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Review Article

Bridging the gaps: how emerging technologies are shaping the future of physiotherapy for all

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ABSTRACT

Physiotherapy has traditionally been delivered face-to-face in clinical settings, but emerging technologies like telerehabilitation, wearable sensors, virtual/augmented reality, robotic exoskeletons, and artificial intelligence (AI) are rapidly changing this model. This narrative review of 42 peer-reviewed, open-access articles published between 2018 and 2026 examines their implications for equitable health service delivery. Results show that telerehabilitation is as effective as in-person care for many conditions, with high patient satisfaction and rare adverse events. Wearable devices enable continuous home monitoring and improve physical activity, while virtual reality increases engagement and motor outcomes in stroke, ageing, and musculoskeletal conditions. Robotic exoskeletons improve walking and upper-limb function in spinal cord injury and stroke, though costs remain high. AI enhances personalisation and prediction, but data are mostly from small studies. From a public health perspective, these technologies offer opportunities to improve access, reduce costs, and address inequalities in rehabilitation care. However, major barriers include the digital divide, lack of equity reporting, and limited implementation in low-resource settings. Without deliberate attention to digital determinants of health, these innovations risk widening existing inequalities. Therefore, emerging technologies can transform physiotherapy into a more accessible, continuous, and person-centred model of care, but future implementation must prioritise affordability, digital literacy, and integration into public health systems.

Keywords: Emerging technologies, Physiotherapy, Public health, Telerehabilitation, Digital health equity, Artificial intelligence in rehabilitation

INTRODUCTION

We often think of physiotherapy as a very hands-on, personal kind of care. It is the therapist's skilled touch, the encouragement face-to-face, and the exercises done in a clinic. For a long time, that was the only way to receive it. But like almost everything else in our lives, technology is changing that in a big way.

Over the last decade, and especially since the pandemic, we have seen an explosion of new tools-from smartphone apps that guide you through exercises to wearable sensors that track every step and robotic suits that help people walk again. These are not just futuristic gadgets; they are quickly becoming essential parts of modern healthcare.[1,2]

This review looks at how these exciting technologies are not just changing the way physiotherapists work, but also, from a wider public health lens, how they are helping to solve some of the biggest problems in our healthcare systems: lack of the access, high costs, and the unequal care.

LITERATURE REVIEW

We conducted a narrative review of peer-reviewed, open-access literature. We searched PubMed, Google Scholar, and the Directory of Open Access Journals (DOAJ) for articles published between January 2018 and March 2026. The search terms used were: "telerehabilitation", "telehealth physiotherapy", "wearable technology rehabilitation", "virtual reality physiotherapy", "augmented reality rehabilitation", "robotic exoskeleton gait training", "artificial intelligence physiotherapy", "digital health equity", and "public health rehabilitation". We included systematic reviews, meta-analyses, umbrella reviews, scoping reviews, and narrative reviews that evaluated the clinical effectiveness, feasibility, or equity implications of emerging technologies in physiotherapy. Only English-language, open-access articles with verifiable DOIs were selected. We excluded conference abstracts, editorials, opinion pieces, and studies focusing exclusively on device engineering without clinical outcomes. After initial screening of 187 titles and abstracts, 42 articles met the inclusion criteria and were included in this review.

BRINGING THE CLINIC HOME: THE QUIET REVOLUTION OF TELEREHABILITATION

Let us start with the most down-to-earth technology: telerehabilitation. Put simply, it is physiotherapy delivered remotely, using a phone, tablet, or computer. For someone living in a rural town, an elderly person who cannot drive, or a busy parent, getting to a clinic can be a real challenge. These barriers often mean people simply do not get the care they need, which can lead to worsening conditions and higher costs down the line for the whole health system. For people in lower- and middle-income countries (LMICs), the problem is even more acute. Health systems there often have very limited access to rehabilitation services.[3,4]

This is where telerehabilitation shines. A large umbrella review that looked at 28 systematic reviews found that telerehabilitation interventions-ranging from simple phone calls to complex video calls and mobile health apps- are just as effective as in-person therapy for improving motor function, balance, and quality of life after a stroke.[5] Another systematic review focusing on musculoskeletal conditions came to a similar conclusion: telerehabilitation works as well as face-to-face care for pain and function, and patients really like the convenience.[6] A separate review of cardiac rehabilitation programmes in rural areas found that telehealth not only improved exercise capacity but also saved patients from long, costly journeys.[7] For people with chronic low back pain, exercise-based telerehabilitation has been shown to be feasible and acceptable, though the authors note that more standardised protocols are needed.[8]

A systematic review on the safety of telerehabilitation analysed 37 randomised controlled trials with over 3,000 participants. It found that adverse events were very rare-only 0.31% of sessions-and most were mild and not directly caused by the remote delivery itself.[9] This is reassuring news for both patients and therapists who worry about the risks of home-based rehabilitation.

