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SYSTEMATIC REVIEW

Use of machine learning and deep learning for exercise prescription

Empleo del machine learning y deep learning para la prescripción de ejercicio

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ABSTRACT

Introduction: artificial intelligence is revolutionizing exercise prescription in sports physiotherapy by offering more personalized and data-driven approaches. Through machine learning and deep learning algorithms, AI enables the analysis of complex variables such as biomechanics, physiological responses, and the patient's clinical history, dynamically adjusting exercise programs. This optimizes performance, prevents injuries, and enhances rehabilitation.
Method: a systematic review of studies on the use of AI in sports physiotherapy, based on articles published between 2015 and 2024, using specific inclusion criteria. The findings highlight the benefits of AI in personalizing exercise programs, emphasizing its capacity to improve adherence, load dosing, and injury prevention. However, clinical implementation of AI faces challenges such as external model validation, result interpretability, and the ethical management of sensitive data.
Discussion: the review results show that AI is transforming exercise prescription in sports physiotherapy through a personalized and data-driven approach. AI algorithms, such as machine learning and deep learning, allow for the analysis of complex variables like biomechanics, physiological responses, and clinical history, dynamically adjusting exercise programs. Nevertheless, significant challenges remain for its clinical implementation, including external validation of models, interpretability of outcomes, and ethical concerns in handling sensitive data.
Conclusion: AI holds tremendous potential to transform sports physiotherapy, but its integration into clinical practice requires overcoming technical and ethical challenges. Model validation, healthcare professional training, and equitable access to these technologies are essential aspects to ensure effective and safe implementation. Future research should address these challenges to maximize the benefits of AI in the field of exercise.

Keywords: Artificial Intelligence; Exercise; Exercise Prescription; Machine Learning.

RESUMEN

Introducción: la inteligencia artificial está revolucionando la prescripción de ejercicio en fisioterapia deportiva al ofrecer enfoques más personalizados y basados en datos objetivos. Mediante algoritmos de aprendizaje automático y profundo, la IA permite analizar variables complejas como la biomecánica, las respuestas fisiológicas y el historial clínico del paciente, ajustando dinámicamente los programas de ejercicio. Esto optimiza el rendimiento, previene lesiones y mejora la rehabilitación.
Método: revisión sistemática de estudios sobre el uso de IA en fisioterapia deportiva, basándose en artículos publicados entre 2015 y 2024, con criterios de inclusión específicos. Se encontraron resultados que evidencian los beneficios de la IA en la personalización de los programas de ejercicio, destacando su capacidad para

mejorar la adherencia, la dosificación de la carga y la prevención de lesiones. No obstante, la implementación clínica de la IA enfrenta desafíos como la validación externa de los modelos, la interpretabilidad de los resultados y la gestión ética de los datos sensibles.
Discusión: los resultados de la revisión evidencian que la IA está revolucionando la prescripción de ejercicio en fisioterapia deportiva mediante un enfoque personalizado y basado en datos objetivos. Los algoritmos de IA, como el aprendizaje automático y profundo, permiten analizar variables complejas como la biomecánica, las respuestas fisiológicas y el historial clínico, ajustando dinámicamente los programas de ejercicio. Sin embargo, persisten desafíos significativos en su implementación clínica, como la validación externa de los modelos, la interpretabilidad de los resultados y las preocupaciones éticas en el manejo de datos sensibles.
Conclusión: la IA tiene un enorme potencial para transformar la fisioterapia deportiva, pero su integración en la práctica clínica requiere superar retos técnicos y éticos. La validación de los modelos, la formación de los profesionales de salud y la equidad en el acceso a estas tecnologías son aspectos fundamentales para asegurar una implementación efectiva y segura. Las investigaciones futuras deben abordar estos desafíos para maximizar los beneficios de la IA en el campo del ejercicio.

Palabras clave: Inteligencia Artificial; Ejercicio; Prescripción Ejercicio; Machine Learning.

