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REVIEW ARTICLE

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Artificial Intelligence in the Management of Low Back Pain

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Abstract

Background: The last decade has witnessed a technological revolution driven mainly by the development of artificial intelligence (AI), a technology designed to replicate human thinking and behavior. AI has significantly penetrated almost all professional fields, including the medical sciences. The study aimed to review the literature data on the application of AI in the management of low back pain (LBP).

Methods and Results: This study summarizes relevant data from PubMed, Google Scholar, and Scopus, published between 2000 and 2023. Only studies published in English were considered. Artificial intelligence showed great promise in improving the accuracy of LBP diagnosis, optimizing treatment approaches, and predicting clinical outcomes. Artificial intelligence has facilitated the development of personalized self-management programs and real-time symptom monitoring. AI models have outperformed traditional statistical methods in predicting long-term pain and functional recovery.

Conclusion: Although current data suggest a promising role of artificial intelligence in managing LBP, ongoing research will be crucial to determine its clinical utility and broader integration into everyday clinical practice.(**International Journal of Biomedicine. 2025;15(3):452-456.**)

Keywords: artificial intelligence • machine learning • low back pain • therapy • clinical outcomes

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Introduction

Low back pain (LBP) is a broad clinical term encompassing a spectrum of conditions characterized by pain and discomfort localized between the costal margin and the inferior gluteal folds.[1,2] Low back pain affects approximately 50% of adults at some point in their lifetime, with peak prevalence occurring between the ages of 40 and 50,[1] and a substantial burden is also observed among older adults.[3]

Low back pain refers to axial, non-radiating discomfort confined to the lumbar region, occurring in the absence of red-flag indicators suggestive of serious pathology—such as neoplastic processes, infectious etiologies, or cauda equina syndrome—as well as without evidence of specific spinal disorders, including spinal canal stenosis, radiculopathy, osteoporotic vertebral fractures, or seronegative spondyloarthropathies such as ankylosing spondylitis.[4,5]

The diagnosis of LBP is primarily established through a process of exclusion, ruling out identifiable etiologies such as intervertebral disc herniation, spinal infection, malignancy, and other red-flag conditions indicative of serious underlying pathology.[6]

Patients presenting with acute LBP are initially assessed for the presence of red flag indicators, which may suggest an underlying serious pathology necessitating prompt and comprehensive diagnostic evaluation.[7] In the absence of alarm signals, doctors usually inform patients about the nonspecific nature of low back pain and the high probability of a favorable prognosis. Patients are instructed to avoid prolonged bed rest and to maintain physical activity within acceptable limits. It encourages an early return to work and daily activities to promote functional recovery.[8]

First-line pharmacologic management of low back pain typically includes acetaminophen, non-steroidal anti-inflammatory drugs (NSAIDs), and muscle relaxants, with subsequent incorporation of physical therapy and rehabilitative interventions as indicated.[9]

Recent technological advances have made AI a key tool in modern healthcare, enabling secure management of patient data, improving medical image analysis, supporting diagnostic decision making, and acting as virtual assistants for both physicians and patients.[10]

The concept of AI was first introduced by Professor John McCarthy at the Dartmouth Conference in 1956, where it was defined as the creation of intelligent machines capable of perceiving, understanding, reasoning, learning, and making decisions in a manner analogous to human cognition.[11]

Artificial intelligence, including machine learning algorithms, has quickly become an integral part of modern healthcare, and the field of rehabilitation is poised to benefit significantly from its analytical and predictive capabilities.[12] The integration of AI into physical therapy and rehabilitation has been linked to improved patient compliance and faster recovery times, primarily through the implementation of personalized, data-driven intervention strategies.[13]

Beyond interpretation, AI has demonstrated utility in enhancing and reconstructing spinal imaging. AI algorithms can be trained to distinguish between high-quality and degraded MRI or CT images, enabling the reconstruction of clearer, diagnostically valuable images from suboptimal input data. This capability not only improves image quality but also has the potential to reduce the need for repeat imaging, thereby minimizing patient exposure to radiation and streamlining diagnostic workflows.[14]

Artificial intelligence can also be effectively utilized to detect pain through neurophysiological approaches.[15] Electroencephalography (EEG), which records the brain's electrical activity, has been employed in conjunction with AI algorithms to not only identify the presence of pain but also quantify its intensity. These advancements suggest a promising role for AI in developing objective, real-time pain assessment tools, particularly in clinical scenarios where patient self-reporting is limited or unreliable.[15-17]

This literature review aimed to explore emerging applications of AI in the management of LBP, with a particular focus on recent biomedical innovations and their clinical relevance.

