Journal of Ecohumanism
2024
Volume: 3, No: 8, pp. 9107 – 9118
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.5529

Technology Innovations in Right Upper Limb Rehabilitation: A Look at Physiotherapy and Occupational Therapy Tools

Sultan Fahad Madani[1], Mazen Abdulaziz Bedaiwi[2], Raeed Abdullah Alghamdi[3], Abdulrahman ahmed Shabaan[4], Abdulaziz Mohammed Almalki[5], Riyadh Ibrahem Albalawi[6]

Abstract

This essay explores the right upper limb rehabilitation with the use of innovative technologies. It focuses on the consideration of what technologies are currently available and highlights the physiotherapy and occupational therapy tools that can be integrated together. After the stroke, rehabilitation therapy is essential for the patient's improvement. Therefore, it is important to have a tool that helps with the rehabilitation therapy of the right upper limb. As an appropriate tool, technology innovation is considered and researched. This essay discusses the thoughts, ideas, applications, and designs of technology innovations in the right upper limb rehabilitation.Physiotherapy and occupational therapy are two different rehabilitations focusing on the same problem, which means they can be integrated together. Having tools that integrate both physiotherapy and occupational therapy together will help with the patient's recovery. Innovative technology trends that can be used in the rehabilitation of the right upper limb are researched and discussed in this essay. Only the upper limb rehabilitation is being considered, while the lower limb rehabilitation is neglected. In addition, it focuses mainly on stroke patients, and other diseases that affect the upper limb are neglected.Tools that are designed to help with the right upper limb rehabilitation are discussed. For the tools, there must be a consideration of whether the tool is for rehabilitating the right upper limb or whether the technology is integrated together for rehabilitating the right upper limb. In addition, whether the tool is designed or something that already exists is also considered. Most tools are designed and newly developed technologies. Some tools are already in use and are being improved by the new technology approach. Another consideration is whether the technology is focusing on the end-user, which is essential for the technology innovation on the rehabilitation tools being explored (Batista e Siqueira et al., 2024). The focus of the technology tools is to provide rehabilitation to the end-user, who is the patient. It is important that tools used in rehabilitation are adaptive and easy to use to help the rehabilitation process.

Keywords: *Physiotherapy, Occupational Therapy, Rehabilitation Technologies, Right Upper Limb Rehabilitation, Stroke Recovery.*

Introduction

Advancements in the field of technology can play a crucial role in the development of innovative rehabilitation approaches. In this research, the focus is on the right upper limb rehabilitation after an injury, specifically exploring the physiotherapy and occupational therapy tools that are currently available. The upper limbs, consisting of the arms and hands, are important parts of the human body and are often exposed to injuries. In recent years, there has been an increase in upper limb injuries due to various recreational, sports, and occupational activities. This results in the need for rehabilitation to restore mobility. With good progress in the recovery of lower limbs, upper limb rehabilitation has not been equally effective with current approaches due to challenges faced by healthcare providers and patients. (Pichard et al.2020)

The current approaches used in physiotherapy for right upper limb rehabilitation include strategies that are traditionally used to bring back the normal range of motions and functionalities. These strategies include maintaining the right environment in the treatment room and utilizing tools to assist exercises and monitor progress. Similarly, the techniques used in occupational therapy target the restoration of the same functions and include bringing in the same context of activities that comprise of daily life tasks. The activities are further assisted by tools that can accommodate a sequence of tasks and monitor the progress on each

[1] Physiotherapist, King Fahd specialist hospital, Email: Sfmadani@moh.gov.sa, (Corresponding Author)
[2] Physiotherapist, King Fahd specialist hospital, Email: Mazenab@moh.gov.sa
[3] Specialist physical therapy, King fahad specialist hospital, Email: Raeedaa@moh.gov.sa
[4] Physiotherapist, King Fahd specialist hospital, Email: Abshabaan@moh.gov.sa
[5] Occupational therapist, King Fahd specialist hospital, Email: Aalmalki153@moh.gov.sa
[6] Physiotherapist, King Fahd specialist hospital, Email: Albalawiriyadh@gmail.com,

Journal of Ecohumanism
2024
Volume: 3, No: 8, pp. 9107 – 9118
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.5529

(Batista e Siqueira et al., 2024). One of the key focuses in rehabilitation is to keep the patient engaged and continuously motivated throughout the recovery process.

