Review Article

Telemedicine-Based Rehabilitation: Evidence, Applications and Innovative Technologies

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Abstract

Objective: This narrative review synthesizes current evidence on telehealth-based physiotherapy and telerehabilitation, focusing on clinical effectiveness, commonly used technologies, and key methodological and equity-related barriers affecting implementation.

Material and methods: The review followed international evidence-synthesis standards. Comprehensive searches were conducted in PubMed/MEDLINE, Scopus, Web of Science, PEDro, and CINAHL for studies published between 2020–2025 using MeSH terms and keywords related to telehealth and digital physiotherapy. Eligible studies included systematic reviews, randomized trials, observational research, methodological evaluations, and qualitative studies. Non-rehabilitation and low-quality studies were excluded. Owing to heterogeneity, findings were integrated thematically.

Findings: Across musculoskeletal, neurological, cardiopulmonary, pediatric, and geriatric populations, telerehabilitation demonstrates safety and clinical effectiveness comparable to in-person physiotherapy, especially for exercise and education-based interventions. Remote functional assessments using video, wearables, and AI tools show strong validity. However, inconsistent protocols, small samples, and limited follow-up restrict generalizability. Digital inequities, technological barriers, and challenges among older or low-literacy users persist. Hybrid models enhance outcomes for complex cases, while structured progression, clinician feedback, and user-friendly platforms are critical for success.

Conclusion: Telehealth and telerehabilitation represent increasingly important components of modern physiotherapy, offering accessible and, under appropriate conditions, effective care. Current evidence indicates outcomes comparable to traditional rehabilitation for selected populations and intervention types, particularly structured, exercise-based programs delivered with adequate technological infrastructure and clinical supervision, although methodological heterogeneity, limited long-term data, and digital access gaps constrain broader generalization. Emerging AI, VR/AR tools, and hybrid models hold promise for advancing telehealth-supported physiotherapy, pending further controlled, long-term research.

Keywords: *Remote consultation, telemedicine, telerehabilitation, virtual reality exposure therapy, wearable electronic devices.*

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1. Introduction

Over the past decade, telehealth and telerehabilitation have undergone substantial evolution, culminating in an unprecedented acceleration in adoption during the COVID-19 pandemic. Prior to this period, telehealth technologies were primarily employed to facilitate access to healthcare services, most commonly through remote consultations and chronic disease monitoring (Leochico et al., 2020). Telerehabilitation, as a specialized extension of telehealth, refers to the remote delivery of rehabilitation services and has progressively gained integration within healthcare systems worldwide (Nguyen et al., 2023). During the pandemic, healthcare systems reported dramatic increases in telehealth utilization, with orthopedic and rehabilitation services among the earliest adopters at scale, underscoring both the feasibility and clinical promise of remote care models (Stawicki et al., 2020; Hurley et al., 2021). Through telerehabilitation, physiotherapy services were able to maintain continuity of care for individuals with mobility limitations, particularly those undergoing stroke rehabilitation and managing musculoskeletal disorders, despite widespread lockdowns and restrictions on in-person services (Leochico et al., 2023; Tukur et al., 2023).

A growing body of evidence has begun to characterize the clinical applications and outcomes of telerehabilitation across specific patient populations and conditions. In the domain of musculoskeletal rehabilitation, real-time telerehabilitation has been shown to produce improvements in physical function and pain that are comparable to conventional in-person care across a range of conditions including chronic low back pain, knee osteoarthritis, and post-surgical orthopedic cases (Cottrell et al., 2017). In neurological rehabilitation, telerehabilitation has shown particular promise for stroke survivors, with a Cochrane systematic review reporting outcomes in activities of daily living, mobility, and upper limb function comparable to those achieved through in-person rehabilitation (Laver et al., 2020). Cardiopulmonary telerehabilitation programs have also demonstrated efficacy; a multicenter randomized trial found that supervised pulmonary telerehabilitation produced comparable improvements in exercise capacity to center-based pulmonary rehabilitation in patients with severe COPD (Hansen et al., 2020). Furthermore, a rapid overview of 53 systematic reviews confirmed that telerehabilitation in physical therapy is broadly effective across multiple conditions and populations, with synchronous video-based delivery emerging as the most widely adopted and evidence-supported modality, offering real-time clinical interaction while asynchronous platforms and mobile health applications supplement supervised sessions and support adherence monitoring (Seron et al., 2021).

