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Technology in Physiotherapy: A Bibliometric Analysis of Artificial Intelligence in Physiotherapy and Rehabilitation

Fizyoterapide Teknoloji: Fizyoterapi ve Rehabilitasyonda Yapay Zekâya Dair Bibliyometrik Bir Analiz

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ABSTRACT

Objective: This study aimed to perform quantitative and qualitative evaluations of the state of artificial intelligence (AI) for physiotherapy and rehabilitation.

Materials and Methods: The bibliometric data have been collected using title and abstract keyword searches from the Web of Science database for AI applications in the physiotherapy field. A total of 187 articles were identified using keywords such as machine learning, deep learning, artificial neural network, artificial intelligence, natural language processing, and physiotherapy.

Results: A total of 187 articles published between 2001 and 2024 were analyzed. The year 2023 had the highest publication volume (47 articles). "Engineering Electrical Electronic" was the most productive research field. Frequently occurring terms included "Machine Learning," "Rehabilitation," and "Artificial Intelligence."

Conclusions: Publications on artificial intelligence and physiotherapy have significantly increased in recent years. These findings underscore the increasing relevance of AI-driven technologies for clinical practice, therapeutic decision-making, and rehabilitation research. For physiotherapists, healthcare professionals, and interdisciplinary researchers, this study provides valuable insight into emerging trends and areas of concentration. Future work can benefit from bibliometric analyses across different databases to support multidisciplinary research.

Keywords: Artificial intelligence (AI), deep learning, machine learning, physiotherapy and rehabilitation, Web of Science (WoS)

ÖZ

Amaç: Bu çalışma, fizyoterapi ve rehabilitasyon alanında yapay zekânın mevcut durumunu nicel ve nitel olarak değerlendirmeyi amaçlamaktadır.

Materyal ve Metot: Bibliyometrik veriler, Web of Science veri tabanında başlık ve özet anahtar kelime aramaları yapılarak toplanmıştır. "Makine öğrenimi," "derin öğrenme," "yapay sinir ağı," "yapay zekâ," "doğal dil işleme" ve "fizyoterapi" gibi anahtar kelimeler kullanılarak toplam 187 makaleye ulaşılmıştır.

Bulgular: 2001–2024 yılları arasında yayımlanan toplam 187 makale analiz edilmiştir. En fazla yayının yapıldığı yıl 2023 olup, bu yıl içinde 47 makale yayımlanmıştır. En üretken araştırma alanı "Elektrik Elektronik Mühendisliği" olarak belirlenmiştir. En sık karşılaşılan terimler arasında "Makine Öğrenimi," "Rehabilitasyon" ve "Yapay Zekâ" yer almaktadır.

Sonuç: Yapay zekâ ve fizyoterapi üzerine yapılan yayınlar son yıllarda önemli ölçüde artmıştır. Bu bulgular, klinik uygulamalar, tedaviye yönelik karar verme süreçleri ve rehabilitasyon araştırmaları açısından yapay zekâ destekli teknolojilerin artan önemini vurgulamaktadır. Fizyoterapistler, sağlık profesyonelleri ve disiplinler arası araştırmacılar için bu çalışma, yükselen eğilimler ve odaklanılan alanlar hakkında değerli içgörüler sunmaktadır. Multidisipliner çalışma yapan araştırmacılar için Scopus ve PubMed gibi farklı veri tabanlarından çıkarılacak bibliyometrik analizler gelecekteki çalışmalara yön verebilir.