Background and Rationale

Rehabilitation has been a key part of human existence as far back as records go. Written records from ancient Greece show the interest of early physicians in using deliberate exercise to enhance health, restore function, and treat disease. Research on the understanding and management of injuries and disorders evolved into specialities that closely relate to the current practice of physiotherapy. Over time, the integration of technology into rehabilitation has also been considered. This ranges from the simplest tools, like a rubber band for exercising fingers after it is broken, to advanced, programmable robots that assist in rehabilitation. Though the simpler prior remedies are effective, the speed of recovery can be enhanced through technology integration, as shown by the recent advances in the development of rehabilitation robots. Rehabilitation is generally divided into two domains: physiotherapy and occupational therapy. While the focus of physiotherapy is on the biological aspect of rehabilitation, occupational therapy looks into the socio-cultural aspect. These two domains are nevertheless closely intertwined and should be viewed as a continuum instead of distinct categories. The right upper limb is focused on here because it is the dominant hand for around ninety percent of the population. Loss of function usually results in greater hindrance, as shown by statistics of the World Health Organization. Furthermore, the right upper limb is most susceptible to work-related musculoskeletal disorders injuries. Prevalent disorders include carpal tunnel syndrome and tendinitis, which also leads to great economic burden, aside from pain and suffering. Strokes can result in upper limb impairment as well. Eighty percent of stroke survivors have upper limb impairments at stroke onset (Demain et al., 2013). An agenda for the development of new tools for physiotherapy and occupational therapy is proposed based on a review of the available tools focused on right upper limb rehabilitation. During the agenda setting, the emerging trends in healthcare technology would be first elaborated, followed by the importance of evidence-based practices and the current gaps in practice that the new tools aim to fill. Emerging trends in healthcare technology can transform how rehabilitation is traditionally perceived and practiced. Health technology is currently a rapidly growing business domain in the global market. Health technology refers to any technology that can be used to promote health, and includes biomedical devices, diagnostic equipment, therapeutic equipment, telemedicine, healthcare information systems, health information technology, and bioinformatics (Batista e Siqueira et al., 2024). Many technologies, like health information systems and telemedicine, can enhance the accessibility to healthcare services and should be considered everywhere, especially in remote areas where healthcare providers are lacking. The recent advancements in technology have also fuelled the growth of personal health technology, which focuses on self-health monitoring and management using mobile gadgets, like smartphones and smart wearables. Personal health technology popularizes the fundamental shift in health management from doctor-centered to patient-centered, as patients can take more responsibility for their own health. Similar to health management, a paradigm shift from traditional rehabilitation and assistive technology integration into daily activities is also how rehabilitation is perceived. The importance of evidence-based practices in healthcare is widely recognized. Rigorous scientific research is needed to support the efficacy of any new rehabilitation tools before adoption in clinical practices. With the rapid development in technology, numerous rehabilitation tools have been developed and some are commercially available as assistive technologies. Two broad categories are found: passive assistive technologies augment activities without directly involving the user, like hoists and adapted furniture; and active assistive technologies directly help the user, like robotic devices, smart gloves, and exoskeletons. While assistive technologies have the potential to improve quality of life, the uptake and implementation of assistive technologies in clinical practices are slow. Despite the increase in the number of assistive technologies, many patients do not use any, or only use their pre-existing assistive technologies. To make up for inadequacies in the current rehabilitation practices, new tools are sought that complement the existing tools instead of replacing them. In summary, technology innovations in rehabilitation are focused on right upper limb and the importance and relevance are also discussed in detail. (Anwer et al.2022)

Journal of Ecohumanism
2024
Volume: 3, No: 8, pp. 9107 – 9118
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.5529

Scope and Significance

The focus of this essay is on the technologies developed for the rehabilitation of the right upper limb. The right upper limb is taken into consideration since most people are right-handed. Hence, disabilities regarding the upper right limb greatly affect the quality of life of individuals. The scope of the technologies is limited to physiotherapy and occupational therapy tools that assist the recovery of the right upper limb for post-stroke patients. With the onset of Covid-19, Healthcare systems worldwide are facing a challenge with treating patients not just for Covid but for regular treatments as well. A focus area in the rehabilitation of patients is now on using technology-assisted rehabilitation. Therefore, Assistive technology in the context of Physiotherapy and Occupational therapy tools for upper right limb rehabilitation is relevant and is focused on here (Demain et al., 2013).

In recent years, the demand for rehabilitation is increasing due to road accidents, stroke and other health issues. However, the number of rehabilitation professionals is not increasing at the same rate. Moreover, the ongoing Covid-19 pandemic has made it even harder to get rehabilitative therapies. This means it is crucial to have technology alternatives that can provide rehabilitation to patients. This research is significant as it looks into the assistive technology alternatives available to Physiotherapy and Occupational therapy in rehabilitating the upper right limb which can be used in clinics as well as at home by patients. The research will involve looking into the different tools developed as assistive technology that aid in the rehabilitation of the upper right limb and understanding their working principles (Batista e Siqueira et al., 2024). This research can help clinicians understand what technologies are available as alternatives to their therapeutic intervention and can accelerate the process of choosing the correct technology for the desired rehabilitation during the development of these technologies. This research will also benefit patients by providing them with a list of technologies that can assist in their rehabilitation. Finally, this research will benefit technologists by providing a better understanding of the clinical procedures involved in rehabilitation and the technologies that need to be developed to assist in this.

Physiotherapy Tools

For patients with right upper limb rehabilitation needs, various physiotherapy tools have been designed to enhance rehabilitation outcomes. These tools range from the most conventional tools used widely in clinics to innovative therapeutic exercise devices designed to facilitate physiotherapy for right upper limb rehabilitation. The development of the innovative tools alters the traditional way of physiotherapy exercise, which requires the consideration of ease-of-use in use and fabrication, the safety of the patient, and the compliance of the patient with the use of the device. Most importantly, it is vital to understand that the patient's exercise regiment should be customized and arranged based on the assessment on the patient so that the best recovery outcome can be achieved. Therefore, the device will only address the limitation of the traditional tools but it cannot replace the role of the physiotherapist (Lee Woods, 2018). Another important consideration in the development of new physiotherapy devices is how the progression of the patient's recovery can be tracked and whether the patient can be engaged in using the device outside the clinic. With the new technologies available at hand, it is also important to explore how they can be utilized to better engage the patient and track their progress. The new techniques can either be incorporated into the newly developed devices or can be stand-alone tools used alongside the conventional physiotherapy devices. The integration of new techniques enables the physiotherapists to improve the efficiency and effectiveness of the rehabilitation session with the patients. A number of physiotherapy tools are explored and discussed here, either new innovative devices or commonly used conventional tools in clinics. The exploration of the tools is solely focused on the facilitation of physical recovery to the right upper limb and does not include the rehabilitation strategies to improve the cognitive capability that often accompanies the physical impairment. In the exploration, it is essential to note that it is the physical recovery to the right upper limb that enables the improvement of the functional capability of both the right upper limb and the associated cognition in a wider context. Hence, the recovery of the right upper limb describes the improvement of the functional capability to the right upper limb while the recovery to the cognition describes the improvement of the functional capability to the associated cognition. Before getting into the details of the specific technology applied in the physiotherapy tools, the most commonly used conventional physiotherapy tools will first be introduced. These conventional tools are widely used in clinics and illustrate

Journal of Ecohumanism
2024
Volume: 3, No: 8, pp. 9107 – 9118
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.5529

the role of physiotherapy in facilitating rehabilitation. An overview of the innovative technology applied to physiotherapy devices will follow. An in-depth discussion on the technology used for both physiotherapy and occupational therapy tools in right upper limb rehabilitation will conclude the section.

