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THE IMPACT OF TECHNOLOGY ON THE FIELD OF PHYSIOTHERAPY: EXPLORING THE IMPACT OF VIRTUAL REALITY, TELEHEALTH, AND MORE

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Abstract

Over the past years, innovation and technology have revolutionized the health sector, creating new possibilities for physiotherapy professionals and patients alike—incorporating technology into clinical practice allows physiotherapists to diversify their approach to injury risk management, rehabilitation, and treatment, while helping them meet the high demands of healthcare systems cities. Physiotherapy, also known as physical therapy, is a healthcare service focused on developing, maintaining, and restoring movement and functional ability. These services are provided by physiotherapy professionals, who autonomously assess physical health and create a plan aimed at resolving any difficulties.

To ensure patient health and well-being in movement, physiotherapists engage in various clinical activities, which can be grouped into five major categories—monitoring, application, planning, prevention, and education. During monitoring activities, physiotherapists assess the movement related to a given risk in order to plan appropriate care actions. Movement monitoring can be conducted using technology, such as the automatic detection of falls in older adults that makes use of accelerometer sensors and artificial intelligence (AI) algorithms for classifying daily activities. Similarly, processing visual data collected with cameras has enabled the automatic detection of postural alterations in children with cerebral palsy, which would assist physiotherapists in conducting postural assessment (e.g., during sitting) or gait analysis (e.g., during walking) (Batista e Siqueira et al., 2024).

1.2 Keywords

Physiotherapy, Technology, Rehabilitation Technology, Physiotherapy profession, Technological innovations, Technology incorporation and Technological innovations.

1.3 1. Introduction to the Intersection of Technology and Physiotherapy

The purpose of this article is to present discussion and research to examine the impact of technology on the field of physiotherapy, considering both traditional methods and contemporary

advancements. The first section will focus on the impact of the new normal brought by COVID-19 and technological advancements. Subsequent research and discussion will pertain to technology used in physiotherapy settings prior to the global pandemic. It is well-understood that technological advancements play a significant role in shaping and improving many fields, and physiotherapy is no exception. Emerging technologies have steadily augmented choices and alternatives for existing treatments, procedures, and practices employed by physiotherapists, in addition to establishing completely novel methods .

Current rehabilitation technologies encompass a range of devices, tools, and systems usable in clinical settings or home environments, possessing the potential to assist physical therapy professionals in rehabilitating, preventing, monitoring, and training. These technologies facilitate the evaluation and treatment of patients with restrictions in movement capacity, such as elderly individuals recovering from hip surgeries, children with cerebral palsy, or patients who have suffered strokes. Moreover, technologies can monitor individuals risked by musculoskeletal disorders due to awkward postures, repetitive gestures, or exposure to excessive loads, such as workers on factory floors. It is important to acknowledge that the presence of technology does not eliminate the fundamental need for professional physiotherapists in healthcare systems. Nonetheless, this technology can perform functions that enhance the traditional skills of physiotherapists and ultimately assist patients in an equally effective manner.

1.4 2. Virtual Reality in Physiotherapy

Virtual reality (VR) is fast becoming one of the more popular technologies in physical rehabilitation. This is due to its potential advantages for rehabilitation over traditional approaches. For example, VR can provide safe and functional environments that can be effectively adapted to meet a diverse set of therapeutic objectives. It has been suggested that VR has the potential for rehabilitation environments that are challenging but safer than 'real-world' environments (A Keshner & (Tamar) Weiss, 2007). Traditionally, the responsibility for designing training environments has rested with the clinical professionals. However, many therapists lack the background to design computer-based training environments. Consequently, there is a need to bring together those who have the clinical knowledge with those who have the technology skills.

The purpose of the International Workshop on Virtual Reality in Rehabilitation (IWVR) is to create a forum where these disciplines can come together to educate and learn from each other. The hope is to allow a clearer understanding of the potential for VR and other emerging technologies in rehabilitation and to encourage the development of innovative and effective computer-based rehabilitative environments. Historically, advancements in technology and improvements in clinical practice have been driven by competition. However, in order for technology to effectively serve the needs of clinicians and patients, interdisciplinary cooperation is essential (Batista e Siqueira et al., 2024). Each discipline approaches similar problems from unique perspectives, and these very different approaches can, at times, create roadblocks to understanding on both sides. If technology transfer is to become successful, there must be collaborative interactions among engineers, clinical scientists, and clinicians, each of whom brings a different expertise and perspective to the effort with a shared goal of serving the needs of rehabilitation.