Anahtar Kelimeler: Derin öğrenme, fizyoterapi ve rehabilitasyon, makine öğrenimi, yapay zekâ, Web of Science (WoS)

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INTRODUCTION

Machine learning (ML) and deep learning (DL) are subsets of artificial intelligence (AI).[1] ML is the study of computer algorithms that automatically improve through experience by applying mathematical approaches, and DL refers to an algorithm that learns by processing input data through artificial neural networks (ANN) that mimic neurons in the biological brain.[1] Both are fast-growing, interdisciplinary fields with remarkable applications in clinical practice in healthcare.[2-4] The interdisciplinary nature of these fields, spanning computer science, mathematics, and healthcare, is a testament to the breadth of recent developments in AI technologies leading to innovative healthcare.[5]

AI usually assists healthcare professionals in clinical decision-making, such as diagnosing diseases, planning treatments, and predicting outcomes.[6,7] Integrating AI technology in healthcare is critical for developing novel approaches to addressing healthcare challenges and discovering new opportunities.[8] During the coronavirus disease 2019 (COVID-19), healthcare services had to limit outpatient services. This crisis also highlighted the significant contribution of AI in enhancing telemedicine and telerehabilitation worldwide, paving the way for new possibilities in healthcare.[9] In addition, previous studies have highlighted the potential of ML and DL in physiotherapy and rehabilitation, an essential branch of the healthcare field, to improve quality of life.[10,11]

AI-based systems, such as virtual reality-based rehabilitation platforms and motion-sensing devices, are being developed to activate clinical evaluation areas such as balance, walking, daily living activities, and upper and lower extremity skills.[12-14] These systems can provide real-time feedback, track progress, and predict clinical outcomes, thereby enhancing the quality of care and patient outcomes.[13-15] AI and ML have been used to record exercises, provide personalized advice, and detect joint angles.[16] ANN has also been used for gait classification and monitoring according to the lower extremity joint angle.[17] Some studies further pointed out the application of ML in musculoskeletal physiotherapy by proposing a digitalized system for physiotherapy and developing a smart sensor-based rehabilitation exercise recognition system.[14,16] Current literature underscores the potential of AI technologies to improve the accuracy, efficiency, and personalization of physiotherapy practices.[10,11,13-16] A few reviews in the literature investigate physiotherapy and rehabilitation practices supported by AI technology. [16-19]

However, there has yet to be a bibliometric analysis that scans research and journals to guide researchers in publishing their work in this common field. This study aimed to perform quantitative and qualitative evaluations of the state of AI in physiotherapy and rehabilitation.

MATERIALS AND METHODS

***Ethical Approval*:** The bibliometric data have been collected using the title and abstract keyword search from the Web of Science database for terms belonging to AI in the physiotherapy field. Ethics committee approval of this study is not required.

Data Collection: The bibliometric data have been collected using the title and abstract keyword search from the Web of Science (WoS) database for terms belonging to AI in the physiotherapy field. The study used the keywords "Physiotherapy" OR "Physical Therapy" AND "Machine Learning," "Deep Learning," "Artificial Intelligence," "Artificial Neural Network," OR "Natural Language Processing." These keywords were selected based on a preliminary review of the literature and common terminology found in prior studies intersecting artificial intelligence and physiotherapy. The aim was to capture a comprehensive range of relevant articles covering core AI methodologies (e.g., machine learning, deep learning) as well as broader AI-related terminology (e.g., artificial intelligence, neural networks, NLP).

The publication periods are from 2001 to 2024 (data accessed: 29 May 2024), and the articles, reviews, conference proceedings, and book chapters published in the English language were included in the research. The comprehensive search has yielded a substantial corpus of 187 documents (Figure 1).

Bibliometric Analysis: Bibliometric analysis was conducted following the guide developed by Donthu and his colleagues.[20] The subsequent step involved the bibliometric analysis of these selected documents, focusing on identifying key patterns and trends in the research field. The bibliometric study helps in understanding research trends and guides researchers and funding agencies in making informed decisions about publication strategies, promotions, research priorities, collaborations, and funding allocations.

This study uses bibliometric analysis to provide an overview of AI trends in the field of physiotherapy and rehabilitation. Initially, the analysis was performed using an advanced WoS search. The WOS was selected due to its comprehensive coverage of multidisciplinary and high-impact journals, as well as its robust citation indexing features, which are highly compatible with bibliometric mapping tools such as VOSviewer and Biblioshiny. Specifically, the advanced search capabilities of WoS provide access to detailed bibliometric indicators, including top source titles, publication counts by quartile, an-

nual publication trends, citation metrics, document type classifications, WoS category distributions, and citation topic clusters. These characteristics made WoS particularly suitable for conducting rigorous quantitative and qualitative analysis. Nevertheless, it is acknowledged that the inclusion of additional databases such as Scopus or PubMed in future studies could further enrich the scope and comprehensiveness of bibliometric evaluations.