Therapeutic Exercise Devices

Therapeutic exercise devices are widely used in rehabilitation for the right upper limb. The rehabilitation exercise devices can broadly categorize into simple exercise devices and multi-function/complex exercise devices. Simple therapeutic exercise devices include equipment with resistance training, training of actively moving joints without resistance, therapy bands, and tools for functional training of one or more joints. They are effective for patients in the early stage of physiotherapy. For patients who can partially recover muscle strength, use them widely to conduct individual exercise prescriptions and effective resistance training. Some of them are also used for advanced patients and for active functional training of the upper limb. Multi-function therapeutic exercise devices are complex equipment and can have several functions with diverse therapies, including passive exercise, assisted exercise with motor power, and resistance exercise. They are used for the right upper limb rehabilitation across different therapy stages. Recent innovations in exercise devices focus on the integration of smart technology during training, providing real-time feedback, assessment, and tracking regarding patient performance . This supports the physiotherapist in better adjusting the exercise program and device. They can also be remotely controlled through applications for patient safety. Additionally, using therapeutic exercise devices has advantages in a clinical setting, as they increase compliance and motivation through competition and game-like training. Case studies or examples are cited for comprehensive rehabilitation results using these tools. Currently, the device is fully or partly applied in rehabilitation institutes to recover the functionality of the right upper limb. The thorough literature review indicates an overview of exercise devices and their applications in clinical settings. There is continuous evolution in the usage of exercise devices in physiotherapy, hence need to be selection based on evidence. (Khalid et al.2023)

Virtual Reality (VR) and Augmented Reality (AR) Applications

Virtual reality (VR) and augmented reality (AR) are emerging immersive technologies developing rapidly in numerous fields, including rehabilitation. As the hardware for VR and AR systems become cheaper and more robust, the interest grows in applying them in rehabilitation, where they can create a stimulating and engaging virtual or augmented environment for the patients while they undergo rehabilitation exercises (Mubin et al., 2019). Generally, the VR or AR applications can either be used standalone as tools where patients can perform exercises separately, or they can be incorporated with existing rehabilitation hardware, creating an immersive environment for the patients while using the hardware to perform rehabilitation exercises.

Immersive technologies have been shown to have a positive effect on motivation; thus, it is not surprising that numerous studies have been conducted on using virtual environments in rehabilitation. In addition to the improved motivation and engagement of the patients, it has also been shown that immersing patients in virtual environments can lead to recovery speed increases. VR technologies can also benefit the staff, as real-time data tracking can relieve them from time-consuming tasks like monitoring patients' movements or keeping track of their training progress (Sveistrup, 2004). Several case studies and empirical evidence show the effectiveness of VR or AR systems to improve outcomes in upper limb rehabilitation. A review of available systems and platforms is provided, followed by an outline of the main challenges for those technologies in rehabilitation today. Finally, future directions are proposed to improve the feasibility of these systems for daily use in clinics.

Currently, most of the existing immersive applications in rehabilitation focus exclusively on the upper limb, as that is where the need is the greatest. The available software and platforms that can be used or are being developed for clinical use are reviewed. Since most software is either free or requires affordable fees, the two other big challenges for rehabilitation clinics – accessibility or availability of the hardware, and often high costs of equipment – are discussed as well. Both challenges can greatly limit the use of even the most effective solutions, and the review shows that ignoring them makes for a much lower chance the technology

Journal of Ecohumanism
2024
Volume: 3, No: 8, pp. 9107 – 9118
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.5529

will be actually used in clinical settings. Future research and project developments should consider these issues, focusing on cheap alternatives that could bring the technologies to many rehabilitation clinics that currently cannot afford to invest thousands of euros in cutting-edge but expensive technology. (Kim et al.2020)

Occupational Therapy Tools

Having discussed physiotherapy tools critical for the rehab process of the right upper limb, attention is shifted to the occupational therapy tools, which are equally essential for the same rehab task. Upper limb rehab is not limited to physiotherapy. Occupational therapy plays an essential role in ensuring the right upper limb regains all its abilities and functionality. An occupational therapist ensures that the patient continues to perform tasks that involve the use of the right upper limb and the hand. This is achieved through the utilization of adaptive devices with a focus on daily living skills and independence. The daily living skills include dressing, eating, bathing, grooming, etc., and the occupational therapy devices are built around these skills so that patients can continue with them even after an injury. There are a variety of occupational therapy assistive devices that assist upper limb conditions either entirely or partially. ADL (Activities of Daily Living) devices improve the functionality of the upper limb and ensure the daily tasks of the patients are done without much help from others. These tools make daily activities easier for patients with disabilities or make these activities possible for them. OTs (Occupational Therapists) design and implement these activities and the devices used in them. Ergonomics and user-centered design play a very important role in the making of these tools. An understanding of the users' needs, limitations, expectations, and behavior ensures that the tools are effective and encourage adaptation. Most of the devices need to be customized for the user to ensure it meets the patient's requirements precisely. The tools discussed are occupational therapy tools but complement the physiotherapy tools perfectly and ensure the upper limb rehab is holistic and multi-faceted. There are case studies on patients where the occupational therapy tools were successfully integrated into the therapy program and details on how they were implemented along with the results obtained. All the case studies involve the rehabilitation of the right upper limb and the hand, which had either been compromised due to an injury or had lost functionality due to a medical condition. The outcome of the case studies proves that the occupational therapy tools are effective in enhancing the performance of the patient's activity and thus reclaiming the upper limb's abilities. With the case studies done on wide-ranging activities, the following subsections illustrate a few occupational therapy technologies that assist in upper limb rehab through occupational therapy. While the focus is on the technology innovations, some non-technological devices are included as well. Therefore, the intersection of technology and occupational therapy ensures the upper limb of the patients is rehabilitated and restored to its former state and functionality (Lee Woods, 2018).

