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Systematic review

Telerehabilitation: Effectiveness, Barriers, and Prospects

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Abstract

Telerehabilitation (TR) has emerged as a significant mode of health care delivery, particularly since the time of the pandemic of COVID-19 pandemic, by delivering rehabilitation services remotely using telecommunication technologies. This systematic review on the effectiveness, barriers, and prospects of telerehabilitation for a variety of clinical populations including those with neurological, musculoskeletal, and cardiorespiratory conditions, reveals that telerehabilitation has robustly demonstrated similar efficacy as that of face-to-face rehabilitation to improve physical function, quality of life (QoL), and patient satisfaction, whilst also being enormously cost-effective and accessible. Although telerehabilitation has demonstrated its effectiveness, there remain barriers, including technological limitations, administrative barriers, and issues related to patient adherence. The meta-analyses have highlighted positive effects on motor function (SMD =

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0.24-0.87) and quality of life (SMD = 0.03-0.91) in various populations; however, the quality of the evidence remains variable. Future lines of inquiry for telerehabilitation may include incorporating novel technologies such as virtual reality (VR) and specifically targeting disadvantaged populations and low-resource settings. Collectively, this systematic review suggests that telerehabilitation can be an effective alternative to traditional rehabilitation, while identifying areas for exploration of systematic reviews to enhance the implementation and equity aspects of evidence-based rehabilitation.

Keywords: Telerehabilitation, Telehealth, Rehabilitation, Digital Health, Patient Outcomes

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Introduction

Telerehabilitation (TR) means rehabilitation interventions delivered via telecommunication technologies, including the use of physical, occupational, and speech therapies provided remotely to patients [1]. TR leverages a variety of digital platforms, such as video conferencing, mobile apps, or wearable sensors, as well as asynchronous modalities, which facilitate the therapy intervention without the in-person service [2]. TR use rapidly increased due to the COVID-19 pandemic, with significant reductions made to both routine and emergency physical health care services, which necessitated alternate methods of providing care [3,4]. TR includes synchronous therapy interventions, such as video-based therapy sessions, and asynchronous interventions, examples that include self-guided exercises monitored through digital platforms. It provides flexibility for clients who experience mobility limitations, have geographic realities, or chronic health outcomes [5].

TR is appropriate across multiple clinical populations, in physical health and rehabilitation contexts, including neurological disorders (e.g., stroke, multiple sclerosis, Parkinson's disease), musculoskeletal conditions (e.g., osteoarthritis, low-back pain), and cardiorespiratory contexts (e.g., chronic obstructive pulmonary disease, post-COVID-19 recovery) [6]. In addressing significant issues in access, such as reducing travel need and facilitating home-based care, TR is transformative for specific populations, especially rural populations, seniors, and people with disabilities [7]. Additionally, TR is a response to the movement toward digital health, incorporating technology such as telemonitoring, virtual reality (VR), and wearable devices to improve rehabilitation outcomes [8].

While promising, the pathway to TR adoption and implementation is not without barriers. Technological barriers, including unreliable internet service and lack of digital literacy, regulatory barriers, and varying adherence rates by patients, are inhibitors [9]. The lack of in-person interactions can limit the ability for hands-on assessments that may matter for certain rehabilitation programs [10,11]. This systematic review aims to bring together the research evidence in systematic reviews, meta-analyses, and randomized controlled trials (RCTs) on TR effectiveness, barriers to adoption and implementation of TR, and identify future pathways to use TR as part of the standard of care. This university's systematic review focuses on forms of TR in neurological, musculoskeletal, and cardiorespiratory areas, which together aim to provide a summary of the current state and potential changes from TR rehabilitation practices on a global scale.

Methods

The authors conducted systematic searches, from January 2013 to July 2024, for the terms "telerehabilitation," "telemedicine," "rehabilitation," and "patient outcomes," in the following databases: PubMed, EMBASE, Cochrane Library, Scopus, and CINAHL. The reviewers included randomized controlled trials (RCTs), systematic reviews, and meta-analyses that assessed the effectiveness,

feasibility, or cost-effectiveness of TR for adults with neurological, musculoskeletal, or cardiorespiratory conditions, including those with chronic conditions. The review's exclusion criteria included articles in languages other than English, articles in the form of case studies, and articles not published in peer-reviewed journals. The primary purpose of the data extraction process was to review articles for selected clinical outcomes, adherence, satisfaction, and cost-effectiveness. Risk of bias for individual trials was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist [12]. The meta-analyses personally conducted used standardized mean differences (SMD) and 95% confidence intervals (CI).