Material and Methods

An electronic literature search was conducted using the biomedical databases PubMed/MEDLINE, Scopus, and the National Library of Medicine, covering publications from 2000 to 2023. Only studies published in English were considered. The keywords used in the search included "artificial intelligence," "low back pain (LBP)," and " LBP diagnosis." Article selection was based on a review of titles and abstracts containing the phrase "artificial intelligence in low back pain management," with a focus on clinical applications. The inclusion criteria for this review encompassed case reports, case series, original research articles, review papers, in vitro and in vivo studies, animal studies, and controlled clinical trials involving the use of AI in physiotherapy-related contexts.

Results and Discussion

The search results revealed a significant number of scientific studies devoted to studying the role and importance of AI in diagnosis, monitoring, and treatment of low back pain.

Artificial Intelligence in LBP Diagnosis

In the context of diagnostic research on low back pain (LBP) by using AI, studies used brain magnetic resonance imaging (MRI) to investigate morphological predictors of LBP, electromyographic (EMG) signals, kinematic parameters, biomechanical metrics, and utilized structured clinical data and unstructured clinical narratives.

Lee et al. utilized brain magnetic resonance imaging (MRI) in conjunction with physiological parameters from a cohort of 53 subjects to differentiate between individuals with low back pain (LBP) and healthy controls, achieving a classification accuracy of 92.5%.[18]

Lamichhane et al.[19] investigated multimodal biomarkers by analyzing brain MRI scans from 24 LBP patients and 27 healthy controls, achieving a classification accuracy of 78.7%. A follow-up study, the same research group[20] enhanced their methodology by incorporating an Elastic Net (Enet)-based subset feature selection technique, which improved the performance of the Support Vector Machine (SVM) classifier, yielding an increased accuracy of 83.1%. Similarly, Shen et al.[21] focused on alterations in brain functional connectivity associated with chronic LBP. Utilizing MRI data from a cohort of 90 patients, they achieved a classification accuracy of 79.3%. These findings collectively highlight the potential of advanced neuroimaging techniques and machine learning methods in distinguishing LBP patients from healthy individuals.

Among the investigations focused on LBP using clinical data, Staartjes et al.[22] applied a fuzzy rule-based classification method, grounded in Chi's algorithm, to clinical data from 262 subjects, achieving a diagnostic accuracy of 96.2% in identifying LBP.

Among the studies focusing on the diagnosis of LBP through electromyographic (EMG) signals and kinematic/biomechanical measurements, Caza-Szoka et al.[23] conducted a surrogate analysis of fractal dimensions derived from surface EMG (sEMG) sensor arrays. They aimed to identify a predictive marker for chronic LBP in a cohort of 24 participants. Using a feedforward neural network, the study achieved a classification accuracy of 80%. Abdollahi et al.[24] leveraged kinematic parameters derived from motion sensor data to stratify a cohort of 94 individuals afflicted with nonspecific low back pain (LBP), employing a support vector machine (SVM) classifier, which yielded a predictive accuracy of 75%. In a parallel investigation, Bishop et al.[25] utilized a feedforward neural network architecture to discriminate among 183 LBP patients by analyzing dynamic motion features, attaining a classification accuracy of 85%.

Regarding investigations aimed at quantifying LBP, Sari et al.[26] evaluated the performance of a feedforward neural network and an adaptive neuro-fuzzy inference system for the objective assessment of LBP intensity. The models utilized inputs comprising skin resistance measurements and visual analog scale scores from a sample of 169 patients, achieving a pain intensity prediction error of 4%.

Artificial Intelligence in LBP Treatment

In recent years, the use of mobile apps for the treatment of various diseases has increased due to the COVID-19 pandemic.[27] The effectiveness of physiotherapeutic interventions for LBP depends on a comprehensive assessment of the patient's condition, including medical history, physical examination findings, therapeutic goals, and selected rehabilitation methods.