Assistive Devices and Adaptive Equipment

The following is a review of rehabilitation tools related to upper limb within physiotherapy and occupational therapy specially focusing on the technology innovations. A literature review is conducted focusing on the recent 5 years scholarly articles. The tools are segregated based on its type, purpose and technology applied. Each tool has different level of complexity, some of them are better suited for clinical setup whereas others can be easily used at home. Some tools an institutional or an NGO can plan to develop, whereas several tools have commercial availability but are not very widely available in India. (Oztemel & Gursev, 2020)

Assistive Devices and Adaptive Equipment

A range of assistive devices and adaptive equipment specifically designed for rehabilitation of upper limb are assessed in this part. These include assistive devices that help with daily activities like eating or writing, promoting independence among patients. Most of the devices covered here are innovations that emerged last five years. Some devices are designed to be used by patients at home, whereas others can be used in clinic set up. All these devices come with an important caveat; personalized assessment of patients is always needed to determine which devices may be most effective and suitable for an individual. These assessments often come at a cost to the patient, whether through insurance or out-of-pocket payment. Smart home technology designed with patient needs in mind ensures that what used to be stigmatizing devices, are now

Journal of Ecohumanism
2024
Volume: 3, No: 8, pp. 9107 – 9118
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.5529

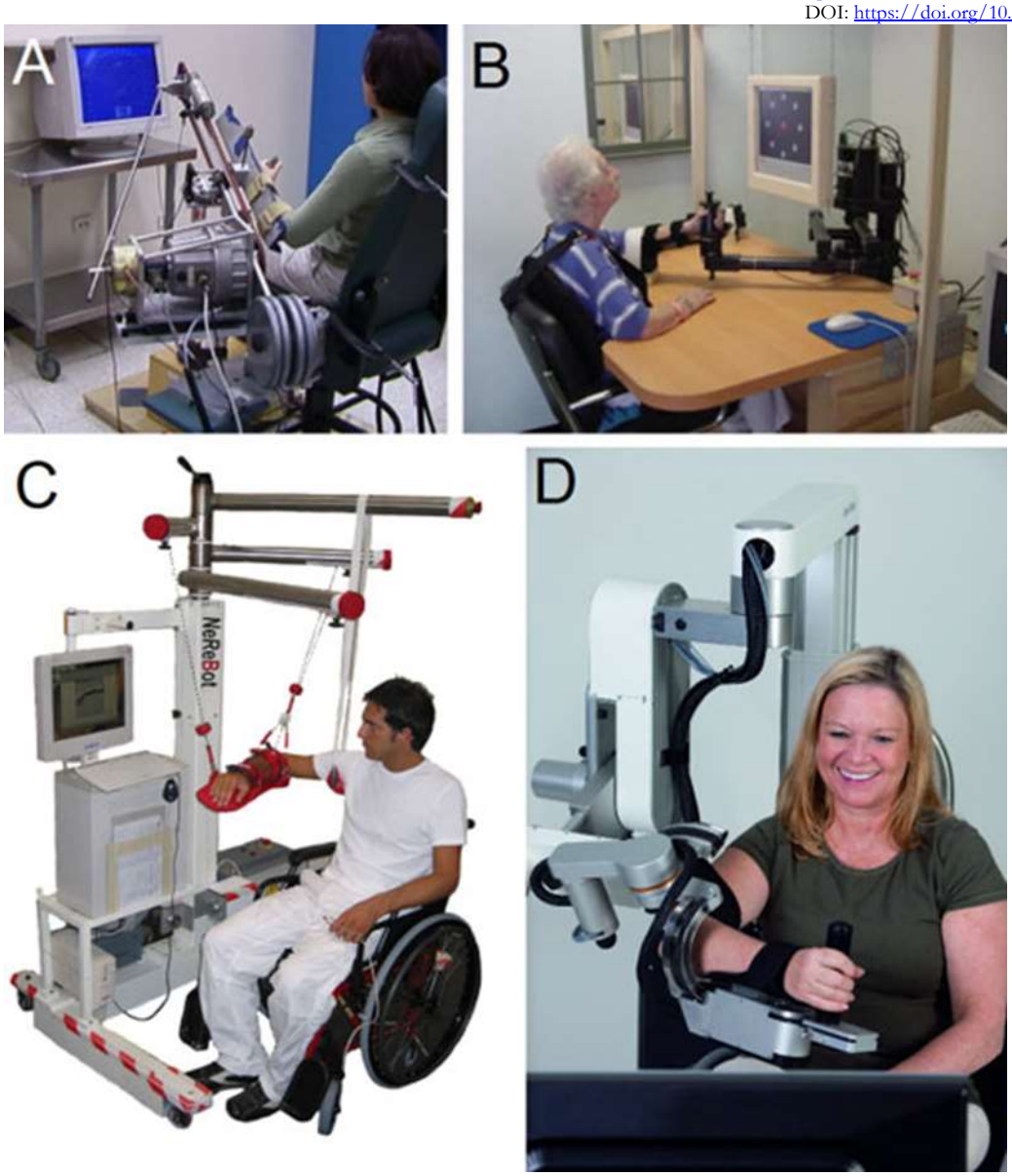
aspirational. An array of products designed for smart homes from security to kitchen items is presented where some items are specifically designed or can be incorporated through basic redesign. Use of everyday items that can work convincingly as adaptive equipment is also presented here; either as DIY equipment or commercially available tools that are radically inexpensive. Some ergonomic tools that are simple yet pivotal in enhancing participants functionality are also highlighted. Although many assistive devices & adaptive equipment designed for rehabilitation of upper limb have emerged in the past five years, most of these devices are not easily accessible to general population. These devices are either normatively expensive or not available in the market. Some of the devices which are easily available in the market; are not marketed through proper platform, making them hard to access. Assistive devices have a profound impact on patients' recovery as testified by several patients whose success stories are presented here. A range of adaptive equipment that can easily available or made accessible to general population is also included. All the assessment devices can be integrated into therapy program to enhance participants functionality & quality of life. To summarize, assistive devices are essential part of occupational therapy specially with regard to upper limb rehabilitation. For best outcome, assistive devices must be introduced in the rehabilitation program from the very first therapy session (Lee Woods, 2018).