Despite this growing evidence base, several critical limitations persist across the literature. First, a substantial proportion of existing studies are characterized by small sample sizes, short follow-up periods, and high risk of bias, which compromises the reliability and generalizability of their findings (Scott-Richardson et al., 2022). Second, considerable heterogeneity exists in the intervention protocols, technological platforms, outcome measures, and patient selection criteria employed across studies, rendering direct comparisons and meta-analytic synthesis methodologically challenging (Saeed et al., 2024). Third, while equity concerns related to digital access, health literacy, and socioeconomic disparities have been acknowledged in individual studies, the cumulative evidence on how these factors moderate intervention effectiveness and scalability remains underexplored (Scott-Richardson et al., 2022). Fourth, prior systematic reviews in this area have tended to focus narrowly on specific diagnostic groups or single modalities, leaving a notable absence of comprehensive evidence synthesis that addresses the full spectrum of physiotherapy applications, implementation determinants, and translational barriers simultaneously

(Nguyen et al., 2023; Leochico et al., 2023).

These gaps collectively limit clinicians' and healthcare systems' capacity to make evidence-informed decisions regarding the selection, design, and implementation of telerehabilitation programs. Without a comprehensive and methodologically rigorous synthesis of the available evidence, the field risks perpetuating fragmented practice patterns, suboptimal resource allocation, and inequitable access to effective remote care. There is therefore a compelling need for a comprehensive evidence synthesis that not only evaluates clinical effectiveness across diverse populations and conditions but also maps the technological and methodological landscape, identifies consistent implementation facilitators and barriers, and delineates the most pressing evidence gaps requiring future investigation.

1.1. Aim

The aim of this study is to systematically examine the current applications, evidence of effectiveness, technological and methodological components, and limitations of telehealth and telerehabilitation, thereby creating a comprehensive guide for clinical practice and research and identifying existing knowledge gaps.

1.2. Research questions

1. What is the current state of evidence regarding the clinical effectiveness and safety of telehealth and telerehabilitation interventions in physiotherapy across different patient populations?
2. Which telehealth modalities, technological components, and delivery models are most commonly utilized, and what are their reported strengths and limitations?
3. What methodological, technological, and equity-related gaps remain in the existing literature, and how can these inform future research and clinical implementation?

2. Material and method

This study is a comprehensive literature review conducted to systematically integrate current scientific evidence on telehealth and telerehabilitation. The methodological framework was structured in accordance with international standards and consisted of a clearly defined search strategy, explicit inclusion and exclusion criteria, and a structured data synthesis process.

2.1. Literature search strategy

A comprehensive electronic search was performed across PubMed/MEDLINE, Scopus, Web of Science, PEDro, and CINAHL. The search strategy combined Medical Subject Headings (MeSH) with relevant free-text keywords. Core search terms included: “telehealth,” “telerehabilitation,” “tele-physiotherapy,” “digital rehabilitation,” “remote physiotherapy,” “virtual rehabilitation.”

The search window was restricted to 2020–2025, a period marked by rapid advances in digital health technologies and their expanded integration into clinical practice following the COVID-19 pandemic.

2.2. Inclusion criteria

Studies were included if they met the following criteria:

- Published in English and peer-reviewed
- Focused on clinical applications related to physiotherapy, rehabilitation, or movement

function

- Employed telehealth-based interventions such as telerehabilitation, tele-physiotherapy, or digital rehabilitation
- Included study designs such as systematic reviews, meta-analyses, randomized controlled trials, observational studies, methodological studies, or qualitative research

This inclusive strategy enabled the integration of high-quality evidence from diverse research designs, providing a comprehensive evaluation of both clinical effectiveness and implementation dimensions.

2.3. Exclusion criteria

The following types of publications were excluded:

- Conference abstracts, opinion papers, editorials, and preprints
- Studies addressing telehealth technologies without a rehabilitation or physiotherapy context
- Reports focused solely on technical solutions without clinical comparison
- Publications lacking sufficient methodological detail or a clear clinical linkage

2.4. Study selection process

Although a formal systematic review protocol was not registered, a structured and transparent screening process was applied to enhance methodological rigor. Search results were screened in two sequential stages: an initial title and abstract review, followed by full-text assessment of potentially eligible records. The combined electronic database search across PubMed/MEDLINE, Scopus, Web of Science, PEDro, and CINAHL yielded a total of 847 records. Following the automated and manual removal of duplicate entries (n = 178), 669 unique records proceeded to title and abstract screening. Of these, 482 were excluded on the grounds that they did not meet the minimum relevance criteria established by the inclusion criteria, primarily due to an absence of a rehabilitation or physiotherapy focus, or because the study population, intervention type, or clinical context fell outside the defined scope of the review.

The remaining 187 records were retrieved for full-text assessment. Following full-text review, 159 records were excluded for the following reasons: studies addressing telehealth technologies without a rehabilitation or physiotherapy context (n = 47); publications lacking sufficient methodological detail or a clear clinical linkage (n = 38); reports focused solely on technical solutions without clinical outcome data (n = 31); conference abstracts, opinion papers, editorials, and preprints (n = 27); and studies published outside the 2020–2025 search window or otherwise failing to meet eligibility criteria (n = 16). A final set of 28 studies was included in the review and is detailed in Appendix 1.