We used the bibliometrix application, specifically biblioshiny 4.1, which is an R tool (R 4.4.0 version used in this study) for comprehensive science mapping analysis. The biblioshiny application, a web interface for bibliometrics, is Java software, and it was used to observe affiliations of published articles.[21] Authors tagged publications according to subbranches of physiotherapy. Publication numbers and citation numbers are shown according to these fields. VOSviewer is a user-friendly tool known for its simplicity, flexibility, and responsiveness to user demands. It offers high-quality graphics but limits alternatives to its pre-programmed functions and requires repeated analysis due to its inability to combine data from different sources. Finally, the documents most comprehensively analysed with VOSviewer were subjected to Network Visualisation, enabling the creation of a visual map that displays the interrelationships between various author keywords. This methodological approach ensures a structured and rigorous literature analysis, offering valuable insights into the convergence of technologies and methodologies within rehabilitation technology.

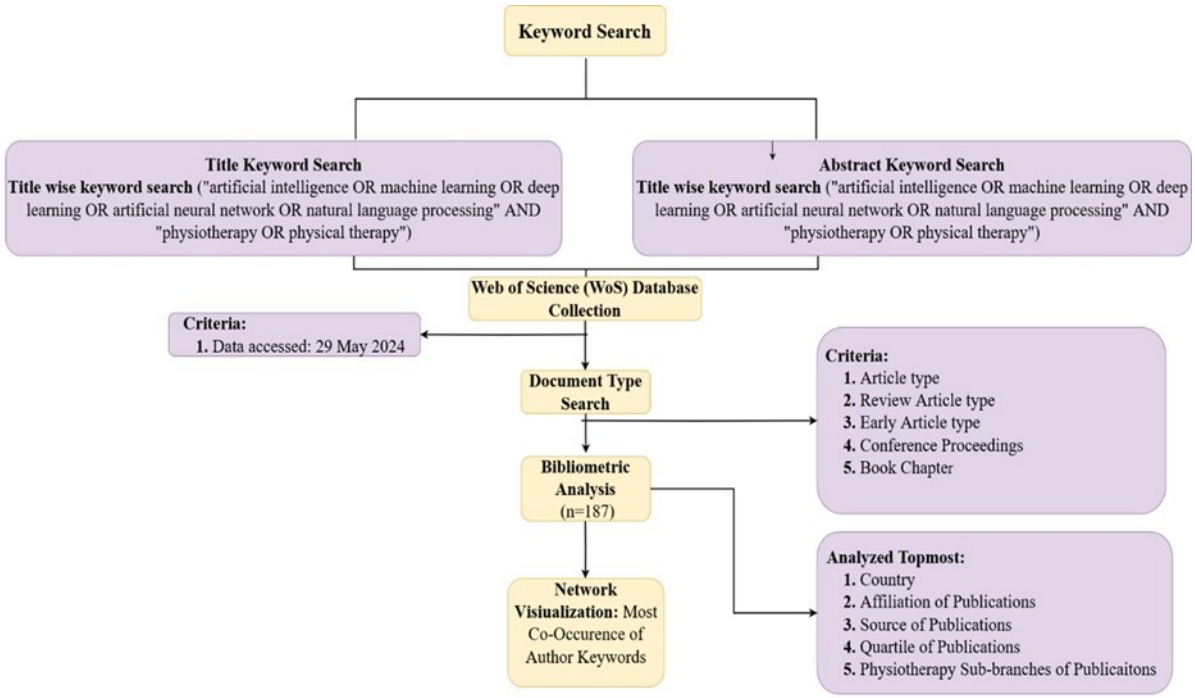

Figure 1. Workflow diagram.

