DIJMSR Received:14-2-2025 Accepted:10-3-2025

Artificial Intelligence Algorithms and Applications in Physical Therapy for Patients with Low Back Pain: Review of the Past Five Years

Abstract: Our concise review aimed to understand the potential of artificial intelligence (AI) algorithms and applications in physical therapy and rehabilitation, specifically focusing on patients suffering from low back pain (LBP). The review outlined both the positive and negative implications of AI and machine learning techniques for enhancing health outcomes and promoting healthier lifestyles.
Methods: Studies were sourced from the WOS, Scopus, PubMed, and IEEE Xplore databases. Two reviewers conducted title/abstract and full-text screening. Data were gathered on model type, input variables, predicted outcomes, and machine learning techniques.
Results: Articles published between 2019 and 2024, focusing specifically on LBP and AI, including 12 papers showcasing a range of AI applications, including the "self back app," a mobile application designed for self-monitoring, prediction, and self-guided management of low back pain patients, demonstrating noteworthy positive outcomes. Additionally, convolutional neural networks (CNNs), a computational method, were utilized to analyze medical images and identify specific weak back muscles, aiding physiotherapists in designing targeted interventions. AI interventions were also employed to show the suitability of acute LBP patients for particular treatments based on collected data. However, some studies indicated that AI interventions are not universally effective. Contrary to expectations, patients engaged in regular exercises exhibited comparable treatment outcomes within similar timeframes to those using AI interventions alongside their routine exercises.
Conclusion: AI is transforming physiotherapy, particularly in treating LBP. This shift is evident in studies on real-time exercise feedback via mobile apps, analysis of trunk movement, and machine learning-based classification in individuals with chronic LBP. Furthermore, medical expert systems leveraging Bayesian networks offer innovative and personalized management strategies, redefining the future of physiotherapy.
Keywords: Artificial intelligence – Low back pain – trials – Applications -machine learning – Physical therapy

Abdelazeem Hussien[1], Abdelrahman Mohammed[2], Doaa A. Abdel Hady[3]

[1,2] Student at Faculty of Physical Therapy, Deraya University, Minia, Egypt.
abdelazim.hussein_2230272@student.deraya.edu.eg & abdelrahman.mohamed_2230297@student.deraya.edu.eg
[3] Assistant Professor Department of Physical Therapy for Women's Health, Faculty of Physical Therapy, Deraya University, Minia, Egypt. doaaabdlnaser@gmail.com -doaa.abdelnaser@deraya.edu.eg
Corresponding Author: Doaa A. Abdel Hady[000000232479402] doaa.abdelnaser@deraya.edu.eg

Manuscript ID: DIJMS-2502-1004 (R1)
DOI: 10.21608/D|JMS.2025.360591.1004

Introduction:

Low back pain (LBP) ranks among the most common health issues, and it is recognized as the foremost chronic health concern globally.[1] Currently identified as a public health dilemma, it stands as one of the major sources of physical impairment in active populations of developed nations, taking into account muscular and skeletal changes, as well as economic and psychosocial challenges, thus necessitating the implementation of suitable strategies to manage pain and enhance the quality of life (QoL) for LBP individuals.[1-5] AI algorithms can personalize instructional content based on specific patient data, increasing the relevance and usefulness of the information offered. AI-enabled interactive learning experiences, like chatbots and virtual assistants, promote real-time patient communication and feedback. Artificial intelligence also improves accessibility by providing mobile applications and multilingual alternatives, allowing patients to learn at their own pace. Wearables allow for the collection and analysis of data, providing extra insights and information about the patient's behaviors. Furthermore, AI's role in pain management education comprises clarifying intricate pain causes, recommending evidence-based therapy, and promoting adherence through individualized prompts and encouragement.[6-14] However, the effectiveness of AI in physiotherapy varies across studies. Some research suggests that conventional exercise routines yield similar outcomes to AI-powered interventions. Therefore, a nuanced perspective is essential when considering AI's role in physiotherapy.The integration of AI and physiotherapy has the potential to redefine the treatment landscape for LBP. This symbiotic relationship empowers patients and equips healthcare professionals with advanced tools for precise diagnostics and targeted interventions. It also enables more efficient patient management, ensuring appropriate care allocation. However, scrutiny is necessary as AI performance may depend on clinical context and patient characteristics. Discussions within the healthcare community are ongoing to determine the optimal integration of AI in physiotherapy and its potential to deliver personalized, effective, and efficient care for individuals with LBP.[15]

Methods:

