Review

Artificial Intelligence in Physiotherapy: Transforming Rehabilitation Through Intelligent Technologies

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Abstract

Artificial intelligence (AI) is revolutionizing the practice of physiotherapy in areas such as assessment, intervention, prognosis, and clinical decision-making.

This review consolidates existing research on AI uses in physiotherapy, encompassing machine learning for predictive outcomes, computer vision for analyzing movements, robotics for motor rehabilitation, virtual physiotherapy assistants for remote care, and decision support systems for clinicians.

An examination of recent systematic reviews indicates that AI technologies hold great promise for enhancing personalized treatment, boosting patient adherence, and improving resource management. Nonetheless, significant challenges remain in relation to external validation, algorithm transparency, data quality, and integration into existing clinical practices. The focus on neurological and orthopedic applications—especially concerning stroke and musculoskeletal conditions—underscores current research trends and underscores a lack of attention in other rehabilitation areas.

This review looks at the evidence available, points out methodological weaknesses, and recommends approaches for the ethical integration of AI in physiotherapy.

***Keywords**: artificial intelligence, physiotherapy, machine learning, rehabilitation, computer vision, robotics, telerehabilitation, clinical decision support*

Introduction

Artificial intelligence has become a game-changing element in various healthcare fields, with physiotherapy emerging as a particularly promising area for the implementation of smart technologies [1]. The interplay of enhancements in computational capabilities, sensor technology, and advanced algorithms has opened new avenues for improving rehabilitation outcomes through data-informed strategies [2]. AI applications in physiotherapy encompass the complete spectrum of care, from initial patient evaluation to intervention execution and ongoing outcome assessment [3].

The international rehabilitation sector faces notable challenges, such as an aging demographic, a rising prevalence of chronic diseases, and ongoing shortages of qualified physiotherapy staff [4]. These factors have intensified the pursuit of technological innovations that can enhance clinical capacity while preserving or elevating care quality. AI technologies present potential remedies through automated evaluations, tailored intervention modifications, remote monitoring tools, and predictive analytics for effective resource management [5].

Modern physiotherapy increasingly utilizes a variety of data sources, including outputs from wearable sensors, video-based movement assessments, electronic health records, and patient-reported outcome measures [6]. The intricacy and volume of this data surpass human cognitive processing abilities, creating significant openings for algorithmic support. Machine learning techniques can uncover patterns that elude clinical perception, potentially disclosing new correlations between treatment strategies and functional results [7].

The adoption of AI in physiotherapy prompts vital questions about clinical validity, ethical application, professional identity, and health equity [8]. While there is much excitement surrounding technological advancements, thorough evaluation of practical effectiveness is crucial for responsible integration. This review explores the existing evidence for AI applications in physiotherapy, examining their roles in assessment, intervention, and decision support while pinpointing essential gaps and future pathways.

Materials and Methods

This narrative review utilized systematic literature searches in databases such as PubMed, Scopus, Web of Science, IEEE Xplore, and PEDro, covering the period from 2018 to 2025. The search strategy employed combinations of keywords including "artificial intelligence," "machine learning," "deep learning," "physiotherapy," "physical therapy," "rehabilitation," "computer vision," "robotics," "telerehabilitation," and "clinical decision support." The inclusion criteria were limited to peer-reviewed original studies, systematic reviews, and meta-analyses that explored AI applications within the context of clinical physiotherapy. Excluded from the review were studies focusing solely on healthy subjects, conference abstracts lacking full text, and articles published in languages other than English.

The review emphasized recent high-quality systematic reviews and ongoing systematic reviews to ensure a comprehensive capture of the evolving evidence base. Data extraction was concentrated on the domains of AI application, methodological strategies, outcome measures, and obstacles to implementation. Quality assessment adhered to PRISMA guidelines where relevant, with special focus on external validation, algorithm transparency, and clinical relevance.

Results

A thorough living systematic review uncovered 240 studies utilizing AI for rehabilitation across various fields. Research efforts were primarily focused on neurological rehabilitation (57.9%) and orthopedic rehabilitation (22.7%), with stroke, Parkinson's disease, and amputations being the most common conditions examined. In terms of geographical distribution, China (24.6%) and the USA (16.7%) led in research contributions, reflecting their commitment to AI in healthcare. AI applications were spread throughout the medical process, with primary focuses on intervention (23.8%), prognosis (17.5%), assessment (16.7%), diagnosis (12.9%), and monitoring (12.5%). Patterns of technology integration showed frequent combinations with wearable sensors, robotic systems, and digital technologies, including inertial measurement units, surface electromyography, mobile applications, and electroencephalography.