RESULTS

A total of 187 articles published between 2001 and 2024 were included. The number of published articles remained low until 2016, followed by a steady rise, peaking at 47 publications in 2023. This trend highlights the growing research interest in the application of computational methods in physiotherapy. Publications rose from 18 in 2020 to 37 in 2022, reaching a peak of 47 in 2023. Category-specific growth followed a similar pattern. Notably, 38 articles indexed in the Science Citation Index Expanded were published in 2023, indicating rising academic interest in the field. This reflects increasing academic recognition and dissemination of computational approaches in physiotherapy across high-impact venues. The notable rise in publications after 2020 likely reflects the increased attention toward remote rehabilitation and AI-driven healthcare solutions prompted by the COVID-19 pandemic. Most documents were original research articles (126), followed by proceeding papers (47) and review articles (11). Other types, such as editorials, book chapters, and data papers, were rare, underscoring a strong focus on peer-reviewed research. Between 2001 and 2015, the number of publications was limited. Over time, however, research expanded across various subfields, with significant contributions in neural systems and rehabilitation engineering. Although the article count was low (3 and 1, respectively), highly cited journals included *IEEE Transactions on Neural Systems and Rehabilitation Engineering*. *Sensors* was the most prolific journal, contributing 15 articles. *IEEE Access* and *Applied Sciences-Basel* followed with six and five articles, respectively. Most papers were published in Q2 of 2023 (Table 1). Specifically, we note that Sensors is an open-access journal with a strong focus on applied technologies in healthcare, which may attract a higher volume of submissions in emerging interdisciplinary areas like AI in physiotherapy.

The most frequently cited sources reflect the interdisciplinary nature of the field, with *Sensors* (107 citations), *npj Digital Medicine* (100), and *JMIR mHealth and uHealth* (85) leading in impact. Other prominent journals include *IEEE Transactions on Neural Systems and Rehabilitation Engineering* and *Composites Part A*, each with 72 citations, followed by *IEEE Access* (69). These highly cited publications span domains such as biomedical signal processing, rehabilitation, digital health, and applied sciences, indicating a broad and growing academic interest. Institution-wise, the University of Toronto led with 22 publications, followed by Harvard University (12), Harvard Medical School (8), and the University of California System (8). Additional contributions came from institutions such as Radboud University Nijmegen and Shanghai Jiao Tong University, each with 6 articles. Citation patterns varied by sub-branch. While musculoskeletal rehabilitation had the most articles, neurological and orthopedic topics had relatively higher citation rates, suggesting greater scholarly influence (Figure 2).

Table 1. Publication count by quartile and proceedings per year.

Publication Year	BOOK	ESCI	PROCEEDING	Q1	Q2	Q3	Q4	Rehabilitation: Q1 Engineering: Q2
2001	0	0	0	1	0	0	0	0
2007	0	0	0	0	0	1	0	0
2009	0	0	0	0	1	0	0	0
2010	0	0	1	0	0	0	0	0
2011	0	0	0	1	0	0	0	0
2013	0	0	1	1	2	1	0	0
2014	0	0	0	0	0	0	0	1
2015	0	0	4	0	1	0	0	0
2016	0	0	2	1	0	1	1	0
2017	1	0	2	0	0	0	1	0
2018	0	0	4	0	1	1	0	0
2019	0	0	6	1	3	3	3	1
2020	0	0	7	1	6	2	2	0
2021	0	1	4	1	11	2	3	0
2022	0	0	8	5	17	2	5	0
2023	0	0	4	6	26	8	2	1
2024	0	0	0	3	8	3	1	0