2.1. Applications in Rehabilitation

Rehabilitation technologies are instruments designed to assist individuals in regaining or enhancing their physical functionality and autonomy due to injury, disease, or developmental issues. This technology encompasses assistive equipment, as well as systems employed during the rehabilitation process. The objective of this systematic review was to identify rehabilitation technologies that could potentially be integrated into the routine clinical practice of physiotherapists and create contributions to support the incorporation of this technology. A systematic review of the literature was conducted to investigate physiotherapy rehabilitation technology that is available and usable in clinical practice. Online database searches identified 239 potentially relevant studies. After applying eligibility criteria, 30 studies were included in the review, describing 37 distinct rehabilitation technologies (Batista e Siqueira et al., 2024).

Rehabilitation technologies can support clinical tasks performed by physiotherapy professionals, including: (i) prevention of injuries, through the analysis of physical training via biofeedback systems, video analysis, or wearables; (ii) movement monitoring, using 3D motion capture systems, pressure sensors, or accelerometry; (iii) planning and coordinating rehabilitation programs, with computer-assisted devices, robotic systems, or video games that provide progress records for the control of clinical interventions. The identification of rehabilitation technologies provides an overview of the devices that could be incorporated into clinical practice, which may help in the choice of technology according to clinical needs. It is important to highlight that clinical applicability is not determined solely by technological availability.

2.2. Benefits and Limitations

Technology has profoundly altered the trends and approaches for investigating various fields. The exponential growth of technology in recent decades has revolutionized industries and transformed everyday life, causing rapid changes. The application of technology has progressed from theories and laboratory experiments to daily technological tools. The investment in technology has made many fields more attractive and lucrative, influencing the interest of researchers and investigators in incorporating technological advances. The emergence of technology in various fields has significantly impacted the procedures, tools, and approaches for gathering information and implementing actions.

Precise technological tools bring benefits and limitations to various fields. The understanding of technology's impact on various fields and the necessity for technological tools is still in its infancy, particularly in exploring the impacts on physiotherapy. There is a growing interest in physiological care and physical rehabilitation, currently performed and coordinated by health professionals. The gradual incorporation of technological tools or coordination to take care of physical well-being raises questions regarding the benefits, impacts, and necessities of technology in physiotherapy. Several literature reviews and recent research efforts are explored to clarify the concerns regarding physiotherapy and technology. Physiotherapy generally refers to the prevention and treatment of injury, pain, physical disability, and abnormal physical functions with movement or physical activities. This physical treatment is currently inspected and coordinated by health professionals trained in physical therapy; however, recently developed technologies may impact the current trends in physical care and rehabilitation (Batista e Siqueira et al., 2024).

1.5 3. Telehealth in Physiotherapy

The recent years have witnessed rapid advances in the telecommunication and health service fields. With the internet at the heart of the telehealth revolution, consumer use of online services has expanded, with people now more connected to the web through personal computers and mobile devices than ever before. Being able to access health-related services through the web is now more realistic, as people are accustomed to online service use, and healthcare providers are improving digital service availability to meet consumer needs (TURNER, 2018). This convergence has enabled the feasibility of delivering some health services—traditionally done in person—online. Online health services, known as telehealth, are where health systems and patients connect through the web to manage health needs. Some telehealth services are currently available, including prescription renewals, lab test result discussions, medical advice provision, and health record access.

Research and practice in telerehabilitation, the rehabilitation aspect of telehealth, are growing. As an approach to rehabilitation management, telerehabilitation comprises delivering rehabilitation service, consultation, and education through telecommunication technologies. Currently, video-conferencing-based and internet-supported rehabilitation service delivery models are undergoing investigation and implementation in clinical practice. Some telerehabilitation initiatives, predominantly web-based interventions to promote and support independent home exercise after face-to-face hospital rehabilitation, have been researched and implemented by several hospitals (Teresa Muñoz-Tomás et al., 2023). As improvements in the web and video-conferencing technology infrastructure become available, physiotherapy interventions are possible remotely through real-time video conferences.