Effectiveness of Telerehabilitation

TR is effective across multiple clinical conditions, and some of the clinical domains of TR have indicated greater effect on physical function, QoL, and patient satisfaction. In a meta-analysis of TR, a group SMD of 0.45 (95% CI: 0.23–0.67) showed statistical significance to QoL mean improvement among stroke, multiple sclerosis (MS), and Parkinson's disease (PD) patients that underwent TR [2]. Consistent with these findings, a systematic review of musculoskeletal conditions indicates similar effects of TR to face-to-face rehabilitation for conditions such as osteoarthritis and low-back pain (for description of SMD interpretation, note that a negative SMD represents a decrease in pain) [6]. This meta-analysis revealed no significant difference in pain reduction between TR and face-to-face rehabilitation conditions (SMD = -0.10, 95% CI: -0.40 to 0.20) [5]. In cardiorespiratory rehabilitation, TR improved exercise capacity and cardiovascular morbidity, with an exercise completion rate of 88.46% in COVID-19 patients [13].

With respect to neurological conditions, TR appears capable of affecting motor function recovery. Cardiac and total knee arthroplasty (TKA) patients had a group SMD of 0.24 (95 % CI: 0.04, 0.43) observed improvements [1]. In contrast, stroke patients reported inconclusive results (SMD = 0.08, 95% CI: -0.13 to 0.29), and the authors of this paper describe that this variability may reflect differences in patient conditions or outcomes of varying severity [6]. Concerning paediatric outcomes within TR, there appears to be a positive effect; in observational studies, the parents of children receiving rehabilitation during COVID-19 expressed high acceptance of TR [14]. Table 1 summarizes the most relevant overall efficacy across clinical conditions.

Table 1: The efficacy of Telerehabilitation across clinical conditions.

Condition	Outcome Measure	SMD (95% CI)	Studies
Stroke	Quality of Life	0.45 (0.23–0.67)	Cacciante et al. [2]
Musculoskeletal (OA, LBP)	Pain Reduction	-0.10 (-0.40 to 0.20)	Seron et al. [5]
Cardiorespiratory	Exercise Capacity	0.24 (0.04–0.43)	Agostini et al. [1]
Pediatric Conditions	Functional Improvement	Not meta-analyzed	Suso-Martí et al. [14]

Cost-Effectiveness

According to a systematic review, cost savings can be significant in favor of Telerehabilitation (TR) compared to conventional rehabilitation. The cost of TR per patient for treating musculoskeletal disorders was, on average $89.55 lower than conventional rehabilitation (95% CI: 4.6–174.5) [7]. Regarding TR specifically in terms of cardiac rehabilitation, TR was also deemed a cost-effective approach, often costing less than conventional rehabilitation and still found to be effective in comparison to conventional center-based cardiac rehabilitation [15]. Cost analyses also have built-in limitations, particularly in excluding patient costs. For example, costs associated with internet or device use, considering that in some cases internet or device access can prohibit individuals, would be upfront costly for some low-income groups [16]. The cost-effectiveness summaries are presented in Table 2.

Patient and Provider Satisfaction

Patient satisfaction with TR is typically high in terms of patient satisfaction and often equal to or even higher than participant satisfaction with in-person care. Using a survey, 64.5% of patient participants preferred TR rather than PT because of convenience and improvements regarding travel [17]. For provider preference regarding TR, the authors report a mixed response; however, they report that during the COVID-19 pandemic that 52% of providers would use TR but preferred in-person to assist with hands-on assessments [9]. Other satisfaction aspects were affected by whether TR was easy to use, whether or not technical support, if required, was sufficient, and whether family members were allowed to join in, which compromises home-based TR [18]. Aspects of satisfaction have been summarized in Table 3.

Table 2: Cost-Effectiveness of Telerehabilitation

Study	Condition	Cost Difference ($)	Key Findings
Nelson et al. [7]	Musculoskeletal	-89.55 (4.6–174.5)	TR is cheaper than in-person care
Piotrowicz & Piotrowicz [15]	Cardiac	Not quantified	Reduced healthcare system costs
Oldridge & Taylor [16]	Coronary Heart Disease	Not quantified	Cost-effective for risk factor management

Table 3: Patient and Provider Satisfaction with Telerehabilitation

Study	Population	Satisfaction Rate	Key Observations
Bhuva et al. [17]	Physical Therapy Patients	64.5% preferred TR	Convenience and reduced travel time
Heiskanen et al. [10]	Providers	52% used TR	Preference for in-person assessments
Chen [18]	Stroke Patients	80% positive experience	Ease of use and family support are critical

Barriers to Telerehabilitation Implementation

While TR has significant benefits, it also suffers from barriers to its implementation. There are technological barriers, including unstable internet and no access to devices, which are especially problematic in rural and low-income settings [9]. Regulatory and reimbursement barriers have also been identified. Many healthcare systems do not have standardized policies to reimburse for TR [19]. Patient engagement has been and continues to be a barrier, with some studies reporting withdrawal due to uncooperativeness or a decline in their medical condition [13]. The lack of hands-on assessments may lead to less satisfaction and the inability to assess goal achievement [9]. Another limitation is the lack of contact with patients (53% of providers responding as a limitation) and the inability to make a physical assessment [9].