Successful outcomes depend on the integration of multifactorial data and evidence-based clinical decision making throughout the treatment process.[28,29]

The benefits of AI can be seen when it is used to monitor and even provide recommendations to patients experiencing chronic back pain. AI algorithms can be used to assess pain quality, monitor opioid use, analyze sleep patterns, suggest self-care methods, and recommend exercises to help the patient manage pain.[30]

Anan et al.[31] evaluated the efficacy of an exercise-based, AI-assisted interactive health promotion system delivered via a mobile messaging app in relieving musculoskeletal symptoms among workers with neck/shoulder stiffness or pain and LBP. Their results show that participation in the program, which included brief targeted exercises, resulted in significant symptom improvement in both regions over the 12-week intervention period. Similar results were found by Rughani et al.[32]

Alzouhayli et al.[33] conducted a randomized clinical trial involving 52 participants to compare the treatment outcomes in patients with LBP using AI-based resistance therapy in both clinical and home settings. The study focused on pain levels, functional status, and kinesiophobia. The authors concluded that AI-based resistance training could serve as a cost-effective adjunct to traditional clinical treatment of LBP. Oude et al.[34] conducted a study in which a predictive model for low back pain was developed using approximately 1,300 simulated cases, subsequently validated on real patient data, achieving a moderate accuracy level of 72%.

Marcuzzi et al.[35] evaluated the effectiveness of an AI-based app (SELFBACK) that provides personalized self-management support in addition to usual care, compared with usual care or non-personalized web-based support (e-Help) in patients with neck and/or low back pain. The intervention did not show significant improvement in musculoskeletal health, highlighting the need for further research.

Integrating AI into healthcare can bridge the existing gap between physicians and patients by enabling more effective communication, maintaining accurate and up-to-date patient records, monitoring patient lifestyle, providing timely reminders for exercise or medication adherence, and providing quick answers to patient questions.[30,36,37]

Artificial Intelligence in LBP Prognosis

Non-surgical rehabilitation is a common approach to the treatment of chronic LBP. Surface electromyography (sEMG) topography has been proposed as an objective tool to assess rehabilitation outcomes. In this context, Hu et al.[38] demonstrated that quantitative time-varying analysis of sEMG topography differed significantly between healthy individuals and individuals with LBP. Jarvik et al.[39] utilized a machine learning approach using the least absolute shrinkage and selection operator (LASSO) to build predictive models incorporating baseline patient characteristics, early interventions within the first 90 days, and changes in disability and pain during this period. Their results showed that baseline factors had a greater impact on long-term (2-year) disability and pain outcomes than the effects of early therapeutic interventions.

Recent advances in artificial intelligence and related algorithms have significantly accelerated progress in the assessment and diagnosis of spinal disorders.[40,41] Traditional T2-weighted lumbar spine MRI lacks sufficient sensitivity to predict LBP. Recent studies show that machine learning (ML) and deep learning (DL) models can significantly improve predictive accuracy, offering the potential for improved diagnosis and more effective patient treatment.[42,43] Muhaimil et al.[42] demonstrated that machine learning (ML) and deep learning (DL) models can effectively predict LBP using T2-weighted lumbar spine MRI. These models have the potential to enhance diagnostic accuracy and contribute to improved patient management and clinical outcomes. The findings of Azimi et al.[44] show that the artificial neural network (ANN) model can effectively predict 2-year postoperative satisfaction and demonstrates superior prediction accuracy compared with the logistic regression model, highlighting its potential for clinical application.

Conclusion

The use of AI in diagnosing, treating, and predicting outcomes for LBP marks a significant breakthrough in modern rehabilitation medicine. By utilizing machine learning algorithms, neuroimaging, electromyographic analysis, and mobile health technologies, AI shows great promise in improving diagnostic accuracy, tailoring treatment approaches, and predicting clinical outcomes. Studies employing MRI, EMG, and biomechanical data have achieved high diagnostic accuracy, confirming the reliability of AI-based tools in differentiating patients with LBP from healthy controls. In the field of LBP treatment, AI has facilitated the development of personalized self-management programs and real-time symptom monitoring; however, the variability of results highlights the need for continuous improvement and rigorous validation. In terms of prediction, AI models have outperformed traditional statistical methods in predicting long-term pain and functional recovery with greater accuracy. While existing evidence highlights the promising role of AI in improving the management of LBP, ongoing research is crucial to enhance these technologies, establish their clinical benefit, and support their wider integration into everyday clinical practice.

Competing Interests

The authors declare that they have no competing interests.

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