The 28 included studies were distributed across the following research designs: systematic reviews and meta-analyses (n = 10), narrative and scoping reviews (n = 7), qualitative studies (n = 4), observational studies (n = 4), and methodological or technical validation studies (n = 2); one additional record was a randomized controlled trial protocol. The predominance of review-level and protocol-stage evidence over completed primary trials is itself a notable characteristic of the current literature and is addressed among the limitations of this review. With respect to target populations, the included studies broadly addressed musculoskeletal conditions, neurological populations (including stroke and multiple sclerosis), geriatric

populations, cardiopulmonary and oncological populations, pediatric and caregiver-mediated contexts, and mixed or general rehabilitation populations, with several studies spanning more than one population group. Regarding intervention modalities, synchronous video-based delivery was the most frequently examined approach, followed by asynchronous platforms and mobile health applications, while AI- and sensor-assisted systems and VR/AR-based interventions were addressed less frequently; many studies incorporated more than one modality. The selection process evaluated key elements including clinical effectiveness, type of technology or intervention, target population, and assessment and implementation characteristics. This structured approach ensured the inclusion of studies offering sufficient clinical and technological detail to support a synthesis of findings that was both interpretable and generalizable across diverse rehabilitation contexts.

2.5. Data synthesis approach

Due to heterogeneity in intervention models, outcome measures, and population characteristics across studies, a statistical meta-analysis was not conducted. Instead, a structured thematic synthesis was employed. The synthesis was organized around the following thematic domains:

- Clinical effectiveness and safety
- Telehealth and telerehabilitation delivery models
- Technological components (video-based systems, wearable sensors, mobile applications, VR/AR platforms, AI-supported tools)
- Patient experience, accessibility, and health-system implications
- Methodological challenges, implementation barriers, and evidence gaps

Findings from each study were compared and integrated to construct a comprehensive and conceptually coherent framework.

2.6. Ethical considerations

As this review relied exclusively on secondary data from previously published studies, ethical approval was not required. Nevertheless, all procedures adhered to scientific ethical standards, and proper attribution was maintained throughout.

3. Integration of telehealth technologies in physiotherapy practice

Telehealth has reshaped physiotherapy and rehabilitation delivery by enhancing accessibility, flexibility, and service efficiency. To provide a structured overview of how telehealth and telerehabilitation are applied across distinct clinical domains, Table 1 presents a comparative synthesis of the current evidence organized by rehabilitation context, target population, intervention modality, effectiveness findings, advantages, limitations, and future directions. This framework was constructed to enable a systematic cross-domain comparison and to highlight both the breadth of telerehabilitation applications and the areas in which evidence remains insufficient or inconsistent. Both synchronous video-based consultations and asynchronous modes of delivery facilitate individualized intervention planning while accommodating patient-specific needs and circumstances (Cottrell and Russell, 2020; Roitenberg and Ami, 2023) (Table 1).

Table 1. Comparison of telehealth and telerehabilitation applications across clinical contexts

Domain	Description / Content	Condition / Population Examples	Effectiveness Findings	Advantages	Limitations	Future Directions
Telehealth / Telerehabilitation Models	Synchronous (live video); asynchronous (apps, platforms, recorded content); telemonitoring; wearable sensors; exergaming and VR/AR-based applications	Multiple sclerosis, stroke, post-orthopedic surgery, cancer rehabilitation, pediatric neurology, COPD, low back pain (LBP), osteoarthritis (OA)	Outcomes equivalent or non-inferior to conventional care (McKeon et al., 2021; Laver et al., 2020)	Flexibility, accessibility, time and cost efficiency, high patient satisfaction	Modality heterogeneity, technical issues, limited long-term data	AI-assisted assessment, expanded VR/AR use, sensor integration
Orthopedic Rehabilitation (TKA/THA)	Home-based tele-physiotherapy, video sessions, sensor-assisted monitoring	Total knee and hip arthroplasty	Comparable ROM, strength, and gait outcomes (Jansson et al., 2020)	Safe, cost-effective, improved access	Insufficient long-term follow-up	AI-enhanced monitoring, standardized protocols
Musculoskeletal Rehabilitation (LBP, OA, Shoulder Pain)	Tele-exercise programs, hybrid models	Low back pain, knee OA, shoulder pain	Non-inferior in LBP and OA; early equivalence in shoulder pain (Wang et al., 2023; Shi et al., 2024)	Increased accessibility, home-based feasibility	Variable evidence quality	Personalized tele-rehabilitation
Neurological Rehabilitation (Stroke, MS)	Tele-exercise, tele-education, home-based functional training	Stroke, multiple sclerosis	Non-inferior ADL and functional outcomes (Laver et al., 2020; Leavitt et al., 2021)	Continuity of care, safe home use	Heterogeneous protocols	VR/AR and sensor-based neuro-rehab
Oncological and Cardiopulmonary Rehabilitation	Telemonitoring, wearable sensors, education modules	Cancer survivors, cardiac rehabilitation patients	Safe and feasible, comparable outcomes in selected studies (Rocco et al., 2024; Garofano et al., 2025)	Improved access in fatigued or disabled patients	Limited economic evaluation	AI-driven telemonitoring and risk management