INTRODUCTION

Artificial intelligence (AI) has emerged as an innovative tool in healthcare, with applications ranging from diagnosis to personalization of therapeutic interventions.[1] In sports physiotherapy, AI transforms exercise prescription by enabling a more precise, adaptive, and evidence-based approach.[2] These advances are particularly relevant in sports performance optimization, injury prevention, and rehabilitation, where individualizing programs is essential to maximize outcomes and minimize risks.[3] AI applied to exercise prescription uses machine learning and deep learning algorithms to analyze large volumes of data and generate personalized recommendations.[4] These models can be used to analyse large volumes of data and generate personalised rec ommendations for exercise.

AI applied to exercise prescription uses machine learning and deep learning algorithms to analyze large volumes of data and generate personalized recommendations.[4] To adjust exercise variables, These models can process complex information, such as movement biomechanics, physiological responses, and the patient's clinical history.[5] For example, recurrent neural networks allow monitoring of the patient's.[5] For example, recurrent neural networks can monitor performance evolution in real-time, while random forest algorithms identify risk factors to prevent relapses or re-injuries.[6] Studies have shown that software programs can be used to monitor performance in real time.

Studies have shown that exercise programs designed with AI can improve accuracy in load dosing, adherence to treatments, and adaptability to individual responses.[7,8] Additionally, integrating technologies such as wearable devices allows for real-time data collection, improving feedback, and continuous personalization.[9] However, challenges remain related to clinical validation, interpretability of models, and ethical considerations in handling sensitive data.[10]

METHOD

This review aims to analyze the current status of AI use in exercise prescription in sports physiotherapy, exploring the types of algorithms used, their efficacy compared to traditional methods, and the opportunities and challenges presented by their implementation.

A narrative literature review will be conducted to analyze the use of artificial intelligence in exercise prescription in sports physiotherapy. The search will be conducted in recognized electronic databases such as PubMed, Scopus, and Web of Science, including studies published between 2015 and 2024. Search terms in English and Spanish will be used, such as 'artificial intelligence,' 'exercise prescription,' 'machine learning,' 'deep learning,' 'sports physiotherapy', and 'rehabilitation.'

Inclusion criteria will be: (1) original studies addressing the use of AI in exercise personalization, (2) peer-reviewed articles, (3) publications in English or Spanish, and (4) studies with application in sports physiotherapy or related areas. Exclusion criteria will be: (1) systematic reviews or meta-analyses, (2) studies in pediatric or animal populations, and (3) articles with restricted access.

The selection of articles will be done in three phases: (1) screening of titles and abstracts, (2) a full-text review of the pre-selected articles and (3) extraction of relevant data such as type of algorithm used, adjusted exercise variables, clinical outcomes, and main findings. The methodological quality of the studies will be assessed using the Critical Appraisal Skills Programme (CASP) tool.

RESULTS

Table 1. Selected studies

Author/Year	Type of Study	AI Model Used	Results
García-de- Villa et al., 2024	Experimental study	Machine Learning techniques with IMU data	A system capable of simultaneously recognising and evaluating physical exercises in older adults using inertial measurement units (IMUs) was developed. The system showed an accuracy of 88,4 % in the identification and evaluation of exercises, demonstrating its potential as a virtual trainer for home-based physical therapy.
Spilz & Munz, 2022	Experimental study	Convolutional Neural Networks (CNNs) and LSTMs	A neural network was trained to assign Functional Movement Screening (FMS) scores to performed exercises, using data from 17 IMUs. The model showed convincing performance in classifying exercise repetitions for known subjects, although a decrease in accuracy was observed with unknown subjects. In known subjects, although a decrease in accuracy was observed with unknown subjects.
Bevilacqua et al., 2018	Experimental study	Machine Learning Techniques	A method was proposed to automatically classify knee rehabilitation exercises using a single inertial unit. The approach showed promising results in classifying exercises performed by clinical and healthy subjects, suggesting its applicability in unsupervised rehabilitation settings.
Jaiswal et al., 2023	Experimental study	Learnable physics simulator	An algorithm capable of diagnosing problems in exercise techniques and providing corrective recommendations in real time was presented. Using MediaPipe for pose recognition and a learnable physics simulator to track movement, the system showed high sensitivity and specificity in exercise assessment, potentially reducing the risk of injury during self-guided training.
Zhao et al., 2021	Study experimental study	Artificial Neural Networks (ANN)	Use of ANN to personalise exercises in patients with sports injuries, showing improvement in recovery and adherence to treatment.
Lee & Kim, 2021	Cohort study	Machine Learning and Deep Learning techniques	Development of an ML-based system for adjusting exercise intensity, with improved post-operative rehabilitation outcomes.
Thompson et al., 2020	Study experimental study	Random Algorithms Forest	Identification of injury risk factors using Random Forest, improving relapse prevention and reducing the risk of re-injury.
Patel & Chan, 2021	Systematic review	Handheld devices and AI	Review of wearable technologies with AI for real-time monitoring, demonstrating that combined use improves adherence to treatment and personalises recommendations.
Black et al., 2020	Experimental study	Sorting Algorithms (Support Vector Machines)	Implementation of SVM for the classification of rehabilitation exercises in patients with ankle sprains, improving accuracy and personalisation.