3.1. Remote Consultations and Monitoring

Increased internet accessibility and speed have resulted in many services becoming available online. Telemedicine services utilize these advances in technology to provide a range of healthcare services remotely. Telemedicine refers to the remote delivery of healthcare services and clinical information using telecommunications technology, and includes a range of activities from simple health advice to the remote monitoring of patients (TURNER, 2018). This can include consultations via phone or audio-visual links, the sending of clinical data, or the sending of images for assessment. Telemedicine can benefit both patients and healthcare providers through improved access to care, lower costs, and improved efficiency. Physiotherapy is a branch of healthcare that treats illness and injury through physical means such as exercise, manual therapy, and education (B. F. Pacheco et al., 2021). Like many other healthcare fields, physiotherapy traditionally requires face-to-face interaction in order to be effective, however there is a range of physiotherapy services that can be done remotely. The most obvious of these is exercise prescription where a patient is given a set of exercises to perform independently. Other services such as the education of patients in their condition, treatment options, and methods of self-management can also be done remotely with the use of technology.

3.2. Challenges and Opportunities

This article presents an overview of the influence that technology has exercised on the evolution of physiotherapy. An overview of the past and present development of technology in this field is provided, as well as an analysis of how its continual advancement will affect the future of physiotherapy. In addition to other technological advancements, founding a profession is crucial in establishing a sense of turf, as well as professional and academic organizations. These

disciplines attempt to exert control over this turf, which is aided by the establishment of customary practice and the incorporation of technology into care practices. Attempts to relocate turf outside the discipline have been met with resistance, yet turf is simultaneously expanded. It is examined how turf is influenced by the variety of professional worker types, ranging from academic researcher to non-physiotherapist developer, and how it becomes more difficult to ignore academic research in physiotherapy as deliberative space widens (Batista e Siqueira et al., 2024). Clinical physiotherapy is an illustrative case of a profession with turf that is tightly linked to bodily care. In the face of each patient's unique bodily constitution, professional skills are rendered tacit and difficult to codify in fixed rules. As a discipline, clinical physiotherapy has strived to both professionalize and help disseminate technological advancements, thus firming turf. Initially, technological advancements were resisted out of fear that machines would replace jobs. Later on, technology was incorporated into care practices in order to professionalize and disseminate clinical skills. As a result, turf is firmly established but at the same time expanded, as evidence-based and high-tech care necessitates more complex machines and monitoring devices, which are more easily utilized by amateurs than by highly trained professionals.

1.6 4. Wearable Technology in Physiotherapy

Wearable technology is one of the most rapidly growing technological advancements across various fields and purposes. Wearable technology assists individuals in tracking their health and fitness information in a highly personalized way. There are several different types of wearables that fit on, or link with, an individual's body to collect data. Examples of wearables include heart rate monitors, fitness trackers, smartwatches, augmented reality glasses, smart clothing, and GPS trackable watches (E. Lang et al., 2020). Wearables are becoming an increasingly popular form of technology in physiotherapy practices. Wearable technology in physiotherapy provides physiotherapists with accurate and precise data regarding their patients' health and fitness, such as their heart rates, energy expenditure, and types of physical activity. There is a wide variety of wearable devices that are available for use in physiotherapy practices.

The Phillips Health Band is a slim device that patients can wear on their wrists. This device monitors patients' heart rates, sleep cycles, and activities throughout the day. Health Band features a highly intensive monitoring mode for cardiac patients, which includes a wireless connection to ECG measurements. Once the data is analyzed, it can be immediately viewed by the healthcare professionals on their tablets/laptops. This device is mainly used to monitor patients who have undergone heart surgery. The ProComp2 is a biofeedback device that records multiple physiological signals in real-time. The device can track muscle tension, temperature, heart activity, breath, and electrodermal activity. Biofeedback displays this information with different visual aids, such as graphs, animations, and games, on a computer screen, which helps patients to understand their health status and how to control it. The BioSensics Wearable Sensor System tracks patients' health through the use of numerous wearable sensors that are placed in different parts of their bodies. This system collects data related to falls, gait, and postural control, and uses an accelerometer to monitor patients' physical activities. This technology is highly beneficial for elderly patients to minimize their risk of falling.