Robotics and Wearable Technology

As technological advances continue to reshape industries globally, a concerted initiative is unfolding in the health tech sector to revolutionize rehabilitation care and patient management practices. Significant strides have been made in devising robotic and wearable solutions tailored specifically for rehabilitating the upper-limb following neurological impairments. Extensive research has focused on developing robotic exoskeletons and assistive robotic counterparts to enhance post-stroke motor recovery. Robotic rehabilitation machines reap the key advantage of delivering real-time feedback to stroke patients on their recovered motor abilities, in tandem with a precise data tracking mechanism for therapists on each patient's recovery progress. Furthermore, these robots can facilitate progressive resistance training, adjusting the rehabilitative force based on the patient's actuated performance as they regain motor function (Onose et al., 2018). Concurrently, a parallel effort is underway in research institutions worldwide to fabricate small, low-cost, and lightweight wearable technology that patients can wear over their upper-limb while executing prescribed rehabilitation exercises. The developed wearable devices primarily encompass motion sensors that monitor patients' movements, providing feedback on their intensity and correctness. Such data reports are invaluable for therapists in comprehending patients' daily exercise compliance and recovery progress. In addition to prosthetic applications, these wearables find versatility in upper-limb rehabilitation solutions afflicted with neuromotor disabilities. Although the feasibility of robotic rehabilitation has been established through various commercial products, academic research prototypes, and pilot clinical trials, challenges persist. Foremost among these challenges are high capital development and maintenance costs, rendering robotic rehabilitation systems inaccessible to many hospitals, particularly small-scale facilities in developing countries (Soltani-Zarrin et al., 2017).

Examples of mechanical structures or robotic devices for upper limb rehabilitation. A: ARM Guide—a simple system using linear bearing to modify orientation; B: InMotion ARM—an end-effector-based

Journal of Ecohumanism
2024
Volume: 3, No: 8, pp. 9107 – 9118
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.5529



commercial system; C: NeReBot—a cable-driven robot; D: ArmeoPower—an exoskeleton-based commercial system (courtesy of Hocoma AG).

Robots with exoskeleton structures replicating human kinematics have emerged as an innovative approach to facilitate active or assisted rehabilitation in post-stroke paralytic patients. These devices can be classified into three categories based on their actuation types: end-effector robotic systems employing a fixed base to move the patient's hand in Cartesian space; exoskeletons consisting of rigid links interconnected by rotational joints replicating the human joints' degrees of freedom; and fixed passive rehabilitation trainers devoid of actuators, solely guiding the patient's limb during rehabilitation. Over the past two decades, several such robotic devices have been developed, actively tested, and assessed in clinical trials across Europe, the USA, Japan, and China. More recently, numerous emerging start-up companies have ventured into this domain, translating academic research designs into commercial devices. A pre-requisite for wide integration of robotics into rehabilitation practice is exhaustive clinical trials demonstrating their efficacy in improving patients' motor skills. An important technological advance in rehabilitation robotics is augmenting commercially available systems with virtual reality (VR) displays, fostering engaging interaction between patients and robots while executing rehabilitation exercises. This trend mirrors the widespread adoption of VR technology across other fields, including gaming and defence training. To enhance patients' interest and participation in rehabilitation tasks, several research groups have explored using VR environments to build serious games compatible with rehabilitation robots. Machine learning offers a means

Journal of Ecohumanism
2024
Volume: 3, No: 8, pp. 9107 – 9118
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.5529

to update the game difficulty based on real-time assessment of patients' performance, ensuring a continual challenge and avoiding monotonous or overly difficult tasks.

Combined Approaches in Rehabilitation

Rehabilitation therapies for a particular body part are usually separate, although physiotherapy and occupational therapy approaches can both be applied to right upper limb rehabilitation. With a focus on the right upper limb, this section discusses the advantages of combined physiotherapy and occupational therapy approaches in rehabilitation and the treatment tools available.

At the healthcare professional level, an interdisciplinary approach is considered vital in developing comprehensive treatment plans for patients (Lee Woods, 2018). This involves collaboration between rehabilitation specialists, physiotherapists, occupational therapists, nurses, social workers, and other relevant professionals. Individual disciplines contribute from their area of expertise, and as a combined group, new consideration can be given to the patient's goals and how best to achieve them. The importance of an interdisciplinary approach has been widely recognised, particularly for the management of patients with complex health needs. Research shows that combined methodologies can improve patient outcomes, particularly in interventions related to the progressive education of patients or carers, exercise training, and therapies that improve communication. While rehabilitation is generally defined as a wide range of services focused on the recovery of function after the onset of health problems, different therapeutic modalities are traditionally considered in isolation. With regard to the upper limb, this is largely due to the persistence of a particular diagnosis and treatments specific to that condition. Nevertheless, upper limb rehabilitation is often complemented by the application of different modalities, leading to a more holistic recovery process. Good communication amongst team members is vital, as is the importance of goal alignment. If goals conflict or are misaligned, therapy can be rendered less effective or even counterproductive. When an intervention is compounded by two or more different therapists, it is essential that each has a similar understanding of the procedure and desired outcome. Several case studies demonstrate the successful implementation of an interdisciplinary approach in the provision of combined rehabilitation and how patient involvement in decision-making can enhance treatment effectiveness.