Methodological evaluations highlighted a majority reliance on supervised learning (70.8%) and classical machine learning (43.8%) over deep learning techniques. Raw data (37.9%) and tabular data (27.5%) were the main inputs, while multimodal integration was observed in only 11.3% of studies. Notably, external validation was rare (5.8%), and methods to enhance explainability were seldom employed (10.2%), which poses challenges for clinical generalizability. Machine learning models reveal substantial potential in accurately predicting rehabilitation outcomes for musculoskeletal and neurological disorders. Algorithms like random forest and XGBoost have provided reliable predictions of disability and pain for chronic low back pain patients undergoing lumbar extension traction, identifying baseline disability scores and treatment compliance as key predictive elements.

Support vector machine models aimed at detecting muscle fatigue from time-frequency features in electromyography signals attained a remarkable 95% accuracy in stroke rehabilitation applications. Initial clinical tests with post-stroke patients indicated a 44% improvement in range of motion, a 45% increase in active torque, and a 36% decrease in passive torque after AI-enhanced hybrid rehabilitation that combined robotic systems with neuromuscular electrical stimulation.

Marker-less human pose estimation through computer vision is experiencing rapid advancements in physiotherapy. These systems analyze human motion using video data without the need for markers or specialized sensors, facilitating remote assessments and home-based rehabilitation monitoring. Deep learning techniques employing convolutional neural networks for movement classification have reached recognition rates of 0.9944 on standardized datasets, reflecting their potential for precise exercise evaluation. Innovative approaches combining spike train encoding with specialized convolutional neural network architectures have demonstrated superior accuracy over traditional methods in multiple physiotherapy datasets. This technique's focus on temporally significant features makes it especially effective in rehabilitation contexts where the accuracy of movement is essential. However, existing systems largely rely on data from healthy volunteers, limiting their direct relevance to clinical applications.

AI-augmented hybrid rehabilitation systems, integrating robotic technologies with advanced control algorithms, show significant promise for supporting upper-limb recovery in stroke survivors. Real-time anatomical adaptation for bilateral therapy paired with machine learning-based fatigue classifications allows for personalized and responsive interventions. The ROS2 framework enables real-time signal processing, adaptive control, and remote clinical oversight. AI-enabled virtual physiotherapy assistants that combine wearable sensors with intelligent algorithms provide real-time feedback and tailored guidance for home rehabilitation. These systems boost treatment adherence, reduce the frequency of clinic visits, and enhance rehabilitation outcomes through continuous monitoring and adaptive adjustments. The integration of inertial measurement units and electromyography sensors aids in immediate corrective feedback for exercise precision.

Case-based reasoning systems employing AI to find similar successful patients from historical records show strong acceptance among physiotherapists and patients. This approach enables personalized treatment recommendations by aligning new patients with prior cases that yielded positive results, shifting care from standardized protocols to individualized approaches. Nonetheless, qualitative assessments indicated that physiotherapists mainly utilize the system to bolster their current practices rather than fundamentally change their clinical decision-making.

Discussion

The incorporation of artificial intelligence into physiotherapy practice presents both significant opportunities and notable challenges. Existing evidence indicates that AI technologies can improve assessment accuracy, tailor interventions to individual needs, forecast outcomes, and facilitate remote care delivery [3,5,9]. Nonetheless, the transition from research breakthroughs to clinical application is still in progress, with many tools remaining in experimental or pilot stages rather than being integrated into standard practice [9]. Methodological shortcomings highlighted in various studies pose serious issues for clinical use. The prevalence of internal validation without external testing raises doubts about the applicability of these findings to varied patient populations, clinical environments, and geographical areas [9,21]. Typically, algorithm performance diminishes when applied to independent datasets due to differences in population characteristics, data collection methods, and contextual factors [20]. Lacking rigorous external validation, clinicians are unable to confidently apply AI tools in their unique practice situations [9]. The limited availability of explainability methods in AI applications for physiotherapy forms another obstacle to clinical uptake. Healthcare providers need a clear understanding of how algorithms form recommendations to blend intelligent suggestions with clinical judgement and patient preferences [8,18]. Black-box algorithms offering results without a comprehensible explanation meet resistance from practitioners accustomed to evidence-based and transparent decision-making [18]. Future research should prioritize creating inherently interpretable models or effective post-hoc explanation techniques [18].