We selected our PICO as shown:
Population: Low back pain patients
Intervention: AI and physical therapy modalities
Comparison: any compactor
Outcome: intervention results
Study area: Physical therapy and artificial intelligence

Search Strategy: (Artificial intelligence) AND (Low back pain) AND (Physical therapy):
1-“Artificial intelligence OR AI OR Machine Intelligence OR Machine Intelligence OR Intelligence, Machine OR Computer Reasoning OR Computer Vision System Knowledge OR Acquisition (Computer) OR Knowledge Representation (Computer) OR computer-controlled robot OR robotics Machine OR Natural language processing OR NLP) AND (Low back pain OR LBP OR Lumbago OR Lower Back Pain OR Low Back Ache OR Low Backache OR Postural LBP OR Recurrent LBP OR Mechanical LBP OR Lumbar Pain OR Spinal pain) AND (Physical therapy* OR PT OR Physical therapy modality* OR Physiotherapy OR Physical Therapy Technique OR Group Physiotherapy*”.
2-Inclusion criteria: PICO, physical therapy related, last 5 years publications.
3-Exclusion criteria: non-humans, not included in our PICO, not related to physical therapy, papers before 2019.

Data collection:
We used WOS, Scopus, PubMed, and IEEE Xplore databases. We also had restricted criteria to limit the results. We extracted more than 23 papers that were published only in 2019. After our title and abstract screening and full-text screening, we ended up with about 12 papers, which we did our review.

Results:

A pilot study with a 6-week follow-up demonstrates that AI algorithms can tailor instructional content by examining individual patient data, enhancing the effectiveness of the information provided. Interactive learning experiences powered by AI, such as chatbots and virtual assistants, facilitate real-time communication and feedback with patients. Additionally, artificial intelligence boosts accessibility through mobile applications and multilingual options, enabling patients to learn at their own pace. Wearable devices can collect and analyze data, offering new insights into patients' habits. Participants filled out the primary result pain-related impairment (Roland-Morris impairment Questionnaire [RMDQ]) at baseline and 6-week follow-up, as well as a variety of secondary outcomes. Metrics on app usage were collected throughout the intervention period. The pilot study discovered that participants used the app on a weekly basis and achieved significant improvements across all three content areas: “physical activity, exercise, and education.” The app was determined to be viable and acceptable for usage, with promising results for pain relief and improved physical function. While the enhancement in the RMDQ from baseline to follow-up was limited, the study gives valuable insights for the development of a subsequent randomized controlled trial weekly.[16]

Fig.1 self BACK application theme (Sandel et al, 2020)[16]

In this study, researchers are attempting to employ modern computer algorithms (particularly convolutional neural networks or CNNs) to automatically evaluate images of lower back muscles obtained from MRI scans. They aim to learn how different computer techniques affect the accuracy of detecting individual muscles in the lower back. Previous studies have demonstrated the potential of these strategies, but the goal of this paper is to compare various approaches and determine their impact on accuracy. The idea is to develop these computer models so that they can be utilized by clinicians to more efficiently identify and assess muscles.
The study used computer models to analyze lower back images from 76 individuals. These images were split into two groups: one for training the models and the other for testing them. The models were trained to identify specific muscles in the back, a process that took only about 6.4 seconds per image. The results revealed that certain muscles, like the erector spinae, were noticeably larger than others, such as the psoas major and multifidus. The goal of the trial was to compare the computer-generated results with manually segmented data to evaluate how accurate the computer models were.[17] In this study, researchers set out to develop a machine-learning model that could predict whether patients with acute LBP would recover. They compared the model's predictions to the methods currently used by physiotherapists. The trial involved 247 patients, and the best-performing machine learning model showed decent results, accurately predicting non-recovery for about half of the patients. While it didn't outperform traditional methods, it did surpass current physiotherapy practices. These models hold the potential for personalizing treatment plans in clinics for patients with acute LBP, but more validation is needed before they can be widely implemented.

