

Artificial Intelligence in Physiotherapy: A Narrative Review of Advancements in Education, Clinical Practice, and Research

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How to cite this article:

Ranjeet Singh, Artificial Intelligence in Physiotherapy: A Narrative Review of Advancements in Education, Clinical Practice, and Research. Physio. and Occ. Therapy Jr. 2024;17(4):247-252.

Abstract

AI is transforming physiotherapy by advancing education, clinical practice, and research. Simulations, virtual reality, and personalized learning platforms enhance education, equipping students with adaptive skills for evolving environments. Machine learning algorithms and wearable sensors enable accurate diagnoses and tailored robotic-assisted therapies, thus improving patient outcomes. AI also accelerates data analysis, supports predictive modeling, and fosters evidence-based practices, driving innovation in the field.

However, challenges like ethical concerns, poor digital literacy among practitioners, and high implementation costs hinder adoption. Addressing these requires interdisciplinary collaboration, ethical standards, and targeted training programs. Embracing AI can modernize physiotherapy, ensuring its relevance in healthcare by optimizing patient care and advancing education and research methodologies.

Keywords: Artificial Intelligence; Clinical Practice; Physiotherapy Education; Research

INTRODUCTION

AI impacts all walks of business, though healthcare stands quite explicitly on the list of its most critical beneficiaries. Since its very definition is intrinsically complex because it aims to recapitulate human intelligence—an event yet so haphazardly understood—this complexity itself holds the possibility of evolving ahead of the cognition that led to expansion over disciplines.⁽¹⁾

AI in physiotherapy promises the processing

of large datasets for identifying patterns and supporting clinical decision-making, with improved patient care being the final outcome. More than the diagnosis and treatment of diseases, AI promises to transform how future generations of physiotherapists will be educated.

This review addresses the challenge of AI in physiotherapy, from education and clinical application to research. It also covers some of the challenges found with respect to ethical concerns and adoption barriers and then discusses paths forward for responsible and impactful integration.

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Received on: 09.09.2024

Accepted on: 16.10.2024



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AI in Physiotherapy Education

The Imperative for AI Literacy

As AI technologies become more widely used in healthcare, the relevance of AI literacy for physiotherapy instructors and students cannot be stressed. They will soon become practitioners and consumers of these technologies, thus understanding both their capabilities and limits is vital for successful implementation. According to Scott William Lowe's study, current data shows that the majority of physiotherapists support adding AI into curriculum. This inclusion is considered a realistic move to prepare graduates for the increasingly digital healthcare sector.⁽²⁾

Examples of AI Applications in Education

1. **Adaptive Learning Systems:** Because AI adaptive learning platforms make tailoring the learning experience possible when materials are set in line with the learner's needs and pace, students who were engaged, motivated, and showed knowledge enhancement displayed they understood the essential concepts before shifting to harder stuff.⁽³⁾
2. **Simulation and Virtual Reality:** Advances like AI-enhanced simulations and VR allow the students to practice clinical skills in risk-free situations. The programs simulate the interaction of patients and enable students to interact and play out realistic scenarios by receiving instantaneous feedback on their performance. This method enhances critical thinking and hones its application in real-life challenges⁽⁴⁾.
3. **Assessment Tools:** AI technologies can help simplify the process of assessment by automating evaluation and providing real-time feedback to students. Automated assessment tools assess areas of weakness, thus allowing educators to change their teaching methods and interventions accordingly. It allows the learning process to "grow" at a personalized level, being one critical ingredient in a supportive learning environment⁽²⁾.
4. **Curriculum Development:** AI can help analyze educational outcomes and find trends in student performance data. This can be used by educators to modify curricula such that they bring them closer to the students' needs and the evolving expectations of the industry. This curriculum development

model ensures that physiotherapy education is dynamic and relevant (3).

AI in Physiotherapy Clinical Practice

Enhancing Patient Care

In clinical physiotherapy, artificial intelligence (AI) has significantly transformed practice by enabling predictive modeling, which helps physiotherapists foresee patient outcomes based on existing data, promoting proactive and preventive care. For instance, innovations like the "Stroke Recovery Predictor" exemplify this shift, as it assists physiotherapists in anticipating a stroke patient's recovery potential by analyzing clinical measures such as Barthel Index scores and hospital stay duration, as highlighted by study of Vivek H. Ramanandi⁽⁵⁾ recent emergence of artificially intelligent machines has enabled human cognitive capacity to recognize previously hidden patterns within massive data sets. These changes are influencing all aspects of society, including but not limited to our social, economic, education, health, legal and moral systems, and may have a more significant impact on human progress when compared to the mechanical revolution brought about by steam engine. Clinicians in the near future will find themselves working with information networks on huge scale, causing need to use artificial intelligence (AI). Such applications enhance diagnostic accuracy, allow for personalized interventions, and enable efficient patient monitoring, thus supporting data-driven decision-making that ultimately improves patient outcomes.