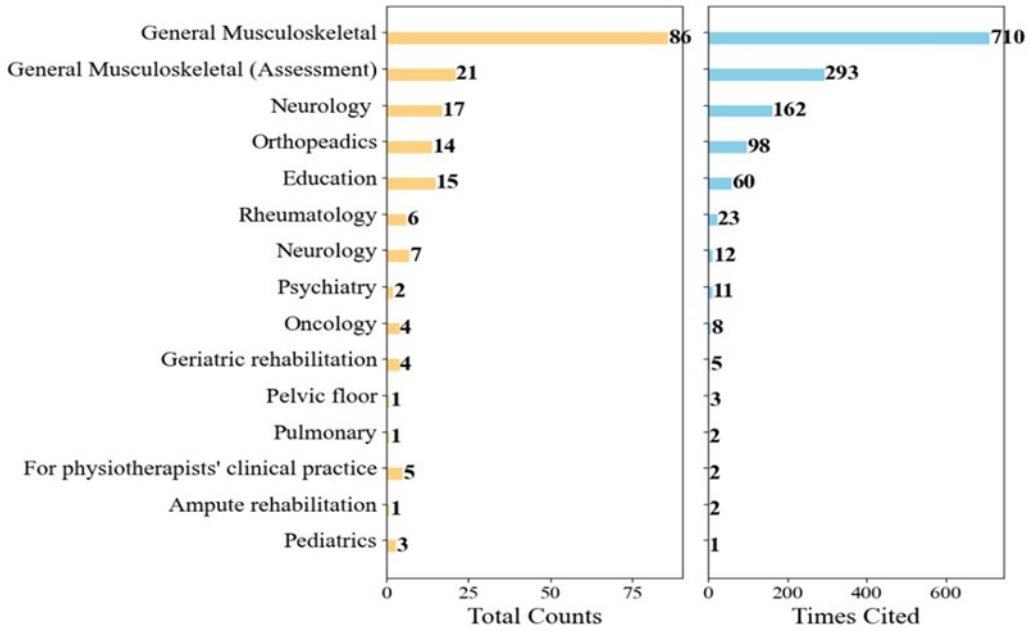

Figure 2. Times cited and total counts across physiotherapy sub-branches.

Other significant fields include AI-related computer sciences and rehabilitation. At the meso level (Figure 3a), “Gait and Posture” led (47.7%), while “Rehabilitation Robotics” was most prominent at the micro level (34.7%), followed by “Falls” (18.9%) (Figure 3b). As depicted in Figure 3c, “Engineering Electrical Electronic” was the dominant category (22.8%), followed by “Instruments Instrumentation” and “Engineering Biomedical” (both 12.6%).

Finally, the co-occurrence network (Figure 4) shows frequent keyword pairings. "Machine Learning" was central, closely associated with "Physiotherapy," "Natural Language Processing," and "Wearable Sensors." Other relevant terms like "Artificial Intelligence," "Virtual Reality," and "Pose Estimation" highlight the field’s interdisciplinary scope and technological integration.