The quality and attributes of datasets underpinning AI physiotherapy applications significantly limit real-world applicability. Most models are trained on small, static, homogeneous datasets that do not adequately reflect the complexity, speed, and diversity inherent in clinical Big Data [19,20]. This constraint underscores an early experimental stage in AI adoption, where challenges relating to data availability, standardization, and interoperability hinder the development of scalable, generalizable models [19]. Although electronic health record usage in physiotherapy is substantial (78.3% in recent studies), significant documentation inconsistencies hinder AI integration [16,17]. Unstructured free-text entries, incomplete records, and variable documentation frequency pose hurdles for effective algorithmic analysis [17]. Often, physiotherapy documentation fails to fully capture the entire care process, with details about interventions, patient progress, and outcome assessments being frequently absent or inconsistently documented [17]. The lack of standardized terminologies and data frameworks across physiotherapy practice further complicates the development of AI solutions [17]. While the International Classification of Functioning, Disability and Health offers a conceptual structure for describing rehabilitation cases, its implementation is inconsistent [23]. Without harmonized data standards, consolidating information across different settings for algorithmic training is challenging, limiting model robustness and applicability [23].

Effective AI implementation in physiotherapy requires careful consideration of how it fits into existing clinical workflows. Technologies that disrupt established practices, increase documentation demands, or require extensive additional time may face barriers to uptake, regardless of their technical capabilities [24,25]. The observation that physiotherapists often use decision support systems to validate existing judgments—rather than to inform new methodologies—suggests that AI tools must complement, not replace, clinical reasoning [15]. Balancing automation with clinical judgment necessitates careful calibration [8]. Excessive reliance on algorithmic recommendations can hinder practitioners' skills and may overlook unique patient complexities not accounted for in training data [8]. Conversely, underusing AI capabilities can forfeit opportunities for improved accuracy and efficiency [5]. Formulating implementation models that position AI as collaborative tools enhancing rather than substituting clinical expertise may promote greater acceptance and better outcomes [5,8]. The roll-out of AI technologies in physiotherapy introduces critical equity considerations. Advanced systems that necessitate significant infrastructure investment, specialized equipment, or high-speed internet access may widen existing healthcare gaps [2,4]. Populations that are already underserved by rehabilitation services—such as those in rural areas, low-income groups, or resource-poor settings—risk further marginalization if AI solutions become concentrated in well-resourced facilities [2,4]. On the other hand, well-designed AI applications can enhance access to quality physiotherapy through telehealth platforms, automated assessment tools, and intelligent home exercise systems [5,14]. Achieving this potential requires deliberate design choices that prioritize accessibility, affordability, and usability for diverse populations and contexts [2,5].

The regulatory environment for AI medical devices is continuously evolving, with physiotherapy applications facing classification ambiguities [5,23]. Determining whether specific applications qualify as medical devices, wellness technologies, or clinical decision support tools has implications for approval processes, liability frameworks, and reimbursement eligibility [5]. Clear regulatory guidance specific to physiotherapy AI would enable responsible innovation and safeguard patient safety [5]. Ethical issues such as informed consent for AI-assisted care, data privacy and security, algorithmic bias, and professional accountability must be continuously addressed [8,24]. Patients should be informed when and how AI technologies contribute to their care, with genuine options to opt-out of algorithmic involvement if they choose [8].

This review highlights several key research priorities. First, robust external validation studies across diverse clinical environments and patient groups are vital for demonstrating real-world effectiveness [9,21]. Second, research into implementation science focusing on strategies for successful workflow integration can accelerate positive adoption [24,25]. Third, economic assessments comparing AI-enhanced care to standard practices will guide reimbursement and policy matters [5]. Lastly, participatory design approaches involving physiotherapists and patients will ensure that AI tools meet authentic clinical needs and preferences [8,24]. Technological advancements should emphasize the integration of multiple data types, merging sensor outputs, video analyses, electronic records, and patient-reported outcomes for comprehensive assessments [6,21]. Developments in explainable AI, privacy-preserving federated learning, and edge computing for real-time processing may help tackle current limitations [18,21]. Hybrid strategies that combine AI efficiency with human clinical insight could enhance care quality and patient experiences [5,8].

Conclusion

Artificial intelligence holds significant transformative promise for physiotherapy practice in areas such as assessment, intervention, prognosis, and decision support. Current studies show encouraging applications in movement analysis, outcome forecasting, robotic rehabilitation, and virtual care provision. Nonetheless, considerable challenges remain regarding external validation, understanding algorithmic processes, data integrity, and integration with clinical workflows. To ensure responsible adoption of AI in physiotherapy, it is crucial to uphold rigorous methodological standards, ethical guidelines, equity considerations, and professional training. AI should complement, not substitute, clinical expertise, with an emphasis on fostering human relationships and personalized care. Future research should focus on real-world effectiveness, strategies for implementation, and cost analysis to fully leverage AI’s capacity to improve rehabilitation results.

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