Pediatric and Caregiver-Mediated Models	Web-based education, gamified exercises, caregiver-supported therapy	Pediatric brain injury, MS, developmental disorders	Feasible with improved access; limited evidence (Jansson et al., 2020; Mulder et al., 2022)	Higher adherence through family involvement	Small samples, heterogeneous protocols	Caregiver training, dyadic models
Patient Experience and Engagement	Usability, satisfaction, accessibility	All populations	High satisfaction and engagement comparable to in-person care (Raymond et al., 2024)	Reduced time and travel burden	Digital literacy barriers	User-centered platform design
Economic and Resource Utilization	Cost-effectiveness and resource allocation	LBP, cardiac rehab, chronic care	Context-specific cost savings; inconsistent evidence (Wang et al., 2023; Shi et al., 2024)	Reduced travel costs	Insufficient economic analyses	Health system-based cost models
Safety and Equity Considerations	Digital access, technical support, home safety	Older adults, low-income populations	Generally safe with persistent access inequities	Low physical risk	Digital divide, device access issues	Policies for digital health equity

A broad spectrum of digital platforms including videoconferencing systems, wearable sensor technologies, and mobile health applications supports remote patient monitoring and tailored program design (Anderson and Bauer, 2025; Youssef et al., 2024). Importantly, multiple studies demonstrate that remote functional assessments exhibit reliability and validity comparable to face-to-face evaluations across a range of outcome measures (Zischke et al., 2021; Bernhardsson et al., 2023). Further advancements in machine learning and algorithm-driven analytics have strengthened remote posture and movement analysis, thereby expanding the clinical utility of teleassessment frameworks (Jourdan et al., 2021; Zhang et al., 2021).

Across musculoskeletal, neurological, cardiopulmonary, pediatric, and geriatric populations, telerehabilitation has produced clinical outcomes comparable to those achieved with conventional, in-person care in many contexts (Cottrell and Russell, 2020; Tsagkaris et al., 2023). Moreover, telehealth-based delivery confers substantial access advantages for underserved and rural populations by mitigating geographic, logistical, and mobility-related barriers to rehabilitation services (Brigo et al., 2022; Davies et al., 2025). Despite ongoing challenges related to digital literacy and technical infrastructure, levels of patient satisfaction consistently remain high across diverse settings (Hall et al., 2021; Oh et al., 2024).

Ethical and legal considerations including data security, patient privacy, and compliance with national and international regulatory frameworks constitute foundational elements for responsible telehealth implementation (Rauzi et al., 2023). Nevertheless, technical limitations and the absence of standardized clinical protocols continue to constrain widespread adoption (Zischke et al., 2021; Siwach et al., 2025). Emerging innovations, such as artificial intelligence–assisted personalization, virtual and augmented reality–based interventions, and sensor-integrated platforms, are anticipated to play a pivotal role in shaping the future landscape of telerehabilitation (Xu et al., 2023; Lee et al., 2022).

As summarized in Table 1, telerehabilitation models applied across heterogeneous patient populations frequently demonstrate non-inferior outcomes relative to conventional care, while offering additional advantages related to flexibility, cost efficiency, and accessibility. Continued advancements in AI-driven personalization, VR/AR applications, and sensor integration are expected to further enhance both the effectiveness and reach of telehealth-based rehabilitation strategies.

4. Evaluation of current evidence on telehealth-based rehabilitation approaches

The 28 studies included in this review, as detailed in Appendix 1, collectively address three interrelated dimensions of telehealth and telerehabilitation in physiotherapy: clinical effectiveness and safety, technological and methodological components, and implementation-related limitations and evidence gaps. The findings presented in this section are synthesized in accordance with these domains, which directly correspond to the research questions guiding this review, and are intended to serve as a comprehensive reference framework for both clinical practice and future research.

Contemporary systematic reviews, meta-analyses, and randomized controlled trials consistently indicate that structured telerehabilitation programs are safe and effective and, in many cases, yield clinical outcomes comparable to those of face-to-face physiotherapy (McKeon et al., 2021; Laver et al., 2020; Jansson et al., 2020). Evidence of clinical equivalence is strongest in exercise-based and education-focused interventions for musculoskeletal conditions, post-arthroplasty rehabilitation, and neurological populations including stroke and multiple sclerosis (Shi et al., 2024; Leavitt et al., 2021). In geriatric populations, tele-exercise programs have demonstrated significant improvements in balance, strength, and mobility (Dawson et al., 2024), while cardiopulmonary and oncological applications have shown promising but more variable results depending on disease severity, monitoring intensity, and patient-specific factors (Rocco et al., 2024; Garofano et al., 2025). Across populations, remote functional assessments conducted via synchronous video platforms have demonstrated validity and reliability comparable to face-to-face evaluations for a range of clinically relevant outcome measures including range of motion, pain, and functional performance (Zischke et al., 2021; Bernhardsson et al., 2023; Özsoy et al., 2025). Adverse events were rarely reported across the included studies, supporting the overall safety profile of telerehabilitation when delivered within structured clinical protocols (Raymond et al., 2024).