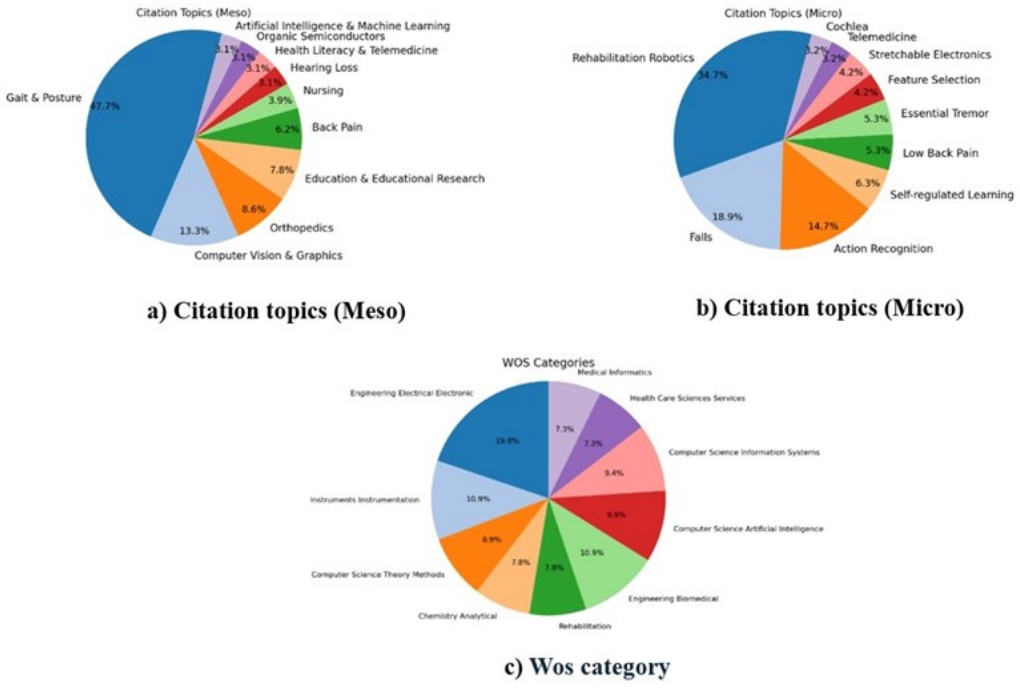

Figure 3. Distribution of Web of Science categories.

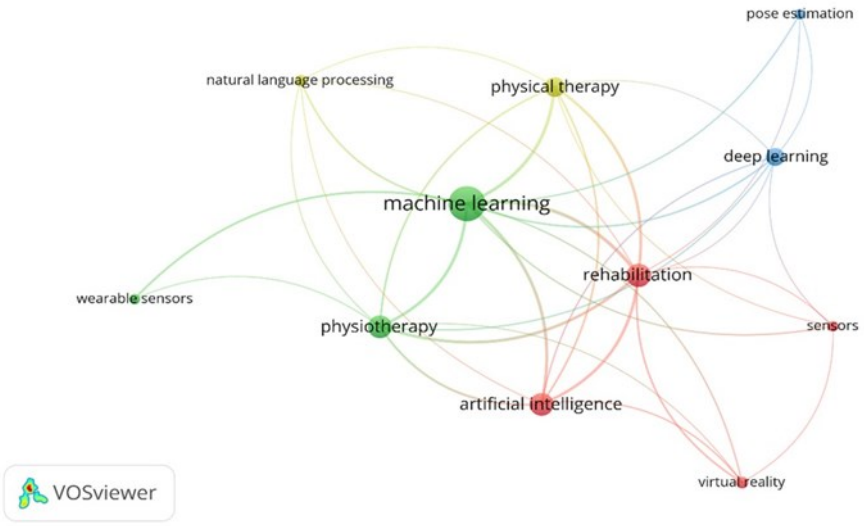

Figure 4. Co-occurrence network visualization of author keywords in rehabilitation technology research.

DISCUSSION AND CONCLUSION

The findings show that articles on AI in physiotherapy and rehabilitation are relevant studies that have started to be published in recent years. The fact that 47 articles were published in 2023, the year with the most publications, shows that the field has been open to development in recent years. These findings are concurrent with the significant contribution of AI in enhancing telerehabilitation during the COVID-19 pandemic.[9] The increasing trend in recent years suggests that telerehabilitation, which gained momentum during the pandemic, is likely to remain a mainstream component of healthcare delivery going forward.[22] According to the WoS categories, "Electrical, Electronic Engineering" is the most published research field. It was observed that the journal “Sensors" stands out in this field, especially as the journal that publishes the most and receives the most citations. It was seen that gait assessment and motion analysis issues are prominent in using AI in physiotherapy and rehabilitation. When the WoS citation topics were considered, "Gait and Posture" was the most studied area, followed by "Computer Vision and Graphics" at the meso level. The systematic review presented in 2024 showed the use of DL techniques in physiotherapy and rehabilitation with an emphasis on exercise and movement analysis.[23] The hybrid models, such as CNN + LSTM (Convolutional Neural Network + Long Short-Term Memory), CNN + GRU (Convolutional Neural Network + Gated Recurrent Unit), and MLP + SVM (MultiLayer Perceptron + Support Vector Machine), were explained in usage for the rehabilitation field.