DISCUSSION

The findings of this review show that artificial intelligence is revolutionizing exercise prescription in sports physiotherapy by offering a more personalized and data-driven approach. Machine learning and deep learning models allow multiple complex variables to be analyzed and exercise programs to be dynamically adjusted, resulting in greater accuracy in dosing and better adaptation to individual responses.[11]

A highlight is the ability of algorithms to identify hidden patterns in data that conventional methods may miss.[12] For example, the use of recurrent neural networks allows not only real-time monitoring of patient progress but also anticipation of possible relapses or complications.[13] These advances can significantly improve the effectiveness of interventions and reduce the risk of recurrent injuries.[14]

Integrating wearable devices (wearables) with AI algorithms has proven to be an effective strategy for collecting real-time data and adjusting exercise programs continuously.[15] This approach allows for dynamic personalization, where exercise variables such as intensity, volume, and frequency are adjusted according to the patient's physiological responses.[16] Furthermore, recent studies suggest that real-time feedback improves patient adherence to exercise programs, a key factor in the effectiveness of the intervention.[17]

Despite these advances, significant challenges remain in implementing AI in clinical practice. External validation of models is crucial to ensure predictions are accurate and applicable to diverse populations.[18] In addition, the interpretability of results is critical for health professionals to have confidence in the

recommendations generated by algorithms.[19] Lack of transparency in some deep learning models may limit their clinical acceptance and application.[20]

Another critical issue is the ethical handling of sensitive patient data. It is essential to establish clear protocols to ensure privacy and security of information in compliance with international data protection regulations.[21] In addition, equity in access to these technologies is a relevant issue, as the availability of AI tools may be limited in environments with fewer resources.[22]

In terms of professional training, it is essential to train sports physiotherapists in using and interpreting AI to facilitate its integration into clinical practice.[23] Interdisciplinary collaboration between engineers, data scientists, and healthcare professionals is essential for developing more robust models adaptable to real clinical needs.[24,25]

In summary, artificial intelligence represents a promising advance in exercise prescription in sports physiotherapy, potentially optimizing clinical outcomes and improving patient experience. However, further research addressing validation, interpretability, equity of access, and ethical implications is essential to ensure safe and effective implementation in clinical practice.

CONCLUSIONS

AI is emerging as a revolutionary tool in exercise prescription in sports physiotherapy, offering more personalized, accurate, and data-driven approaches. Machine learning and deep learning algorithms allow for a more detailed analysis of physiological and biomechanical variables, facilitating the continuous adaptation of exercise programs according to individual patient needs. This ability to personalize and dynamically adjust improves exercise dosage, treatment adherence, and injury prevention, representing a significant advance in sports rehabilitation.

However, despite promising advances, implementing AI in clinical practice faces significant challenges. The external validation of models, the

interpretability of results, and ethical implications related to handling sensitive data are issues that need to be addressed to ensure safe and effective implementation. In addition, equity of access to these technologies and adequate training of healthcare professionals are key issues to maximize the impact of AI in sports physiotherapy.

In summary, while artificial intelligence has great potential to transform exercise prescription in sports physiotherapy, practitioners and researchers must continue to work on overcoming technical and ethical challenges. Only then will this technology be effectively and safely integrated into clinical practice, optimizing patient outcomes and advancing the continuous improvement of therapeutic interventions.

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FINANCING

None.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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