As detailed in Appendix 1, telerehabilitation interventions are delivered through a diverse range of technological modalities, the systematic documentation of which constitutes a core objective of this review. Synchronous video-based platforms constituted the most frequently examined modality and were consistently associated with higher clinical effectiveness compared to asynchronous approaches, owing to their capacity to support real-time assessment, therapeutic instruction, and patient-therapist interaction (Cottrell and Russell, 2020; Roitenberg and Ami, 2023). Asynchronous platforms and mobile health applications

were more commonly employed as adjuncts to supervised sessions, primarily to enhance exercise adherence and self-management behaviors (Anderson and Bauer, 2025). Wearable sensor technologies and machine learning-based motion analysis systems have expanded the scope of remote assessment by enabling objective monitoring of gait, posture, and movement quality with a level of precision approaching that of laboratory-based systems (Jourdan et al., 2021; Zhang et al., 2021). Emerging VR/AR-based systems have demonstrated particular promise in neurological and pediatric rehabilitation through enhanced patient engagement and gamified motor training paradigms (Lee et al., 2022; Calcaterra et al., 2025). The neurobiological mechanisms underpinning VR-based motor recovery-including sensorimotor integration, corticospinal reorganization, and neuroplasticity-have been systematically examined alongside robotic and brain-computer interface (BCI) technologies in integrated neurorehabilitation frameworks, providing important mechanistic context for the clinical observations reported in telerehabilitation literature (Eryilmaz, 2026a). AI-assisted platforms further support individualized and adaptive program design by enabling real-time feedback and automated progression based on patient performance data (Xu et al., 2023; Delbaere et al., 2025). The integration of genetic, epigenetic, and AI-driven biomarkers into personalized exercise prescription represents a complementary and emerging dimension of precision rehabilitation, offering data-informed approaches to tailoring intervention intensity and progression at the individual level (Eryilmaz, 2026b). Across all modalities, structured progression criteria, objective performance monitoring, and consistent clinician feedback emerged as the most robust determinants of clinical effectiveness, irrespective of the specific technological platform employed (Raymond et al., 2024).

Despite these encouraging findings, methodological heterogeneity, limited sample sizes, and relatively short follow-up periods remain pervasive limitations across the included studies, constraining the robustness of conclusions and the extrapolation of results to broader clinical contexts. Many studies relied primarily on feasibility metrics and patient satisfaction as proxies for clinical effectiveness rather than standardized, condition-specific outcome measures, and economic evaluations were largely absent or methodologically insufficient (Oh et al., 2024; Hudon et al., 2024). Digital inequities, restricted access to appropriate devices, and variable levels of digital literacy continue to exert a significant moderating influence on patient adherence and engagement, particularly among older adults, low-income populations, and individuals in low-resource settings (Siwach et al., 2025; Hudon et al., 2024). In clinical practice, telerehabilitation demonstrates greatest utility as a structured adjunct to in-person care for stable, low-risk patients, while hybrid care models are increasingly recommended for populations requiring closer clinical monitoring, manual therapy components, or heightened safety oversight (Calcaterra et al., 2025; Tomaskovic et al., 2025). Ethical and regulatory considerations, including data security, patient privacy, and the absence of standardized implementation frameworks, continue to represent foundational challenges for sustainable and equitable telerehabilitation deployment at scale (Rauzi et al., 2023; Siwach et al., 2025).

5. Discussion

The present review systematically examined the clinical effectiveness, technological components, methodological characteristics, and implementation-related limitations of telehealth and telerehabilitation across physiotherapy practice, drawing on 28 included studies spanning musculoskeletal, neurological, cardiopulmonary, geriatric, pediatric, and oncological populations. The principal finding of this review is that structured telerehabilitation programs consistently demonstrate safety and clinical effectiveness

comparable to conventional in-person physiotherapy when delivered through supervised, protocol-driven frameworks, a conclusion supported across the majority of included study designs. A secondary finding is that the effectiveness of telerehabilitation is not primarily determined by the specific technology employed, but rather by the clinical structure, supervision intensity, and implementation quality surrounding it. Taken together, these findings extend and consolidate the existing evidence base by providing a cross-domain synthesis that integrates effectiveness data with technological, methodological, and equity-related dimensions-an approach not consistently adopted by prior condition-specific reviews.