The most cited article was about wearable biometric monitoring devices (BMDs) and artificial intelligence (AI), enabling patient data to be measured and analyzed remotely. The authors emphasized that considering patients' perspectives ensures that technology is utilized effectively without compromising the human aspects of care, causing undue burden, or intruding on patients' lives in their study. The second most cited article was about a home care system using a commercial smartwatch and ML model that could facilitate participation in home education and be used for home care therapy in the treatment of chronic stroke patients.

Co-occurrence analysis, which identifies high-frequency keywords appearing in various studies, can assist researchers in quickly grasping the key points of a relevant topic. In this study, the most frequently used keywords were "Machine Learning," "Artificial Intelligence," "Rehabilitation," "Physiotherapy," and "Deep Learning." Additionally, the keywords "Sensors," "Wearable Sensors," and "Virtual Reality" were found to form the same cluster.

In addition, the area most researched at the micro level in our study was rehabilitation robotics, which probably accounted for the most significant proportion due to its emerging potential to improve patient recovery and quality of life. "Rehabilitation Robotics" was followed by "Falls" in our study. "Falls"

was the second most common topic, highlighting the critical need for effective fall prevention and management strategies, especially in the aging population. Numerous scoping and systematic reviews exist in the literature on the prevention and detection of falls in older adults using AI applications.[24,25] A bibliometric analysis like our study was also found on AI and falls in older adults.[26]

The literature systematically maps the use of machine learning in neurorehabilitation, which includes diseases such as stroke and spinal cord injury, neurodegenerative disease, Parkinson's disease, and quadriplegia.[27] It has been concluded that ML is a field of computational intelligence research that examines the development of methods that can extract concepts (knowledge) from data samples, and is most used in stroke patients. Recent studies have further demonstrated the feasibility of AI integration in clinical and telerehabilitation settings, particularly through wearable sensors, VR systems, and intelligent robotic devices.[28,29,30] These findings support the notion that real-world adoption of AI is accelerating, especially for gait analysis, post-stroke rehabilitation, and motion tracking.

The integration of AI and machine learning into physiotherapy is reshaping clinical practice by enabling personalized, data-driven interventions. Tools such as wearable sensors and predictive models not only enhance assessment and treatment but also lay the groundwork for standardized, technology-informed clinical guidelines. These developments point toward a future where hybrid care models and AI-assisted evaluations become integral to rehabilitation protocols.

In conclusion, to our knowledge, this is the first study in which bibliometric analysis has been conducted on AI-related physiotherapy and rehabilitation subjects, which have recently gained attention worldwide. This study provides a comprehensive bibliometric analysis of AI applications in physiotherapy and rehabilitation, highlighting a sharp rise in publications, particularly following the COVID-19 pandemic. While the overall number of publications remains modest, the increasing trend underscores growing interest in areas such as gait analysis, rehabilitation robotics, and telerehabilitation. It also highlights the need for a multidisciplinary approach involving clinicians, engineers, and data scientists to advance rehabilitation technologies. One of the limitations of this study is the exclusive use of the Web of Science (WoS) database for bibliometric analysis. Future studies could benefit from incorporating data from multiple scientific databases, such as Scopus and PubMed, to provide a more comprehensive understanding and support researchers working in multidisciplinary fields. To guide future work, researchers should focus on developing explainable AI models that can be integrated into clinical workflows, particularly for personalized therapy, remote monitoring, and outcome prediction. Promising areas include adaptive exercise systems, intelligent prosthetics, and AI-assisted movement analysis. Practitioners may benefit from AI tools for motion tracking, progress monitoring, and patient adherence, especially in telehealth settings.

Ethics Committee Approval: The bibliometric data have been collected using the title and abstract keyword search from the Web of Science (WoS) database for terms belonging to AI in the physiotherapy field.

Conflict of Interest: No conflict of interest was declared by the authors.

Author Contributions: Concept- GKA, TBO, IA; Materials – IA, GKA, YSA; Data Collection and/or Processing – TBO, IA, GKA; Analysis and/or Interpretation – TBO, IA, GKA, YSA; Writing – TBO, IA, GKA, YSA.

Peer-review: Externally peer-reviewed.

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