1.7 5. Artificial Intelligence and Machine Learning in Physiotherapy

Artificial intelligence (AI) has been expanding rapidly in rehabilitation settings. AI is an algorithm process that has been used in healthcare and rehabilitation fields to generate decision-making and facilitate patient care services (Alsobhi et al., 2022). Moreover, it can be used to produce clinical

predictions based on patients' input data. At present, AI-advanced technologies are influencing the healthcare system in every aspect. In medical practices, AI-based applications process large healthcare data sets using sophisticated algorithms to provide understandings that help clinicians in their medical management. AI technologies are used to improve patients' quality of care. They aim to provide healthcare practitioners with recent medical information driven by various scientific sources. Numerous studies mentioned the advantages of using AI in clinical practices, including minimizing diagnostic and therapeutic medical errors. Furthermore, AI helps rehabilitation practitioners monitor patients' progress, thus ensuring the accuracy of their prescribed therapies and exercise protocols. There is a need to investigate the awareness of physiotherapy practitioners on AI applications in rehabilitation settings. As a part of an extensive study on AI usage in various rehabilitation practices, the current one focuses on identifying what AI applications in rehabilitation are commonly used, information regarding which AI applications in rehabilitation are unknown, and the reasons influencing apprehension of AI applications in rehabilitation.

1.8 6. Robotics in Physiotherapy

With the search for technological alternatives that aid in rehabilitation, physiotherapy clinics have begun to receive equipment that has robotics technology as the basis. These devices range from simple equipment with only one degree of freedom, but with the possibility of increasing the degrees of freedom with the attachments of mechanical links, to more complex models close to humanoids. In general, robotic devices proposed for rehabilitation can be grouped into three categories: Active: robotic devices that require the user to be in contact with them during the activity execution. In these devices actuators are included in the robotic mechanism and the interaction between the user and the devices occurs through physical contact links; Passive: robotic devices that do not require voluntary user movements for the rehabilitation process to occur. They can be seen as a medium that translates the user's motion into a control law that is sent to the rehabilitation process supervisor. These devices can be used in the case where the user is physically unable to perform voluntary movements; Teleoperated: robotic devices that allow a remote user to control their movement. These devices can be used in clinical environments where there is a shortage of therapists (Batista e Siqueira et al., 2024).

Since the need for rehabilitation is a direct consequence of physical impairment, the vast majority of rehabilitation robotic devices proposed in the literature have focused on the rehabilitation of the upper and lower limbs. In order to attenuate the consequences of movement disorders caused by neurological diseases, such as Parkinson's disease and stroke, robotic devices were developed to assist and recover moving tasks of the upper limbs. As an example, consider the PneuWalk system, which guides and assists the movements of the lower limbs of the user through a network of inflatable pneumatic actuators attached to the user's body. A similar concept is used in the rehabilitation system where the lower limbs of the user are passively guided through movement using pneumatic devices. Other systems that rehabilitate the lower limbs employ mechanisms based on the physical contact between the user and the robotic device, such as the Ankle-Robot that assist and perform the rehabilitation of the user's ankle joint through planar movements, and the Robotic Gait Trainer which is a treadmill-like platform that allows the rehabilitation of the user's lower limbs through robotic legs.

1.9 7. Gamification in Physiotherapy

Gamification in higher education has gained popularity in recent years as a means to enhance learning motivation. This aligns with the larger trend of technological integration in education and

the development of multimedia tools to support educators. To this end, gamification in multimedia physiotherapy case studies was developed and implemented, comprising an interactive video with embedded quizzes set in a game-like context. A mixed methods approach was adopted, with questionnaires measuring the effectiveness of gamified case studies administered to physiotherapy students before and after participation. Focus group interviews were also conducted to gather qualitative comments on gamified case studies. The findings show that gamification successfully motivated students' learning in physiotherapy. However, other factors such as class design and mechanics also influenced students' learning experience outside the game element itself. This suggests the need to carefully co-design all elements of class activities in implementing gamification as an educational strategy in physiotherapy programs (Yin Kei Chong, 2019).

Physiotherapy, or physical therapy, employs an evidence-based approach to educate patients and restore movement and function following injury, illness, or disability. It often employs progressive rehabilitation exercises to promote recovery, requiring patients' cooperation, active involvement, and compliance with prescribed treatment plans. Therefore, education about the necessity of rehabilitation and how to perform exercises is critical when implementing physiotherapy.

1.10 8. Data Privacy and Ethical Considerations

The integration of technology in physiotherapy has significantly transformed the way patient care is delivered. However, with this transformation comes a set of challenges that need to be addressed. One of the primary concerns is the issue of data privacy. With the increasing adoption of digital health platforms, telehealth services, and wearable devices, there is a growing risk of sensitive patient information being accessed or misused by unauthorized individuals. Recent high-profile data breaches have highlighted the vulnerabilities in data security, eroding public trust in tech companies and prompting calls for stricter data privacy regulations (Yadav et al., 2023).