However, telerehabilitation is not a perfect solution. The same studies point out significant barriers. Many people, especially older adults and those in low-income communities, lack the necessary digital literacy or have limited access to reliable internet and devices.[3,6,7] A scoping review on equity in digital stroke rehabilitation found that very few studies even reported on key factors like education, income, or social support-factors that we know strongly influence who can benefit from these technologies.[10] A rapid review on ethical and equity dimensions in telerehabilitation confirmed that disparities related to age, gender, socioeconomic status, and geographic access remain major challenges. The authors call for structured, equity-driven frameworks to guide future implementation.[11] From a public health perspective, telerehabilitation is a game-changer for improving access, but we must work just as hard to close the "digital divide" to ensure we do not leave the most vulnerable people behind.

THE SILENT ASSISTANT: HOW WEARABLE TECH IS CHANGING DAILY LIFE

If telerehabilitation brings the clinic to your home, wearable technology makes your home a living, breathing rehab clinic. We are talking about smartwatches, fitness trackers, and more specialised sensors that you wear on your body. These devices can monitor your movements continuously, providing a level of detail that is impossible to capture in a brief clinic visit.

For physiotherapists, this is a goldmine of information. Instead of relying on a patient's memory of how many exercises they did, a wearable sensor can track repetitions, range of motion, and even walking patterns in real-time, at home. A systematic review of commercially available wearable devices found that consumer-grade wearables can be used as effective adjuncts to traditional physiotherapy. The review analysed 18 studies covering over 1,700 patients across orthopaedics, stroke medicine, oncology, and general surgery. All six randomised controlled trials showed that wearable-driven feedback increases physical activity, and two orthopaedic trials even demonstrated that wearable-guided self-directed rehabilitation was as good as traditional physiotherapy.[12]

A systematic review on diversity factors in wearable assistive technologies found that diversity has not been adequately addressed in this field. The authors argue that we lack sufficient knowledge about which diversity-related aspects researchers must consider when evaluating wearable devices, and they provide actionable recommendations for more inclusive research and development.[13] For older adults at risk of falls, a scoping

review of smart wearable technologies for balance rehabilitation identified 17 systems. While many use motion tracking and gamification, the review found significant gaps in AI integration, remote accessibility, and clinician-driven data analytics.[14]

The potential here for public health is enormous. By shifting care from episodic clinic visits to continuous home monitoring, we can prevent complications, catch declines early, and reduce the need for emergency room visits and hospital readmissions. But the challenges are real. The devices can be expensive, and integrating this constant stream of data into a clinician's daily workflow is not yet straightforward.[12] Also, many wearables are not designed with diverse user populations in mind, leading to usability issues.[13] Despite this, the trend is clear: the future of physiotherapy will be data-driven, and wearable sensors will be a key part of that ecosystem.

ADDING FUN TO FUNCTION: THE ENGAGING WORLD OF VIRTUAL AND AUGMENTED REALITY

Let us be honest; rehab exercises can be boring. Doing the same leg lifts or arm circles day after day requires immense discipline. This is where virtual reality (VR) and augmented reality (AR) are making a huge difference. VR creates a completely immersive, computer-generated world, while AR overlays digital information onto the real world. In physiotherapy, this means a patient can practise balance by "walking the plank" in a safe, virtual pirate ship, or reach for objects in a simulated grocery store.