Interdisciplinary Collaboration

Rehabilitation professionals play a crucial role in helping disabled and injured patients adjust to their physical limitations and recover their lost capacities, so as to reintegrate them into the community. As a result, the design and development of rehabilitation technology that can assist rehabilitation professionals in their activities is a significant approach to boost the efficiency and effectiveness of rehabilitation services. As right upper limb is the most used limb for manipulating the environment, lowering limb injuries, disabilities, or strokes can severely affect the individual's quality of life (QoL). Therefore, physiotherapy and occupational therapy rehabilitation for right upper limb is critically demanded. Moreover, development of new rehabilitation technology and its effect on the clinical practice of rehabilitation professionals has drawn a lot of attention from researchers (Batista e Siqueira et al., 2024). However, simply focusing on technology development is not sufficient to address the required rehabilitation professionals, rehabilitation protocols and treatment strategy issues for applying the new technology in practice. Therefore it is necessary to take a deeper look at the rehabilitation professionals' perspective in a specific context of technology for right upper limb rehabilitation. An extensive review of the status and challenges of current technology innovations in the context of physiotherapy and occupational therapy for right upper limb rehabilitation is presented. In addition, three case studies of technology innovations with potential to be adopted in the clinical practice of rehabilitation professionals are illustrated. Interdisciplinary collaboration will play a critical role on further enhancing the rehabilitation outcomes. In this case, rehabilitation professionals co-work with designers, engineers and researchers who have diverse expertise in rehabilitation technology, to achieve a more effective treatment strategy for the patients. As the technology innovations are originally designed for rehabilitation professionals, their perspectives are addressed in detail at the first place. However, it is equally important to discuss how the expertise of other disciplines can further assist and enhance the impacts of these technology innovations on the patients' recovery. Physiotherapists,

Journal of Ecohumanism
2024
Volume: 3, No: 8, pp. 9107 – 9118
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.5529

occupational therapists and other healthcare professionals all had the similar benefits from collaborating with one another. Sharing knowledge and skills with other professionals can not only bring new ideas and insights to improve the treatments, but also avoid the professionals from being trapped in a narrow working routine. The impact of combining different disciplines makes sense at both the individual professional level and the service level of a particular discipline. At the individual professional level, collaboration offers an opportunity for professionals to broaden their clinical horizon by learning from other disciplines, enhancing the diversity and comprehensiveness of their service to the patients. At the service level, collaboration encourages the development of innovative service strategies. For example, integrating different professional disciplines can help eliminate the service duplication and division problems, and instead encourage the teamwork and shared decision-making strategy. Physiotherapy and occupational therapy involve the treatment of similar patients but from different perspectives and treatment approaches. Therefore, during the discussions on the technology innovations, the need to integrate these two disciplines has been identified as a means to offer more comprehensive and effective treatments to the patients. Moreover, as different disciplines adopt and prioritize different professional ethics and values, interdisciplinary collaboration can also raise questions and reflections on the professional practice itself. At the patients side, multi-disciplinary collaboration helps to address the complexity of patients' needs and conditions, ensuring that all different aspects of the patients are taken care of. Although there is a general agreement on the necessity of collaboration, it is difficult to achieve an effective collaboration due to various challenges. For example, the differences in professional cultures lead to a difficulty in finding a common ground on the most basic issues like terminology. Even with the efforts in interdisciplinary education to promote collaboration, it usually becomes a choice merely at the administrative level to satisfy the funding agencies. In addition, simply having regular meetings with the participation from different disciplines does not guarantee a successful collaboration, as it may often result in one discipline dominating the discussions while others merely providing suggestions or feedbacks. In general, different professional disciplines tend to emphasize different aspects of treatments either for philosophical reasons or due to the historical and educational backgrounds, and therefore adopt different priorities and approaches in professional practice. Consequently, it is often expected that each discipline has its own professional autonomy.

Hybrid Technologies

Based on the analysis of recent and emerging technology innovations for right upper limb rehabilitation, the tools are classified as either physiotherapy tools, occupational therapy tools, or hybrid technologies encompassing both applications. Tools designed exclusively for physiotherapy or occupational therapy are also investigated, focusing on innovative applications that have a clinical, research, or educational use. Currently, hybrid technologies that blend both physiotherapy and occupational therapy tools in rehabilitation are still in an early development stage. However, emerging technologies of this kind can offer personalized and versatile solutions for patients recovering from some upper limb disabilities (Batista e Siqueira et al., 2024). Moreover, they can ensure a smoother transition between physiotherapy and occupational therapy treatment phases, especially when carried out in parallel, as often happens with pediatric patients after neurological disorders.

Technologies such as exercise-tracking systems with assistive capabilities or exoskeletons with built-in therapeutic exercises can generate a hybrid approach to rehabilitation. On the one hand, patients can benefit from assisted solutions promoting their independence and productivity. On the other hand, therapists can conduct therapeutic exercises for patients unable to perform them unassisted. Additionally, hybrid technologies could implement RAGT and an assisted model simultaneously, which is advantageous for patients unable to perform prescribed activities without assistance (Lee Woods, 2018). Utilizing hybrid models for rehabilitation interventions can address a wider spectrum of requirements in comparison to their singular counterparts. Most developed hybrid technologies focus on combining physiotherapy and occupational therapy functions within one solution. Nevertheless, stand-alone tools dedicated to one type of therapy but facilitating both kinds of interventions are also available. The main advantages of hybrid technologies imply the simultaneous availability of different therapeutic approaches, increased patient engagement, adherence to therapy, and variety of treatment paths. Meanwhile, typical drawbacks involve difficulties in integrating various technologies into one system or requiring patients and therapists to train,

Journal of Ecohumanism
2024
Volume: 3, No: 8, pp. 9107 – 9118
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.5529

study, or use multiple technologies. Still, these drawbacks are common for all multi-technology interventions. Some hybrid solutions target noble therapy procedure enhancement goals, such as a personalized treatment path or experimental exam observations. Future trends focus on development and wider acceptance of hybrid solutions in clinical practice. Beyond that, several hybrid technologies for upper limb rehabilitation are under consideration, emphasizing their innovative potential in modern rehabilitation.