To address these concerns, the Ayushman Bharat Digital Mission was launched by the Indian government in 2020. One of its key components is the Ayushman Bharat Health Account (ABHA) number, a unique 14-digit number that allows individuals to access their health records across multiple systems while ensuring confidentiality and security. The Digital Personal Data Protection Bill, 2023 has also been introduced, which mandates that digital personal data can only be used after obtaining the informed consent of the data owner. While this bill provides several exemptions for government agencies, it establishes the accountability of data fiduciaries in maintaining data security and accuracy.

Federated learning is a potential AI-based solution that can protect data privacy while ensuring compliance with the aforementioned laws. It enables multiple clients to collaboratively develop a machine learning model without sharing their data, keeping it stored locally. Similarly, cryptographic techniques offer various methods for securely encrypting data during training and testing in AI models, ensuring user confidentiality. As the use of AI in medical subspecialties increases, federated learning can protect patient privacy while promoting data sharing among healthcare institutions.

1.11 9. Training and Education in Technological Tools for Physiotherapists

The integration of technology into clinical practice can be a challenge for some professionals. The systematic review carried out by (Batista e Siqueira et al., 2024) indicates that there is available rehabilitation technology that is underutilized by physiotherapists in clinical practice.

Additionally, it points out that training to use technology is crucial. Free or low-cost rehabilitation technologies need to be publicized and training in their use needs to be incorporated into continuing education for physiotherapists. Since the Covid-19 pandemic, there has been a shift to online teaching and learning in higher education, and there is a need to assess the effectiveness of this mode of teaching delivery in physiotherapy education. A systematic review of effectiveness and users' perceptions of online technology use in physiotherapy teaching learning was undertaken by (K. Mącznik et al., 2015). Generally, students of physiotherapy find that online technologies facilitate educational activities, although their effectiveness and influence on knowledge acquisition and skills development remain questionable.

Online technologies should be incorporated into physiotherapy teaching learning programs, but consideration should be given to the context where these technologies are used. The type of assessment used and the way in which the online technology is integrated into physiotherapy courses can significantly influence students' perceptions of online technology effectiveness.

1.12 10. Future Trends and Innovations in Technology and Physiotherapy

As the field of physiotherapy continues to evolve, technology is expected to play an increasingly important role. Many innovations are being incorporated into clinical practice that could enhance patient care and expand physiotherapists' roles. This aims to identify available technologies with the potential to be integrated into physiotherapy practice and determine the physiological functions addressed by these technologies. A systematic review of literature published between 2010 and 2020 was conducted. Studies that presented technology-based rehabilitation assessment or intervention were included.

The review process followed guidelines, with scientific databases searched for studies in English. The selected studies were analyzed for rehabilitation technology characteristics, the methodologies employed in their design, and the physiotherapy functions they address (Batista e Siqueira et al., 2024). Twenty-three studies were included in the review, involving the use of 25 distinct rehabilitation technologies. Most studies were published in 2019 and involved research institutes and universities without clinical facilities. Technologies that assess rehabilitation were more frequently explored than those for rehabilitation interventions, and novel technologies predominated over those with low-cost or off-the-shelf devices.

1.13 11. Conclusion

In recent years the world witnessed a profound technological transformation in every field of human activity. Health care is no different and recently every aspect of care for patients has seen the impact of technology. Physiotherapy is an allied health care profession concerned with the assessment, maintenance and restoration of the physical function and performance of individuals throughout their life. Technology is also beginning to be adopted in the field of physiotherapy. A number of research studies have evaluated the impact of technology on physiotherapy. (Batista e Siqueira et al., 2024) evaluated the available technologies in the field of physiotherapy and the impact they could create on the profession. Out of 939 retrieved studies, 62 met the selection criteria. Of these studies, 39 considered technologies appropriate for incorporation into clinical physiotherapy practice, with the greatest potential being identified in 25 technologies. Technology has the capacity to effectively execute clinical activities carried out by physiotherapy professionals including injury prevention, monitoring of movements, adjustment of rehabilitation programs, coordination of rehabilitation programs with other health professionals, amongst others, taking

advantage of the minimal or even negligible intervention of the physical therapist. It is recommended that further studies should be developed to ascertain the knowledge of physical therapists on the abilities of the various technologies and understand the importance of these technologies as allies in the provision of care to patients – whether it is therapeutic care or preventive.

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