The primary benefit of VR is engagement. When therapy feels like a game, patients are more motivated, exercise longer, and adhere better to their programs. A scoping review of VR interventions for mobility rehabilitation screened over 2,700 articles and found that 73% of studies reported statistically significant improvements in motor outcomes following VR intervention. The majority of studies were conducted in clinical settings, suggesting that research in this area is moving beyond proof-of-concept and toward real-world clinical applications.[15] A systematic review comparing immersive VR (using head-mounted displays) with non-immersive VR (using screen-based systems) for post-stroke upper-limb rehabilitation found that both approaches produce improvements over conventional therapy. Immersive VR may offer greater gains for gross motor recovery, while non-immersive systems are more practical and accessible for fine motor and dexterity training.[16] A systematic review of VR-based therapy for chronic low back and neck pain concluded that VR interventions can effectively reduce pain intensity and associated disability.[17]

For children with cerebral palsy, a systematic review found that VR-based physiotherapy improves upper limb function, though the authors call for larger, more standardised studies.[18] An umbrella review of 14 meta-analyses on musculoskeletal diseases concluded that VR effectively reduces knee pain, improves balance, alleviates pain in fibromyalgia and back pain, and even enhances psychological well-being.[19]

From a public health standpoint, VR offers a scalable way to deliver high-intensity, engaging therapy that patients actually want to do. This could be a powerful tool for managing chronic conditions, preventing falls, and improving mental well-being. However, low awareness, training gaps, and equipment costs have reduced its adoption in clinical settings. The good news is that feasibility studies suggest low-cost VR solutions-using smartphone-based headsets-can be safely employed even in resource-limited settings.[15] The challenge is to move from proof-of-concept to real-world, affordable implementation.

THE POWER OF MACHINES: ROBOTICS AND EXOSKELETONS FOR SEVERE IMPAIRMENTS

For some people with severe mobility impairments from a stroke, spinal cord injury (SCI), or multiple sclerosis, traditional therapy has its limits. A human therapist can only provide so many repetitions of a specific movement. This is where robotic exoskeletons come in. These are wearable, motorised devices that support and move a person's limbs, allowing them to perform intensive, repetitive, and task-specific training.

For someone with a spinal cord injury, a robotic exoskeleton can literally help them stand and walk again. A comprehensive literature review on robotic rehabilitation for SCI patients found that upper limb robotic systems, including end-effector and exoskeleton types, improve motor outcomes, especially in the subacute phase. For lower extremity rehabilitation, ambulatory exoskeletons such as ReWalk, Ekso, Indego, and HAL have been shown to offer safe and feasible gait training, with reported improvements in walking independence, balance, and stride parameters. Preliminary evidence also suggests that exoskeleton-assisted walking may positively influence bowel and urinary function, though current data are limited.[20]

A systematic review of portable exoskeletons for upper limb rehabilitation evaluated five studies with 70 patients post-stroke or after neurological surgery. The devices demonstrated significant improvements in motor function, range of motion, and spasticity reduction, with high adherence and no severe adverse events. The authors conclude that portable exoskeletons are promising tools for upper limb rehabilitation, though they note moderate risk of bias and small sample sizes as limitations.[21] Another systematic review on robotics in physical rehabilitation showcased recent advancements in exoskeleton technology and brain-computer interface

integration, highlighting both the potential and the challenges of widespread clinical adoption.[22]

The public health impact here is profound. Regaining the ability to walk or use an arm is not just about physical health; it is about independence, returning to work, and reducing the lifelong burden of care on families and social systems. However, these technologies are incredibly expensive. Widespread clinical adoption remains constrained by a lack of standardised protocols, limited evidence from large-scale studies, and practical issues such as device weight, comfort, and ease of use in community settings.[20] Recent developments-such as adaptive control algorithms and AI integration-are addressing these barriers, but cost-effectiveness studies are still scarce. For these robots to have a broad public health impact, we need continued innovation to make them lighter, smarter, and more affordable.

THE INVISIBLE BRAIN: HOW AI TIES IT ALL TOGETHER

AI is the invisible engine powering many of the technologies we have discussed. It is what allows a wearable sensor to distinguish between a normal step and a faltering one, or a VR system to adapt the difficulty of a game in real-time based on a patient's performance. In physiotherapy, AI is being used for everything from movement analysis to personalised exercise prescription and clinical decision support.