Examples of AI Applications in Clinical Practice

1. **Predictive Analytics:** AI algorithms can analyze a vast amount of data about patients, from their health histories to the response of treatment and even demographic information, in order to predict clinical outcomes. For instance, these models may guess the possibility that a patient may recover from injury or any other surgical intervention, and the physiotherapists may determine appropriate related decisions in interventions. The predictive ability will consequently allow for just-in-time adjustments of the treatment plan hence closer care to a patient.⁽⁶⁾
2. **Robots in Rehabilitation Devices:** The rehabilitation landscape has transformed with artificial intelligence-based robotic systems. The robots can accompany

patients in sessions, real time feed, and resistance adjustment according to patients' performance, opening new dimensions. In this respect, technologies have proven to be useful for neurorehabilitation by giving a patient's reliable support to motivate the patient for engagement in sessions involving transparent as well as effective tracking of progression.⁽⁷⁾

3. **Telehealth and Tele-Monitoring:** AI progress has made it less complicated in its delivery as far as telehealth is concerned. Applying AI-enriched wearable devices, the medical practitioners can track the patient's advancement remotely. It helps them monitor such aspects as the range of motion, strength, or adherence to the prescribed exercises. This provides the physiotherapists with the basis upon which they can make decisions on continuing treatment and patient education and, in this way, opens access to people unable to access other health care services.⁽⁸⁾
4. **Applications of AI in Patients Empowerment:** AI technologies enable the involvement of the patient in the rehabilitation process. Patients can develop a tailored exercise program and will be reminded about their exercise activities by using mobile applications. This will encourage adherence to home exercises. The physiotherapists will get better results and greater satisfaction rates from this⁽⁶⁾.

AI in Physiotherapy Research

Advancement in Research Methodologies

Besides practice, AI is the technology transforming the methodology of research in physiotherapy. It can accelerate the innovation process while raising the quality of findings during research into treatment efficacy and patient outcomes. This opens new possibilities for research into treatment efficacy and patient outcomes.

Examples of Applications of AI in Research

1. **Data Mining and Analysis:** AI algorithms are most effective in searching through large and complex data sets to identify patterns and correlations not apparent with more

conventional analysis techniques. Through this, researchers are able to gain new insight into the efficacy of various treatments, thus leading to evidence-based practice⁽⁴⁾ the recent emergence of machines with artificial intelligence has allowed human cognitive abilities to recognize previously hidden patterns in huge datasets. These changes affected every aspect of society, including but not limited to the social, economic, educational, medical, legal, and moral systems, and may have had a greater impact on human progress than the mechanical revolution brought about by the steam engine. In the near future, doctors will work with large information networks, which will lead to the need for the use of artificial intelligence (AI).

2. **Clinical Trial Optimization:** AI innovations can make clinical trial design and implementation more fluid. Predictive modeling in AI will help researchers to profile candidates for a better study while providing some predictions on enrollment rates and timelines. Optimization, in this case, enhances the research process and chances of success.⁽³⁾
3. **Systematic Review -** AI tools can help with systematic reviews by automating potentially laborious activities such as literature searches and data extraction. This saves the time and effort that researchers need to synthesize evidence, enabling crucial findings to be disseminated quickly to the physiotherapy community. This was highlighted by Jennifer Sumner *et al.* in their study, which emphasizes the potential of AI in improving efficiency and accessibility in rehabilitation research.⁽⁸⁾
4. **Generation of Real-World Evidence:** The algorithms could assist in the collection and analysis of real-world data, which is important for establishing the effectiveness of interventions away from the clinical trial environments. Real-world evidence goes a long way in enhancing this knowledge body on treatment effectiveness among various populations.⁽⁷⁾

Ai in Physiotherapy

Category	Application	Description
Education	Virtual Simulations	Use of AI-based virtual reality simulations for interactive learning and practicing physiotherapy techniques in simulated environments.
	Automated Assessment	AI tools for evaluating students' skills during practical sessions using motion analysis and biomechanics data.
	Personalized Learning Platforms	AI-powered adaptive learning systems to customize educational content based on individual student performance and needs.
	Interactive Teaching Assistants	Chatbots and virtual tutors answering student queries, providing additional study resources, and assisting in coursework.
	AI-based Curriculum Development	AI aids in structuring courses to align with current advancements and best practices.
Clinical Practice	Diagnostic Assistance	AI tools enhance diagnostic accuracy by interpreting imaging and patient data.
	Patient Assessment	AI-powered diagnostic tools for analyzing gait, posture, and movement patterns.
	Treatment Planning and Optimization	AI supports creating personalized treatment plans based on patient-specific data.
	Tele-rehabilitation	AI-driven platforms enabling remote physiotherapy sessions with real-time feedback on exercises.
	Wearable Technology Integration	Wearables with AI for tracking patient progress and generating actionable insights for both patients and therapists.
	Real-time Patient Monitoring	Wearable sensors and AI monitor patient progress and provide actionable insights.
	Predictive Analytics	Forecasting patient recovery trajectories and potential risks, aiding in proactive intervention.
	Rehabilitation Robotics	Robotic devices powered by AI assist in precise, repetitive therapy for improved recovery.
Research	Data Analysis and Pattern Recognition	AI facilitates analyzing extensive data sets to identify meaningful trends in physiotherapy.
	Clinical Trial Optimization	AI tools enhancing participant recruitment, data management, and result interpretation in physiotherapy research.
	Natural Language Processing (NLP)	Analyzing large volumes of medical and physiotherapy literature for evidence-based practice insights.
	Predictive Analytics for Patient Outcomes	Machine learning models forecast recovery trajectories and treatment success.
	AI-Powered Hypothesis Testing	Machine learning models aiding researchers in testing hypotheses by simulating various conditions and treatments.
	Innovative Device Development	AI contributes to designing cutting-edge therapeutic tools and technologies.