The body of evidence synthesized in this review demonstrates that telehealth and telerehabilitation have become increasingly robust components of physiotherapy practice, although the consistency and strength of findings vary considerably across clinical contexts, intervention modalities, and patient characteristics. While a substantial proportion of included studies — particularly those involving musculoskeletal and post-arthroplasty rehabilitation — report outcomes comparable to conventional in-person physiotherapy, closer examination reveals meaningful variation in effect sizes and methodological quality that influences how these findings can be translated into routine clinical care. The systematic review by Cottrell and Russell (2020) and the Cochrane review by Laver et al. (2020) together establish that equivalence is most reliably demonstrated for exercise-based and education-focused interventions in musculoskeletal and stroke populations, respectively, and the present review corroborates and extends these conclusions by identifying consistent patterns across a broader range of conditions and modalities.

Most studies evaluating exercise-based telerehabilitation consistently show non-inferiority to face-to-face interventions in terms of pain reduction, functional improvement, and mobility outcomes. The randomized controlled trial by Shi et al. (2024) demonstrated comparable physical and psychological outcomes for telerehabilitation-based exercise in patients with nonspecific low back pain, while Jansson et al. (2020), in a systematic review of lower-limb joint replacement rehabilitation, reported equivalent gains in range of motion, strength, and gait. These findings support the view that, for clinically stable patients whose primary treatment consists of therapeutic exercise and education, remote delivery does not diminish clinical benefit. However, the evidence becomes notably more heterogeneous in neurological, geriatric, pediatric, oncological, and cardiopulmonary populations. In multiple sclerosis, Leavitt et al. (2021) reported significant improvements in physical activity through a group-based telehealth intervention, yet noted high variability in engagement across participants. In geriatric populations, Dawson et al. (2024), in a systematic review and meta-analysis, demonstrated significant functional improvements through tele-exercise for older adults with frailty and mobility limitations, while Goldman et al. (2023) found telerehabilitation to be feasible and effective even in older adults with cognitive impairment. In oncological rehabilitation, Rocco et al. (2024) reported promising but variable functional outcomes, while the cardiac telerehabilitation protocol of Garofano et al. (2025) represents an ongoing study whose effectiveness data are not yet available; together these underscore that generalizability in cardiopulmonary and oncological populations cannot be assumed with the same confidence as in musculoskeletal care. Furthermore, certain included studies highlight limitations in cases requiring hands-on assessment or manual techniques, where remote-only models have yielded inferior results, suggesting that telehealth should be seen as complementary rather than universally substitutive (Siwach et al., 2025; Tomaskovic et al., 2025).

Across the literature, it is evident that the success of telerehabilitation is shaped less by the

technology itself and more by the clinical structure that surrounds it. The rapid overview by Seron et al. (2021), encompassing 53 systematic reviews, and the systematic review by Raymond et al. (2024), which examined allied health telehealth delivery across randomized controlled trials, both identify structured progression criteria, synchronous supervision, and regular clinician feedback as the most consistent determinants of adherence and clinical outcome. The growing availability of reliable remote assessment tools has further improved the clinical utility of telerehabilitation: Zischke et al. (2021) and Bernhardsson et al. (2023) each demonstrated that video-based physiotherapy assessments achieve validity and reliability comparable to face-to-face evaluations across a range of musculoskeletal outcome measures, while Jourdan et al. (2021) confirmed the accuracy of machine learning-validated wearable sensors for gait monitoring. At the same time, these tools highlight a key challenge identified across multiple included studies: without adequate digital support and guidance, technological complexity can reduce accessibility and engagement, particularly among older adults, individuals with cognitive impairment, and those with limited digital literacy (Oh et al., 2024; Hudon et al., 2024).

The translation of existing evidence into clinical practice therefore requires careful attention to patient selection, risk stratification, and contextual factors. The findings of McKeon et al. (2021) and Jansson et al. (2020) support the particular suitability of telerehabilitation for stable musculoskeletal conditions and postoperative recovery following knee or hip arthroplasty, where exercise and monitoring constitute the primary therapeutic components. Hybrid models emerge as a pragmatic solution for high-risk or clinically complex populations, as supported by the systematic review and meta-analysis of Calcaterra et al. (2025), which reported promising motor outcomes for home-based telerehabilitation in pediatric neurological motor disorders while emphasizing the need for further controlled trials and Tomaskovic et al. (2025), who recommended hybrid approaches for patients with post-COVID condition requiring multimodal intervention. For many patients, especially those in rural or underserved regions, telehealth provides a means of overcoming logistical, geographic, and mobility-related barriers that would otherwise limit access to rehabilitation services, a finding consistently reported across included implementation-focused studies (Davies et al., 2025; Brigo et al., 2022). Yet these advantages are counterbalanced by persistent digital inequities, which disproportionately affect older adults and lower-income populations and remain one of the most significant barriers to widespread implementation, as documented by Hudon et al. (2024) and Siwach et al. (2025).