Challenges and Limitations

As technology enhances rehabilitation options and outcomes, patient access to these innovations must be addressed. Presently, many cutting-edge therapeutic technologies remain confined to clinical environments. Once the machinery is procured, it is often relegated to a single clinical site, particularly in public health systems that prioritize affordability. Even when technology becomes available, accessibility concerns abound, such as the need for patient transfers to a hospital or health center, which may be logistically challenging. Home-based options exist, but they typically come at a high price, raising questions about patient affordability and health service prioritization. There is a risk that advances in health technologies will widen the equality gap significantly (Demain et al., 2013). The screening and assessment processes, crucial for technology efficacy, necessitate highly trained and proficient users, which may not extend to all health professionals. Thus, personnel training must accommodate any new technology.

Patient adherence to technology-based solutions significantly contributes to their rehabilitation efficacy. An all-too-common outcome of increased patient choice is reduced engagement with technology. Failures typically occur with patients expected to regularly use anything beyond therapy provided directly by a health professional. Even existing home-based rehabilitation solutions often go unused. Recent evidence suggests that older patients are considerably less likely to adopt and regularly use new technology. Wider adoption of rehabilitation technologies relies on engineered solutions to promote health-tech engagement. Moreover, patient engagement must be prioritized during technological development. It is essential to understand that no single technological intervention will address all patient needs; how patients interact with technology will vary widely in different clinical settings (Batista e Siqueira et al., 2024).

As health technologies proliferate, data security and privacy concerns are growing. Ethical considerations must guide new technology adoption. For example, with personal data at risk, either a technology must respect the data's individual ownership, or informed consent on its use must be obtained. The latter is questionable unless the person conducting the risk assessment understands the health technology, or it should be independently validated by experts. Misinterpretations of risk can lead to detrimental legal or reputational fallout affecting the health institution and individuals involved. With most new health technologies reliant on digital networking, low technology literacy among health professionals and patients limits understanding and obscures significant risks. Ingeniously designed technologies can fail because hardware objects do not work as intended and software bugs or incorrect settings can render health technologies unusable. (Laymouna et al.2024)

Finally, while the reviewed technologies genuinely wish to improve rehabilitation, gathering objective proof before widespread use can be challenging. Models often consider testing "gold standards" as a prerequisite for technology adoption; however, developing and embedding new technologies can take years. Consequently, even after extensive initial testing, new technologies may never be subjected to "gold standard" assessment. Rehabilitation experiments necessitate clinicians' time and, with each expert's approach varying, experimental outcomes will also differ. Furthermore, clinical observations may be at odds with numerical proof; for instance, clinicians may see no improvement with one patient's technology use that beginners deem significant. Each technological development strongly desires a clinical proof of use but burdening the technology with proof requirements that are potentially unachievable or ill-defined is futile. To consider a technology clinically "successful," developers typically want it used in routine rehabilitation; hence, hurdles technologically-supported rehabilitation requires must be addressed to encourage new technology adoption. (Lang et al., 2020)

Journal of Ecohumanism
2024
Volume: 3, No: 8, pp. 9107 – 9118
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.5529

Future Trends and Innovations

This section explores potential innovations and emerging trends in technology used for right upper limb rehabilitation. There is a growing interest in research and developments that utilize artificial intelligence and machine learning to enhance existing rehabilitation tools and systems or create new ones. While these innovations have the potential to transform rehabilitation and improve patient outcomes, considerations related to usability, accessibility, and ethics are essential to ensure all patients can benefit from advancements in technology (Lee Woods, 2018).

Traditionally, when developing rehabilitation tools and systems, the focus has been on the technology's capabilities. However, it has been recognized that the end-user experience is paramount for rehabilitation technology to be effective. A user-centered design is essential to create effective rehabilitation technology. Future developments in technology for right upper limb rehabilitation will explore new advances while focusing on usability, accessibility, and ethics concerns. Emerging innovations aim to construct tools and systems that are more personalized and adaptable to meet the diverse needs of patients at different stages of recovery. (Ríos-Hernández et al.2021)

The COVID-19 pandemic highlighted the need for accessible rehabilitation services and the potential role of telehealth and other remote monitoring technologies in meeting this need. Looking ahead, technology developments will consider how tools and systems can be used to expand the accessibility of rehabilitation services. Collaboration between technology developers and healthcare providers in the rehabilitation field is crucial for successful innovation. The importance of partnerships between clinicians and engineers or computer scientists is emphasized, particularly in deciding how technology should be applied to best address a current challenge in rehabilitation. (De et al.2020)

With new technology innovations in rehabilitation, regulatory processes are anticipated to ensure safety and efficacy before public use. Upcoming changes in regulations that will affect how emerging technology is adopted into rehabilitation practice are discussed. Examining these changes is important, as there are questions and concerns about whether these processes will keep pace with emerging technology innovations. Overall, this section provides insight into possible future developments in the use of technology for right upper limb rehabilitation and highlights the exciting opportunities that lie ahead in this field.