Limitations and Challenges

Despite the promising possibilities that AI brings to physiotherapy, several limitations and challenges warrant consideration. Addressing these issues is crucial for ensuring that AI integration enhances rather than undermines the human-centered aspects of physiotherapy practice.

1. **Lack of Human Touch:** Therapeutic relationships are a cornerstone of effective physiotherapy practice. There is concern that an overreliance on AI might diminish the personal connection between therapists and

patients, which is necessary for fostering trust and empathy within treatment settings⁽⁷⁾. That human touch is important, especially in managing the emotional and psychological needs of patients.

2. **Cost and Accessibility:** The price of AI technologies is currently a barrier that can limit access to many healthcare providers and patients. These costs are often unaffordable for low-resource settings, which would require increasingly advanced technology to implement. Equitable access to the benefits of AI is highly topical in any healthcare

landscape⁽⁶⁾.

3. **Data Privacy and Security:** Application of AI throws up huge ethical issues in the context of data privacy and security. All such sensitive information of patients is gathered, stored, and even analyzed. This demands adequate safeguards to ensure confidentiality among patients. Considering the concerns raised by physiotherapists and healthcare organizations, these should be of top priority while integrating AI technologies in practice (4) the recent emergence of machines with artificial intelligence has allowed human cognitive abilities to recognize previously hidden patterns in huge datasets. These changes affected every aspect of society, including but not limited to the social, economic, educational, medical, legal, and moral systems, and may have had a greater impact on human progress than the mechanical revolution brought about by the steam engine. In the near future, doctors will work with large information networks, which will lead to the need for the use of artificial intelligence (AI).
4. **Risk of Algorithmic Bias:** Any AI system learns from data that exists and may implicitly carry biases in that data into the underlying clinical decision-making process. If the training data are not representative of the diverse face of the patient population, the AI algorithms may perpetuate unfair outcomes. The risks should be monitored closely, and such possibilities must be tackled to avoid compromising the fairness and equity in which these new patients should be treated.⁽⁸⁾
5. **Thical and Legal Considerations:** Involving an ethical implication, the introduction of AI in practice raises questions about accountability and transparency over treatment decisions. As AI dependence in physiotherapeutic practice increases, it is important that there exist guidelines on who is to be held responsible for decisions by these systems in cases where treatment leads to adverse outcomes.⁽⁹⁾

FUTURE DIRECTIONS

To tap into the full power of AI for physiotherapy, many strategic directions need to be pursued:

1. **Curricular Integration for Education:** Educational institutions have a mandate

to focus on developing AI literacy within their curricula for physiotherapy training. Arming future practitioners to effectively negotiate this complex realm of AI capabilities would make them much more adept at incorporating these technologies meaningfully and effectively into their practice settings.⁽²⁾

2. **Continued Research on Effectiveness:** Following competence, the physical therapy profession will do more study to assess the therapeutic efficacy of AI applications. How AI links to real patient results will readily interpret into best practices and influence future growth in the practice.⁽⁸⁾
3. **Interdisciplinary Cooperation:** Physiotherapists, data scientists, and AI developers should work together to create relevant AI solutions for physiotherapy's challenges. Interdisciplinary collaboration will guarantee that AI technologies remain aligned with the professional needs and applications relevant and useful.⁽³⁾
4. **Standardization of Guidelines and Best Practices:** Effective facilitation to adopt AI in physiotherapy shall require standardizing guidelines and best practice. This would give clear guidelines about how AI technologies should responsibly and ethically be used by a physiotherapist.⁽⁶⁾
5. **Human Element Focus:** Last but not least, as the practice of accepting AI grows, the human aspect in physiotherapy must become increasingly important. The professional core value and efficacy should be preserved if AI complements rather than replaces the therapeutic connection.⁽⁷⁾

CONCLUSION

AI can revolutionize clinical practice, research, and education in physiotherapy. Indeed, in the wake of AI technology, physiotherapists will be able to enhance patient care, educational outcomes, and even the methodology of research. However, at the same time, it is essential to bring forth the limitations so that value is derived meaningfully without diminishing the human touch in the profession. To further increase the profession and deliver it appropriately towards enhancing patients' outcomes, it must integrate current or continuous research and education. This future of AI-powered physiotherapy will be bright because

of the appreciation for technology breakthroughs and a foundation that will fiercely stick to compassionate care.

1. **Conflict of Interest:** The author declares no conflict of interest in relation to this work.
2. **Funding:** This study did not receive any financial support or funding from any organization or individual.
3. **Ethics Declaration:** This article is a narrative review and does not involve human or animal subjects; therefore, ethical approval was not required.

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