Despite the overall promise of telehealth-based physiotherapy, the evidence base is constrained by several methodological limitations. Small sample sizes, heterogeneous intervention protocols, inconsistent reporting of adherence and adverse events, and a predominance of short-term follow-up were identified as pervasive limitations across the included studies. Many studies — including Goldman et al. (2023), Hall et al. (2021), and Roitenberg and Ami (2023) — relied heavily on feasibility metrics and patient satisfaction rather than comprehensive clinical endpoints, and economic evaluations were largely absent or methodologically insufficient across all clinical domains. Moreover, the included literature seldom differentiates which patient subgroups are most likely to benefit from telerehabilitation, even though emerging evidence from Dawson et al. (2024) and Oh et al. (2024) suggests that outcomes vary significantly depending on clinical stability, cognitive capacity, home environment, and digital competency. These limitations represent an important contribution of the present review in that they are here identified and articulated systematically across the full breadth of telerehabilitation applications, rather than within the narrow scope of a single condition or modality.

Future research should therefore prioritize long-term comparative trials, standardized intervention frameworks, and rigorous cost-effectiveness analyses. More sophisticated designs are needed to determine whether improvements observed in short-term trials persist over time, whether certain diagnostic categories respond more favorably than others, and how AI-enhanced, sensor-based, and VR/AR-supported models - such as those described by Xu et al. (2023), Delbaere et al. (2025), and Lee et al. (2022) - can be integrated safely and effectively into mainstream practice. Of particular relevance in this regard is the growing evidence on technology-integrated neurorehabilitation, including robotic, VR, and BCI systems, which has established dose-response relationships and mechanistic frameworks applicable to remote delivery models (Eryilmaz, 2026a). Similarly, the incorporation of AI-driven biomarker-informed personalization strategies - drawing on genetic and epigenetic data — into tele-rehabilitation platforms represents a frontier of precision care that merits investigation in future controlled trials (Eryilmaz, 2026b). Qualitative and implementation-focused research will also be crucial for understanding the lived experiences of patients and clinicians, identifying persistent barriers, and developing strategies to mitigate digital inequities. In addition, comprehensive economic evaluations, systematic reporting of adverse events, and qualitative investigations into implementation barriers will be essential for achieving sustainable and equitable integration of telerehabilitation into routine care pathways (Hudon et al., 2024). Future investigations should prioritize the evaluation of long-term functional outcomes, the identification of patient subgroups most likely to benefit, and the rigorous assessment of asynchronous and AI-enhanced models.

6. Conclusion

This review synthesized evidence from 28 studies across five clinical domains-musculoskeletal, neurological, cardiopulmonary, geriatric, and pediatric/oncological rehabilitation-and yielded three principal findings with direct implications for clinical practice and future research, which should be interpreted in light of the considerable heterogeneity in study designs, patient populations, and intervention protocols described above. First, in clinically stable, low-risk patients receiving structured, supervised, exercise-based programs, telerehabilitation achieves clinical outcomes comparable to in-person physiotherapy, with the strongest and most consistent evidence observed in musculoskeletal conditions, post-arthroplasty rehabilitation, and stroke; comparability is less established for populations requiring hands-on assessment, manual therapy, or close clinical monitoring. Second, clinical effectiveness appears to depend less on the specific technological platform employed and more on the quality of the clinical structure surrounding its delivery — including adequate technological infrastructure, supervision intensity, progression criteria, and therapist feedback — with synchronous video-based delivery currently representing the most evidence-supported modality across populations. Third, the translational potential of telerehabilitation remains constrained by methodological heterogeneity across the existing literature, persistent digital inequities disproportionately affecting older and lower-income populations, and a near-universal absence of long-term outcome data and rigorous economic evaluations; these limitations warrant caution in generalizing the present findings beyond the populations and contexts in which they were demonstrated. Hybrid care models integrating remote and in-person components represent the most evidence-informed approach for clinically complex or high-risk populations. Taken together, these findings position telerehabilitation not as a universal substitute for conventional physiotherapy, but as a comparable and structurally distinct mode of care delivery under defined clinical conditions, whose broader and more equitable implementation will depend on standardized intervention protocols, targeted digital inclusion strategies, long-term and economically

focused longitudinal research, and the rigorous evaluation of emerging AI-supported and sensor-based rehabilitation models.