There are also ethical issues, including data privacy and informed consent in remote settings [20]. In pediatric TR, parental respondents were much more likely to accept TR; however, the lack of randomized controlled trials (RCTs) may limit its wider implementation and generalizability [14]. Language and cultural barriers have also been recognized as impediments to the implementation of TR, particularly when working with diverse populations [21]. Table 4 lists all challenges to TR implementation.

Table 4: Barriers to Telerehabilitation Implementation

Barrier Category	Specific Issue	Study
Technological	Unreliable internet, device access	Stampa et al. [9]
Regulatory	Lack of reimbursement policies	Prvu Bettger & Resnik [19]
Adherence	Patient withdrawal, uncooperativeness	Estela-Zape et al. [13]
Ethical	Data privacy, informed consent	Bilder et al. [20]

Discussion

Telerehabilitation (TR) is efficient in certain clinical contexts, but there's variation in quality and outcomes that must be taken into account and evaluated with a cautious approach. High-quality evidence supports the argument, TR is non-inferior to in-person rehabilitation for musculoskeletal examples, such as osteoarthritis, low-back pain, and cardiorespiratory examples, such as chronic obstructive pulmonary disease and post-COVID-19 recovery, with positive standardized mean differences (SMD) showing pain problem reduction and exercise capacity [5, 1]. However, neurological outcomes, specifically after stroke, are not consistent as a whole, with two meta-analyses exhibiting non-significant improvements in motor function (SMD = 0.08, 95% CI: -0.13 to 0.29) [6]. This could be due to differences in the protocol design of the intervention, patient severity, or that neurologically impaired patients have more complex, individualized rehabilitation needs [2]. Adherence rates were high with the TR interventions relating to COVID-19 adherence rates reaching up to 88.46%. The high adherence rates, in turn, demonstrate TR's feasibility in crisis settings where future access to healthcare is reduced or will significantly diminish [13]. The long-term sustainability of TR remains unclear, with potentially significant technological barriers such as connectivity issues with internet service in rural to remote locations, as well as regulatory barriers such as adopting policies across health care systems that allow for consistent reimbursement [19, 22].

The cost-saving possibilities of TR are an additional attractive factor for health care systems with limited resources. Evidence surrounding costs indicates substantial savings, with TR significantly reducing the costs of overall care, with costs reduced by $89.55 per patient for musculoskeletal disorders' patients (compared to in-person care) [7]. Cardiac TR also estimates reduced costs through reduced hospital readmissions, the good use of resources [15]. Indirect costs such as expended patients' costs due to the use of devices, internet, and/or home renovation modifications remain under-discussed, may in fact add to inequities in access to TR, in particular low-income populations [16]. This expands the need for robust economic evaluations, which examine the economic implications from the healthcare system and patients' perspectives, to also recognize indirect patient costs to avoid exacerbating inequities in access to TR [23].

The overall satisfaction of both patients and providers also helps to validate the acceptability of TR. In several studies, patients' ratings of their satisfaction typically reflect very high satisfaction, with approximately 64.5% of patients preferring TR for receiving physical therapy as it offers convenience, less time traveling, and more available scheduling options [17]. This was especially true for patients unable to travel for appointments, patients with limited mobility, or patients living in remote areas, as TR provided greater available time by removing logistical difficulties [18]. In comparison to patients, providers appeared to have mixed sentiments about TR. About 52% of providers were utilizing TR during the COVID-19 pandemic, but many expressed a preference for in-person appointments where hands-on assessments could be administered. The hands-on assessment is an essential component of therapy, which providers need to make an appropriate diagnosis and plan treatment [10]. A future goal could be developing valid remote physical or tele-examination processes, such as standardized physical tele-assessment tools, or wearable sensors for assessment or diagnostics [24]. The inclusion of family members or caregivers along with the delivery of technical assistance also serves to improve patient satisfaction, particularly in the context of home TR, where family or caregivers are integral in supporting the physical interventions [18].

Using technologies such as virtual reality (VR) and artificial intelligence (AI) could be an effective way

to further promote an interactive experience in TR. VR-based interventions are beneficial for promoting motor function recovery in neurological conditions by providing engaging, immersive environments to facilitate adherence [8]. AI-based platforms can be used to provide exercise programmes that are personalised based on real-time patient performance and, more importantly, could reduce dropout rates and enhance outcomes [25]. However, creating equitable access to these technologies in settings that have limited resources, such as low- and middle-income countries (LMICs), is more complicated. There is a scattered amount of evidence emerging from this geography, and only a few studies have shown mixed results for conditions such as spinal cord injury, which suggests that convincing solutions to improve outcomes in these environments must be determined in context to fit within the infrastructure and competing priorities [21, 26].

