe aphasia, including those without digital competence and experience. It means that stroke survivors can attain independent proficiency to continue practicing and improving their language skills beyond a therapy discharge. Potentially, telerehabilitation including a low cost system improving speech pathology can meet the requirements of stroke survivors who either immobile or have insufficient insurance coverage.

Cherney et al. examined asynchronous telerehabilitation using an oral reading for language in aphasia system [17]. The study involved 32 aphasia patients, specifically, 19 of them underwent telerehabilitation, since 13 individuals used placebo videogame. The participants trained 90 minutes a day during 6 days a week for 1.5 month. Specifically, they used a virtual therapist to read aloud repeatedly. Also, there was a clinician oversight. The study revealed improvements in language outcomes for aphasia patients after they finished the telerehabilitation.

Another study by Meltzer et al. [18] explored the rehabilitation of patients with aphasia or cognitive-linguistic communication disorders. Specifically, 44 patients underwent 1 hour weekly sessions during 10 weeks. The patients performed synchronous tablet-based exercises at home. Most individuals used the TalkPath software allowing them practicing speaking, writing, listening, reading, and trained memory and other cognitive skills. They were assigned in telerehabilitation and in-person groups. The patients in the telerehabilitation group participated in the therapist guided videoconferencing once a week, discussing the outcomes and performing conversational exercises. Both groups showed statistically significant improvements in the Western Aphasia Battery aphasia quotient (WAB-AQ). However, the communicative confidence was higher for in-person group.

Øra et al, 2020 [19] carried out a randomized controlled trial with chronic stroke patients in Norway. To explore whether augmented telerehabilitation for aphasia post-stroke patients was effective, feasible, and acceptable, they enrolled 30 patients from the Sunnaas Rehabilitation Hospital. The participants performed 1 hour per day training (5 times a week) over 4 consecutive weeks. The rehabilitation was delivered via therapist-patient videoconferencing. Additionally, the therapists used remote-control software to support the patients and manage technical issues. Conventional equipment (laptop, webcam, speakerphone, etc.) was used. The study revealed synchronous TR for post-stroke aphasia patients was feasible and acceptable in addition to usual care, although there were tolerable technical fault rates. Patients demonstrated high satisfaction with telerehabilitation practice, since the speech-language pathologists showed lower satisfaction. The study shows that telerehabilitation is a viable service delivery model for aphasia patients' rehabilitation. Also, the access to clinical and technical expertise is needed when developing telerehabilitation services.

Braley et al, 2021 [20] assessed the feasibility and clinical efficacy of a virtual speech, language, and cognitive

digital therapeutic for individuals with post-stroke aphasia against standard of care in their virtual, randomized, and control trial. The study involved 32 post-strike patients (USA, Canada) participating in 30 min a day 5 days a week during 10 weeks. The study showed the feasibility of the fully virtual trial for post-stroke patients with aphasia, especially given the ongoing COVID-19 pandemic. Moreover, tolerable and efficacious digital therapeutic for language and cognitive rehabilitation was used.

Another study [21] summarized the experience of speech-language pathologists who delivered online Telerehabilitation Group Aphasia Intervention and Networking to aphasia patients. Importantly, each therapist experienced no less than 12-week rehabilitation of aphasia patients using telepractice. In general, the clinicians underlined the feasibility of telerehabilitation, although they faced technological challenges and required learning and adapting the online environment. Also, the therapists reported the telerehabilitation improving access to health services for the patients. Moreover, it was flexible satisfying clinicians.

To sum up, the telerehabilitation is feasible sustaining recovery of patients from stroke. It is beneficial for individuals with sever pathologies, patients living remotely from medical facilities and rehabilitation centers, and during the pandemic. Also, the telerehabilitation is available continuously for a large number of post-stroke survivors, avoiding waiting lists for conventional rehabilitation at medical institutions and during medical staff shortages or overloads. Moreover, to maximize treatment dosages and clinical outcomes the patients can stay in their own homes performing cognitive, memory, and linguistic exercises guided online by therapists or using self-paced activities through offline training systems at any convenience.

Although, the reviewed studies demonstrated positive effects of telerehabilitation on post-stroke patients with aphasia, cognitive and memory problems, there were the following limitations. First, they mentioned the need for technological requirements and specific hardware and software for telerehabilitation to be occurred. Also, findings indicate instability and slow internet connection negatively affecting rehabilitation process. Next, low digital proficiency and non-acceptance of telerehabilitation among some aged people were reported. The challenges with technologies arose for both patients and therapists, requiring their education and support. While telerehabilitation enhances patients' motivation, some studies report on the lack of immersion among exergames, reducing engagement of participants.

Patients also underlined the need for customization and flexibility of telehealth treatment. Other studies reported participants were treated with the same means regardless of disease severity and comorbidity factors, and hence, personalization of rehabilitation is required. The dose of the telerehabilitation should be tested depending on the patient's health status, age and telepractice approaches. Not all the studies collected data with respect to participant's accuracy and reaction time. Furthermore, the main telerehabilitation limitation is the loss of face-to-face contacts between therapists and patients, resulting in that the home-based asynchronous therapy faced self-management, regimen training compliance, and feedback issues. The reviewed studies incorporated more than 300 participants, however, most studies used small samples of 20–46 individuals. Finally, economic evaluation and cost-efficiency of telerehabilitation needs to be further researched.

Conclusion

Telerehabilitation is used to improve cognitive, memory, speech and language domains among post-stroke patients. It is feasible providing significant clinical outcomes and can be organized synchronously and asynchronously for a large population of post-stroke patients, including patients living remotely or during pandemic. The asynchronous telerehabilitation allows patients training independently in their own homes at convenient time and pace, while synchronous treatment via videoconferencing facilitates recovery through patient-therapist interactions. Both approaches grant patients access to rehabilitation services sustaining continuous recovery from the stroke. Although positive effects of the telerehabilitation were observed there were some limitations. To overcome limitations further clinical studies on large samples are required.

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