Conclusion

Rehabilitation from upper limb motor impairments caused by neurological disorders is a meticulous process involving both therapy and time. While patients desire swift recovery, the brain's adaptability necessitates a gradual approach. To aid recovery, it is imperative that patients perform the prescribed exercises accurately and consistently. This requirement highlights the significance of using proper equipment and tools to assist patients in conducting exercises throughout their recovery journey. Recent advancements in technology and rehabilitation engineering and the ongoing quest for effective therapeutic solutions have led to the emergence of innovative equipment and systems to assist rehabilitation experts. These innovations go beyond conventional hardware systems, incorporating smart and portable devices, software applications, and virtual environments to create enjoyable and gamified exercise experiences. The intelligent use of these technological innovations, designed to be easy and accessible for patients at home, can empower them to take control of their rehabilitation process, ensuring that prescribed exercises are performed accurately and repetitively, even outside clinical settings. The combination of these innovative tools can enhance therapy sessions conducted by therapists, resulting in better therapeutic outcomes (Demain et al., 2013). This article explores the advancements in technology innovations to assist the rehabilitation of the right upper limb, which is commonly affected by upper limb motor impairment due to stroke. It specifically focuses on the recent advancements in available physiotherapy and occupational therapy tools and equipment. The emphasis is on discussing tools that assist both physiotherapy and occupational therapy, as the integration of such tools can greatly benefit patients with combined motor impairment and help rehabilitation experts create a more robust and holistic rehabilitation strategy. However, it is important to acknowledge that the

Journal of Ecohumanism
2024
Volume: 3, No: 8, pp. 9107 – 9118
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i8.5529

inclusion of combined health tools restricts the scope of the discussion. Therefore, an overview of the challenges and limitations of the newly developed technologies is also presented, along with some recommendations for future development and research. As technology continues to evolve rapidly, ongoing developments in the discussed tools and the emergence of new tools are anticipated. Embracing technological advancements is vital for rehabilitation experts as these innovations have the potential to greatly enhance rehabilitation practices (Batista e Siqueira et al., 2024).

References

Batista e Siqueira, T., Parraça, J., & Paulo Sousa, J. (2024). Available rehabilitation technology with the potential to be incorporated into the clinical practice of physiotherapists: A systematic review. ncbi.nlm.nih.gov

Pichard, R., Kopel, L., Lejeune, Q., Masmoudi, R., & Masmejean, E. H. (2020). Impact of the COronaVIrus Disease 2019 lockdown on hand and upper limb emergencies: experience of a referred university trauma hand centre in Paris, France. International orthopaedics, 44, 1497-1501. springer.com

Demain, S., Burridge, J., Ellis-Hill, C., Hughes, A. M., Yardley, L., Tedesco-Triccas, L., & Swain, I. (2013). Assistive technologies after stroke: self-management or fending for yourself? A focus group study. ncbi.nlm.nih.gov

Anwer, S., Waris, A., Gilani, S. O., Iqbal, J., Shaikh, N., Pujari, A. N., & Niazi, I. K. (2022, January). Rehabilitation of upper limb motor impairment in stroke: a narrative review on the prevalence, risk factors, and economic statistics of stroke and state of the art therapies. In Healthcare (Vol. 10, No. 2, p. 190). MDPI. mdpi.com

Lee Woods, S. (2018). Integrating Neuro Technology into the Clinic: a proposed tool for promoting the clinical integration of neuro rehabilitation technology. [PDF]

Khalid, S., Alnajjar, F., Gochoo, M., Renawi, A., & Shimoda, S. (2023). Robotic assistive and rehabilitation devices leading to motor recovery in upper limb: a systematic review. Disability and Rehabilitation: Assistive Technology, 18(5), 658-672. [HTML]

Mubin, O., Alnajjar, F., Jishtu, N., Alsinglawi, B., & Al Mahmud, A. (2019). Exoskeletons With Virtual Reality, Augmented Reality, and Gamification for Stroke Patients' Rehabilitation: Systematic Review. ncbi.nlm.nih.gov

Sveistrup, H. (2004). Motor rehabilitation using virtual reality. ncbi.nlm.nih.gov

Kim, W. S., Cho, S., Ku, J., Kim, Y., Lee, K., Hwang, H. J., & Paik, N. J. (2020). Clinical application of virtual reality for upper limb motor rehabilitation in stroke: review of technologies and clinical evidence. Journal of clinical medicine, 9(10), 3369. mdpi.com

Oztemel, E. & Gursev, S. (2020). Literature review of Industry 4.0 and related technologies. Journal of intelligent manufacturing. researchgate.net

Onose, G., Popescu, N., Munteanu, C., Ciobanu, V., Sporea, C., Mirea, M. D., Daia, C., Andone, I., Spînu, A., & Mirea, A. (2018). Mobile Mechatronic/Robotic Orthotic Devices to Assist–Rehabilitate Neuromotor Impairments in the Upper Limb: A Systematic and Synthetic Review. ncbi.nlm.nih.gov

Soltani-Zarrin, R., Zeiaee, A., Langari, R., & Tafreshi, R. (2017). Challenges and Opportunities in Exoskeleton-based Rehabilitation. [PDF]

Laymouna, M., Ma, Y., Lessard, D., Schuster, T., Engler, K., & Lebouché, B. (2024). Roles, users, benefits, and limitations of chatbots in health care: rapid review. Journal of medical Internet research, 26, e56930. jmir.org

Lang, C. E., Barth, J., Holleran, C. L., Konrad, J. D., & Bland, M. D. (2020). Implementation of wearable sensing technology for movement: pushing forward into the routine physical rehabilitation care field. Sensors. mdpi.com

Ríos-Hernández, M., Jacinto-Villegas, J. M., Portillo-Rodríguez, O., & Vilchis-González, A. H. (2021). User-centered design and evaluation of an upper limb rehabilitation system with a virtual environment. Applied Sciences, 11(20), 9500. mdpi.com

De Biase, S., Cook, L., Skelton, D. A., Witham, M., & Ten Hove, R. (2020). The COVID-19 rehabilitation pandemic. Age and ageing, 49(5), 696-700. nih.gov.