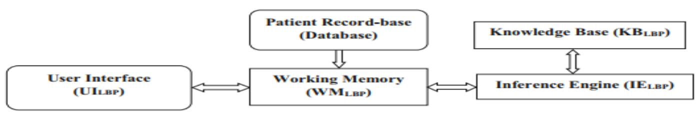

Fig.2 the machine learning model mechanism[18] (Knoop et al, 2022)

In this study, 312 patients with acute LBP were observed. Data was collected from 247 patients at the start, 240 at follow-up, and treatment information from 208. After three months, about 47% of patients had not recovered. The researchers compared various prediction methods, and the best model included factors like a patient's resilience, disability from previous back pain, and expectations for recovery. This model showed moderate accuracy at 63%. Traditional methods and physiotherapists' predictions didn't perform as well. Interestingly, a simpler model that focused on resilience and the frequency of previous back pain episodes had a slightly better accuracy of 68%.[18]

1- The goal of this research was to assess the effects of personalized self-management support provided through an AI-based software (SELFBACK) alongside standard treatment, compared to standard care alone or non-tailored online self-management assistance (e-Help), on musculoskeletal health.This RCT involved participants who had been referred to a specialist for neck and/or LBP. The findings indicated that the personalized, evidence-based support offered through the AI app, when used in conjunction with standard care, did not lead to a substantial boost in musculoskeletal health after 3 months compared to standard care alone or non-targeted online support. The study suggests that future research should explore the effectiveness of digitally supported self-management interventions in specialist care settings, as well as identify tools that can better capture changes in self-management behaviors.[19]

2- This innovative research, explores the creation of a sophisticated medical system aimed at diagnosing the complex and common issue of LBP. Utilizing state-of-the-art artificial intelligence (AI) methods, such as Bayesian networks and effective knowledge representation, the system demonstrates remarkable clinical performance, with precision, recall, accuracy, and F1-score metrics ranging from 71.11% to 76.67%. LBP affects a significant portion of the population (70-85%) and presents unique challenges due to the wide variety of potential pain sources. The system's capability to deliver accurate diagnoses, especially in complicated LBP cases, underscores the immense potential of AI-driven expert systems. It addresses the urgent need for standardized assessments in the complex field of LBP, providing a thorough solution that can be applied in various clinical environments. The MES-LBP, which includes a user interface, information base, working memory, and inference algorithm, stands out as a quick and dependable diagnostic tool poised to transform LBP management. Nonetheless, there are hurdles to overcome, particularly with intricate LBP cases that involve multiple disorders and clinical factors. The dependence on manual medical knowledge raises issues regarding the integration of recent advancements and uncommon clinical situations, which could affect the system's reliability in clinical decision-making. While the design effectively manages clinical uncertainties regarding conflicting results, it does not fully address other uncertainties, such as incompleteness and imprecision. The research highlights the importance of addressing these challenges, expanding testing with a larger patient population, and incorporating clinical investigation data to improve the system's reliability and effectiveness in managing LBP.[20]

This research explores the various lifting techniques used by individuals suffering from CLBP. It employs advanced algorithms to categorize these techniques based on video data from 115 participants. The results highlight four unique lifting patterns within the CLBP group, even among those experiencing similar pain levels. Given that CLBP is a common issue impacting millions globally, it often results in changes to trunk muscle control. While traditional methods classify lifting techniques simply as stoop or leg lifts, this binary classification may not adequately reflect the complex realities faced by CLBP patients. The study aims to know the various lifting patterns in people with CLBP, utilizing untrained machine learning and motion analysis. Furthermore, the research investigates how pain self-efficacy affects these movements, providing a fresh perspective that could tailor rehabilitation strategies for CLBP sufferers. In this study, 115 participants aged 25 to 60 who were experiencing CLBP were recruited from a physiotherapy clinic. Participants need to have been experiencing pain in the area between the gluteal fold and the twelfth thoracic vertebra for more than three months, whether or not they also had leg pain. Importantly, these participants had not received any prior physiotherapy treatments. Assessments of pain self-efficacy were performed using the Pain Self-Efficacy Questionnaire (PSEQ). Individuals were asked to lift an 8 kg weight, producing data from eight studies, with the first two considered practice rounds and excluded from the analysis.[21] This study seeks to determine whether exercising with a machine learning-based motion-detecting mobile exercise coaching application (MDMECA) is more effective than video streaming-based exercise in enhancing quality of life and reducing LBP.[22].A 14-day daily training program that included five exercises was completed by 104 participants in person and 72 participants through video streaming. The Medical Outcomes Study Short Form 36-Item Health Survey (SF-36) and LBP levels were evaluated both pre- and post-workout. After the program, participants provided scores for the treatment-satisfaction subscale of the VAS, their intention to continue with a disease-oriented exercise program, their willingness to recommend the program to others, and their available budget for such a program. Found that In terms of sticking to exercise routines, enhancing QoL, and alleviating LBP, MDMECA shows better results than video streaming-based exercise. MDMECAs could serve as valuable tools for improving health outcomes and boosting patient satisfaction.[22]