The fragile foundations of culture and language also complicate the practice of TR. When unnecessary distinctions are made based on an individual's culture and language, it becomes challenging to implement TR among diverse population groups that require tailored interventions for applicability and accessibility [21]. Ethical considerations (e.g., data privacy, informed consent on digital platforms) also need to be addressed to maintain trust with patients, while remaining compliant with regulations [20]. Future work should develop standard protocols for remote assessments, improve access to technology to support less privileged individuals, and conduct longitudinal studies to understand the impact of TR in the long term across varied clinical and demographic cohorts. If these barriers are overcome, TR can establish itself as a new form of rehabilitation that will change clinical care as well as equity in healthcare.

Future Directions

The future of TR will be based on new technologies and responding to limitations. Virtual reality (VR) and augmented reality (AR) are promising options to enhance engagement and motor function recovery, especially with respect to neurological conditions [8]. However, research on the implementation of VR-based TR is in its infancy, and studies have pointed out the need for larger trials to examine effectiveness [27]. Artificial intelligence (AI) could personalize TR by altering exercises based on patient progress. This could lead to higher adherence [25].

The expansion of TR to low- and middle-income countries (LMICs) is very important in order to address problems in health equity. As indicated, there is a lack of current evidence regarding TR from LMICs. A recent review included only five studies from LMICs, which found mixed results in spinal cord injury management outcomes [26]. Hybrid models, using a combination of both in-person sessions and remote sessions, could help balance TR's ability to improve accessibility while accommodating the clinical need for physical assessments [28]. It is also important to establish harmonized regulatory frameworks that include standards for provider training to help with the scalability of TR [29].

Future studies should aim to conduct higher-quality RCTs with a larger sample size and follow-up intervention to definitively establish TR's efficacy across a variety of patient populations [5]. RCTs comparing TR to in-person care for orthopedic or musculoskeletal injury for non-inferiority may also help substantiate TR as a standard intervention [30].

Conclusion

Overall, telerehabilitation has proven to be an effective substitute to in-person rehabilitation with great patient-reported outcome measures and satisfaction, while also providing cost savings. However, there are challenges to implementing TR

to a wider audience: technology, regulatory, and adherence. TR research needs to address many of these barriers. Future research should integrate prospective technologies, provide services in no/low access populations, and test TR in rigorous RCTs to substantiate the level of evidence. By fulfilling these roles, TR can be a major influential component of rehabilitation going forward and leverage its influence towards health equity and access.

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إعادة التأهيل عن بُعد: الفعالية، المعوقات، والآفاق المستقبلية

الملخص

برزت خدمات إعادة التأهيل عن بُعد (Telerehabilitation) كإحدى وسائل تقديم الرعاية الصحية الأساسية، لاسيما منذ جائحة كوفيد-19، حيث توفر خدمات إعادة التأهيل عن طريق تقنيات الاتصالات عن بُعد. تستعرض هذه المراجعة المنهجية فعالية إعادة التأهيل عن بُعد والمعوقات والآفاق المستقبلية لها في مجموعات سريرية متنوعة شملت الحالات العصبية، العضلية الهيكلية، والقلبية التنفسية. وأظهرت النتائج أن إعادة التأهيل عن بُعد توفر فعالية مماثلة لإعادة التأهيل الوجاهي في تحسين الوظائف الجسدية وجودة الحياة ورضا المرضى، بالإضافة إلى كونها شديدة التكلفة وواسعة الوصول .ورغم هذه الفعالية المثبتة، لا تزال هناك معوقات تشمل محدودية التقنيات، العوائق الإدارية، وقضايا الالتزام من جانب المرضى. وأبرزت التحاليل التلوية (Meta-analyses) آثارًا إيجابية ملحوظة على الوظائف الحركية (القيم الموحدة للفرق: 0.24–0.87) وجودة الحياة (0.03–0.91) في مجموعات مختلفة، إلا أن جودة الأدلة لا تزال متفاوتة .شمل مجالات البحث المستقبلية في إعادة التأهيل عن بُعد دمج تقنيات حديثة مثل الواقع الافتراضي (VR)والتركيز على الفئات المحرومة منخفضة الموارد. وبذلك تشير هذه المراجعة إلى أن إعادة التأهيل عن بُعد يمكن أن تكون بديلًا فعالًا لإعادة التأهيل التقليدي، مع تحديد مجالات للمراجعات المنهجية المستقبلية لتعزيز التنفيذ وجوانب العدالة في الرعاية التأهيلية المبنية على الأدلة.

الكلمات المفتاحية :إعادة التأهيل عن بُعد، الصحة الرقمية، إعادة التأهيل، الصحة الإلكترونية، نتائج المرضى