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Appendix 1. Studies included in this review

Author(s) & Year	Study Design	Population	Intervention / Exposure	Comparator	Primary and Secondary Outcomes	Key Findings	Clinical and Methodological Implications
Cottrell & Russell (2020)	Systematic Review	Musculoskeletal, neurological and orthopedic patients	Synchronous and asynchronous telerehabilitation	Conventional face-to-face care	Pain intensity, functional outcomes, ADLs	Telerehabilitation was non-inferior to in-person rehabilitation across most outcomes	Supports equivalence of telerehabilitation for routine clinical care where physical examination is not critical
Roitenberg & Ami (2023)	Qualitative Study	Mixed user populations	Telehealth platforms and digital systems	Not applicable	Usability, acceptability, feasibility	High technical feasibility and scalability	User-centered platform design is critical
Anderson & Bauer (2025)	Narrative Review	Musculoskeletal and neurological patients	mHealth-based exercise delivery	Not applicable	Exercise adherence and compliance	Mobile apps improved adherence	Routine integration increases long-term adherence
Youssef et al. (2024)	Narrative Review	Musculoskeletal patients	App-supported telerehabilitation + video	In-person physiotherapy	Pain, functional capacity	Comparable or superior outcomes	Improves accessibility without loss of effectiveness
Zischke et al. (2021)	Systematic Review	Individuals undergoing functional testing	Video-based remote assessment	Face-to-face testing	Validity, reliability	High agreement with in-person	Valid alternative for assessment
Bernhardsson et al. (2023)	Systematic Review	Musculoskeletal patients	Remote physical examination	Face-to-face assessment	ROM, strength, mobility	High concordance	Safe for selected cases
Özsoy et al. (2025)	Methodological Study	Musculoskeletal patients	Video-based functional tests	Gold standard tests	Reliability, validity	Strong psychometrics	Reduces time/location limits
Jourdan et al. (2021)	Systematic Review	Movement analysis users	ML-based motion analysis	Optical lab systems	Accuracy, precision	High accuracy	Enhances objectivity
Zhang et al. (2021)	Technical Study	Motion analysis users	Computer vision + ML	Not applicable	Sensitivity, feedback	Improved sensitivity	Key for personalization
Dawson et al. (2024)	Systematic Review & Meta-analysis	Adults ≥65 years	Tele-exercise	In-person/home exercise	Balance, strength, mobility	Significant functional improvements	Strong geriatric evidence

Goldman et al. (2023)	Qualitative Study	Adults with neurological, MSK and chronic conditions	Telehealth rehabilitation	Not applicable	Patient experience, satisfaction	Positive patient experience; barriers identified	Identifies opportunities for remote care
Brigo et al. (2022)	Systematic Review	Pediatric neurological patients	Telerehabilitation	Traditional rehab	Motor function, adherence	Improved access	More trials needed
Kudritzki & Howard (2023)	Narrative Review	Older adults	Telehealth services	Not applicable	Access, usability	Reduced barriers	Useful for chronic care
Hall et al. (2021)	Observational (Survey) Study	Rehab patients	Tele-rehab experience	Not applicable	Satisfaction	High satisfaction	Supports adoption
Davies et al. (2025)	Scoping Review	Rural populations	Telehealth implementation	Local services	Access rates	Reduced inequality	Strategic for underserved areas
Oh et al. (2024)	Systematic Review	Telehealth users	Utilization patterns	Not applicable	Digital literacy	Lower literacy reduced adherence	Education needed
Rauzi et al. (2023)	Narrative Review	Not applicable	Telehealth systems	Not applicable	Ethics, privacy	Data protection critical	Regulation required
Siwach et al. (2025)	Observational Study	Telehealth users	Multiple platforms	Not applicable	Technical failures	Reduced user experience	Infrastructure needed
Maresca et al. (2020)	Narrative Review	Home-exercise patients	Tele-exercise + monitoring	Unsupervised exercise	Adherence, motivation	Low motivation reduced adherence	Feedback essential
Xu et al. (2023)	Systematic Review	Not applicable	Sensor-based AI	Not applicable	Personalization	High adaptability	Future core component
Delbaere et al. (2025)	Observational Study	Older adults at fall risk	AI feedback exercise	Fall-prevention programs	Balance	Effective personalization	Improved safety
Lee et al. (2022)	Qualitative Study	Pediatric neurological patients	VR/AR rehab	Motor training	Motor skills	Higher engagement	Promising modality
Calcaterra et al. (2025)	Systematic Review & Meta-analysis	Pediatric neurological motor disorders	Telerehabilitation interventions	In-person rehab	Functional outcomes	Promising motor outcomes; more trials needed	Recommended for complex cases
Tomaskovic et al. (2025)	RCT Protocol	Post-COVID-19 condition	Tele-exercise	Physiotherapy	Pain, function	Protocol — outcomes pending	Outcomes pending (protocol)
Garofano et al. (2025)	Cohort Study Protocol	Cardiac patients	Tele-cardiac rehab	Conventional rehab	VO_2max, fatigue	Protocol — VO_2max outcomes pending	Outcomes pending (protocol)

Rocco et al. (2024)	Scoping Review	Cancer patients	Video-based rehab	Supportive care	Fatigue, QoL	Functional gains	Effective approach
Raymond et al. (2024)	Systematic Review (rapid)	Rehab patients	Tele-rehab + feedback	Not applicable	Experience	Improved adherence	Feedback crucial
Hudon et al. (2024)	Qualitative Synthesis	Telehealth users	Various models	Not applicable	Barriers	Digital divide	Inclusive design needed