	MDMECA (n=104)	Control (n=72)	*p* value
Age (yr)	36.67±8.03	38.28±7.04	0.17
Sex			<0.01*
Male	41 (39.4)	51 (70.8)	
Female	63 (60.6)	21 (29.2)	
History of spinal surgery			>0.99
Underwent spinal surgery	1 (1.0)	0 (0.0)	
None	103 (99.0)	72 (100.0)	
Low back pain, VAS	4.27±2.11	3.65±2.04	0.06
Daily sitting time (hr/day)	8.88±1.96	8.76±1.78	0.70
Daily home exercise duration before workout, min (%)			0.51
0	36 (34.6)	27 (37.5)	
0–30	47 (45.2)	34 (47.2)	
30–60	18 (17.3)	11 (15.3)	
>60	3 (2.9)	0 (0.0)	
Exercise days out of 14 (day)	14.00±0.00	6.76±3.91	<0.01*
Daily exercise achievement rate (%)	100.00±0.00	66.94±26.52	<0.01*
SF-36	65.94±14.36	72.96±12.00	<0.01*
Physical functioning	87.64±13.49	88.40±13.05	0.71
Role limitations due to physical health	87.02±24.13	93.75±14.38	0.02*
Role limitations due to emotional problems	84.29±34.14	85.65±27.88	0.74
Energy/fatigue	41.73±23.95	47.50±16.80	0.06
Emotional well being	54.50±24.19	64.33±16.39	<0.01*
Social functioning	56.37±17.15	59.97±20.84	<0.01*
Pain	63.53±28.04	74.65±20.55	<0.01*
General health	52.45±12.64	59.44±15.73	<0.01*

Fig.4 results of the feedback application [22]

This Pilot study aimed to evaluate the effectiveness of the Computer Kinesiology medical information system in treating patients with LBP. The pilot study included 55 patients suffering from LBP, 51 individuals without LBP, and a control group of 67 healthy volunteers. Patients in both the LBP and non-LBP groups received therapy based on their diagnostic results. The findings revealed significant improvements in the H score for LBP patients in both groups after therapy, highlighting the system's effectiveness in managing LBP.

- MEIS CK is designed to diagnose and treat musculoskeletal system disorders, focusing on physiological and reflex responses. All three groups underwent diagnostic tests using specialized procedures, with treatment provided to Groups 1 and 2. MEIS CK employs 46 physiotherapy tests to evaluate various movements and reflexive changes. The effectiveness of the treatment was measured using a grading system. Notable improvements were seen in LBP patients who received MEIS CK therapy, confirming its therapeutic benefits. The research demonstrated the effectiveness of CK therapy, with an 8.8% difference in enhancement rates between Group 1 and Group 2, supporting its advantages for back pain patients. Conversely, Group 3 showed no changes. This study emphasizes CK therapy's efficacy in improving participants' conditions, There are Significant improvements were observed in both groups, with the 'H score' decreasing by at least one point in **87.3%** of patients with back pain and **78.4%** of participants without back pain.[23]
- Importantly, improvements were independent of factors such as gender, age, BMI, and therapy length.[23]

These results suggest the potential of the Computer Kinesiology system for both primary and secondary prevention of back pain and functional disorders.

Figure (5): Computer Kinesiology

In this Pilot study analysis, we explored the relationship between variables using three different algorithms from the tool.

1. The Naive Bayes algorithm serves as a classifier that analyzes data to create models for categorizing class labels. It operates under the assumption that all predictor variables are independent, meaning they do not influence one another. This classification method has a wide range of applications.
2. Another algorithm employed was designed to uncover association rules, focusing on identifying strong relationships within the data by examining the patterns in which they occur. The before algorithm is particularly effective for grouping data with shared characteristics. This approach is beneficial because the collected data often contains multiple occurrences of the same variable, which aids in machine learning for predictive purposes. For instance, the variable "leg numbness" may have several potential values for patients within the same group. Analyzing these values can reveal associations with other variables, leading to various diagnoses.
3. The final algorithm utilized was J48, which constructs a decision tree. This allows for a clearer understanding of how the values of the variables relate to the ways the machine takes when making decisions based on this dataset.[24]