A systematic review of deep learning techniques in musculoskeletal physiotherapy analysed 23 studies and found that innovation is primarily seen in the adoption of hybrid models, with convolutional neural networks being extensively utilised. Body signals and images are predominantly used as data sources, but the authors note that texts and structured data present promising avenues for groundbreaking work.[23] A systematic review on AI-assisted physiotherapy for non-specific low back pain found that AI-driven interventions can effectively guide exercise prescription and monitor patient progress, though more high-quality randomised controlled trials are needed.[24]

A living systematic mapping review on AI in rehabilitation identified 240 studies meeting inclusion criteria, with most focusing on neurological (57.9%) and orthopaedic (22.7%) rehabilitation, particularly involving stroke, Parkinson's disease, and amputation. Research activity is mainly concentrated in China (24.6%) and the USA (16.7%). AI has been tested across all stages of the medical process, with a slight predominance in intervention (23.8%), followed by prognosis (17.5%).[25] A systematic review on AI for diagnostic methods in musculoskeletal conditions highlighted the promising role of AI technologies in enhancing the accuracy and efficiency of musculoskeletal diagnostics, potentially reducing the likelihood of misdiagnosis and enabling more personalised rehabilitation programmes.[26]

The public health implications of AI are vast. It has the potential to massively increase the efficiency of physiotherapy services, allowing a single therapist to manage a larger caseload of patients doing home-based AI-guided exercises. It can help reduce outcome inequalities by providing consistent, high-quality guidance to everyone, regardless of where they live. However, the ethical concerns are significant and cannot be ignored. Current evidence remains largely based on small datasets and limited external validation.[25] We must be vigilant about data privacy and algorithmic bias, where an AI trained on one population might not work well for another. The goal is not to replace the human touch of a physiotherapist but to augment it with powerful, intelligent tools.

THE PUBLIC HEALTH LENS: EQUITY, ACCESS, AND IMPLEMENTATION

All of these technologies sound exciting, but from a public health perspective, we have to ask a hard question: who actually gets to use them? Digital health technologies present transformative opportunities, but access is heavily influenced by what researchers now call the "digital determinants of health"-things like digital literacy, access to high-speed internet, and availability of devices.

A systematic review on equity in digital stroke rehabilitation found that fewer than 5% of studies reported on key equity factors like education, social capital, and socioeconomic status-factors known to influence digital exclusion and health outcomes.[10] A rapid review of ethical and equity dimensions in telerehabilitation confirmed these findings, showing inconsistent reporting and limited depth in addressing patient autonomy, privacy, and adverse events, alongside disparities related to age, gender, socioeconomic status, and geographic access.[11] The authors call for structured, equity-driven frameworks such as the metaverse equitable rehabilitation therapy (MERTH) framework to guide future implementation.

In LMICs, the situation is even more challenging. A systematic review on the effectiveness of telerehabilitation for adults with neurological conditions in LMICs found promising potential, but the lack of long-term follow-up data limits understanding of sustained benefits.[27] A scoping review on features of telerehabilitation for resource-limited settings analysed 135 articles and found that only 18% focused on LMICs. The authors conclude that future research should expand focus on resource-limited settings, discuss financial considerations, and pay attention to health systems integration.[28]

But there are reasons for hope. Innovative programmes are emerging that use low-cost, offline-first technologies. A systematic review of end-users' perceptions of facilitators and barriers in accessing tele-rehabilitation

services identified key facilitators such as having an internet-enabled device, cost benefits, e-healthcare knowledge, and motivation. Barriers included affordability of devices, network connectivity issues, lack of technical skills, and digital literacy.[29] These findings point to clear targets for intervention: we need to invest in digital literacy training, subsidise devices for low-income patients, and design technologies that work even with limited connectivity.

CONCLUSION

Looking at all these technologies together, a clear picture emerges. We are on the cusp of a major shift in physiotherapy. The old model of care was location-dependent, episodic, and limited by the therapist's time. The new model, driven by these tools, is home-based, continuous, data-rich, and personalised.

From a public health perspective, the potential is immense. We have the power to bring high-quality care to the most remote villages and the busiest city-dwellers. We can make therapy more engaging and effective, and we can empower people to take control of their own health like never before. However, access to digital health technologies is influenced not only by well-recognised social determinants of health but also by digital determinants such as digital literacy and access to digital infrastructure. Addressing these challenges is essential to benefit diverse and under-represented communities.

The barriers we have identified-cost, the digital divide, data security, and the need for robust clinical evidence-are not just technical problems; they are public health challenges that require policy solutions. As we move forward, our focus must be on equity. We must design technologies that are affordable, accessible to people with low digital literacy, and available in multiple languages. We need to train a new generation of physiotherapists who are comfortable working with AI and data. We also need health systems to invest in the infrastructure-internet, devices, technical support-that makes digital physiotherapy possible for everyone.

The technology is ready and waiting. Now, we need the will and the wisdom to deploy it in a way that truly leaves no one behind. This is not just about better physiotherapy; it is about fairer, more just healthcare for all.

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