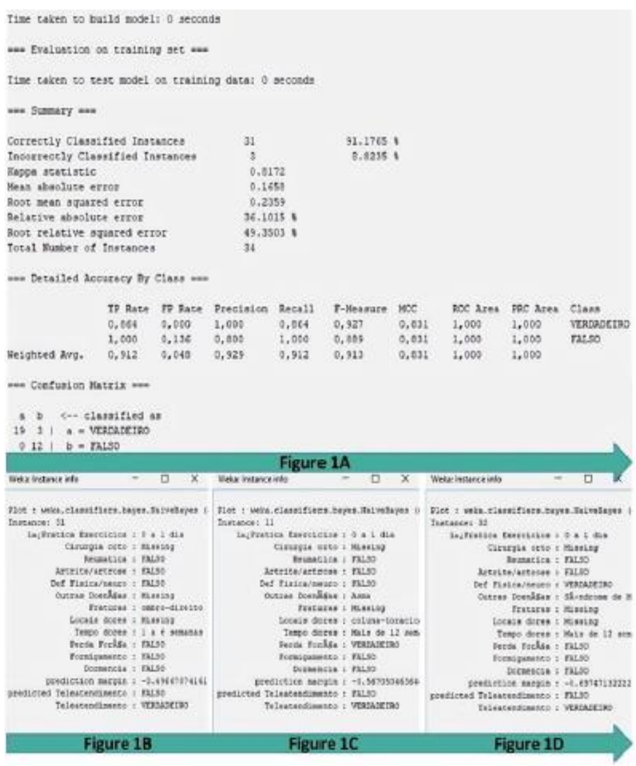

Fig 6: Accuracy assessment"[24] (Neto,et al.,2024)

The application enables patients to sign up in advance using a QR code offered by their physiotherapist, initiating the anamnesis process. This includes entering their name, date of birth, email, password, CPF, cell phone number, gender, telephone number, height, weight, and signing the terms of use for MEDME.CARE® (as shown in part A of Fig 7). The next step in the process for registration of the patient involves filling out additional information that aids in the evaluation, such as their physical activity habits, previous orthopedic problems, rheumatic diseases, physical or neurological disabilities, other medical conditions, fracture history, localized pain, and the duration of their pain. There is also a brief specific assessment for the legs, which includes questions about weakness during movement, tingling, and/or numbness (illustrated in part B of Fig 7). To pinpoint where the patient has pain or has previously experienced a fracture, a playful method has been created that allows patients to indicate the location easily. This approach facilitates understanding for the healthcare professional who may assist them (depicted in part C of Fig 7). According to the information provided, the software can recommend the most suitable approach for the patient, which might involve scheduling an initial evaluation and physiotherapy follow-up through teleconsultation or suggesting exercises that the individual can do at house.[24]

Neto et al. (24) explored the use of AI to optimise diagnostic and treatment pathways for LBP.

- Their AI-driven software provided prognoses, diagnoses, and treatment suggestions, leading to more accurate interventions.[24]
- Notably, **23 out of 34 patients** were directly referred for evaluation and management with a physiotherapist based on algorithmic analysis, highlighting the potential for AI to streamline patient care.[24]

Fig 7: Initial description of the anamnesis in the application (Neto, et al.,2024).[24]

In this paper, machine learning techniques like Optuna, CNN, and Random Forest Classifier were used to analyze and predict LBP in postnatal females based on their trunk movements. The study involved a dataset of 100 postpartum women, including those who experienced LBP and those who did not. The most effective regression model was the optimized Optuna Regressor, while the basic CNN and Random Forest Classifier achieved nearly perfect results in classifying pain. Key indicators of pain included pain level, range of motion, and average movements. Although the dataset was limited, the machine learning models provided valuable and accurate insights into the factors contributing to LBP. These findings underscore the criticality of machine learning to improve risk assessment for LBP and to tailor treatment strategies[25]. Abdelhady et al. used machine learning models to analyze trunk movement patterns in postpartum women with LBP.

- Key predictive features identified included pain intensity, flexion and extension range of motion, lateral flexion, and average movement.
- The models demonstrated robust performance in both regressing and classifying trunk biomechanics, effectively distinguishing characteristics related to LBP.
- The study suggests the potential utility of machine learning in enhancing the identification of LBP risk factors and optimizing treatment outcomes.

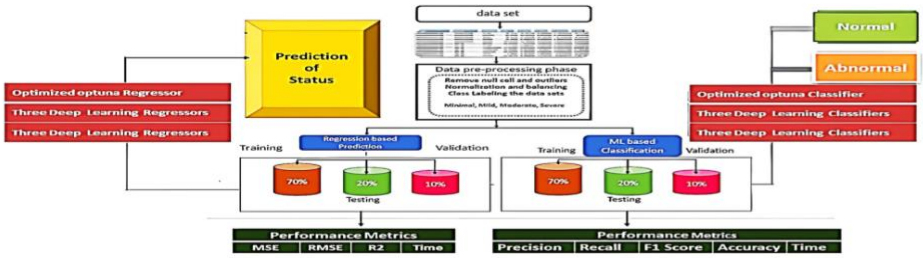

Fig 7: The general framework of the proposed prediction model.[25]

A single-blind, two-armed RCT was conducted to determine if a TLRH program is as effective as a clinical exercise program in alleviating pain and enhancing various functional outcomes in patients with nonspecific LBP. Tele-Rehabilitation: AI-driven mobile applications and virtual reality (VR) platforms have facilitated remote physical therapy sessions, improving access to care for patients suffering from LBP.[26] Villatoro-Luque et al. assessed the effectiveness of a telerehabilitation (TLRH) programme compared to traditional clinic-based exercise for patients with chronic NLBP.

- The study indicated that **TLRH is as effective as clinic-based exercise** in improving pain and functional variables.
- Both groups exhibited a reduction in pain during flexion and right lateral flexion movements, alongside improvements in range of motion (ROM) in specific lumbar movement control tests and decreased kinesiophobia.
- These findings support the feasibility and efficacy of telerehabilitation as a means of delivering exercise-based interventions for chronic NLBP.[26]

This clinical pilot trial was conducted with a single group of patients diagnosed with CNSLBP. The aim was to analyze how a home-based, technology-supported high-intensity training (HIT) program utilizing telerehabilitation could be implemented at home. This study evaluates a telerehabilitation HIT program's feasibility and clinical effectiveness for individuals with LBP. Participants engaged in a six-week high-intensity training (HIT) exercise program that consisted of 12 rehabilitation sessions, occurring twice a week. The initial four sessions were conducted in person at REVAL, establishing a standardized baseline and a strong foundation for the participants. These in-person sessions provided essential instruction and feedback on how to perform the exercises correctly and safely, ensuring that participants were well-prepared before transitioning to the telerehabilitation HIT program. The remaining eight sessions took place in the comfort of each participant's home, supported by the Physitrack smartphone application. The results suggest that a technology-assisted HIT program could be an effective and clinically beneficial intervention for patients dealing with chronic nonspecific low back pain (CNSLBP).[27] Meus et al. found that technology-supported HIT programs are a feasible and potentially clinically effective intervention for people with chronic non-specific low back pain (CNSLBP).

- Improvements were seen in pain, disability, and exercise capacity.
- The telerehabilitation HIT program shows promise for supporting adherence to exercise programs and improving clinical outcomes.

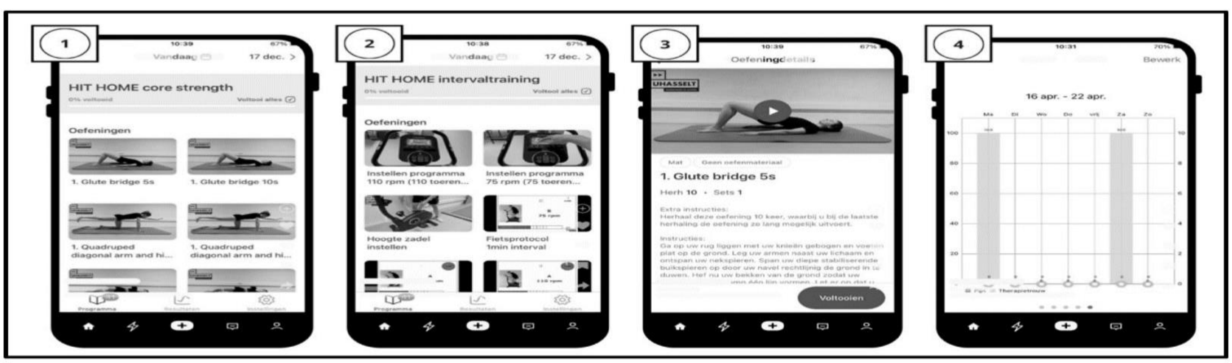

Fig 8. Visualization of the HIT program.[27]

Discussion:

While each study focuses on a distinct intervention, common threads emerge regarding the importance of exercise, personalised treatment approaches, and the potential of technology to enhance LBP management. The Honcu et al. study underscores the value of a Medical Expert Information System, while the Neto et al. study highlights the role of AI in streamlining patient referrals. The Villatoro-Luque et al. study broadens accessibility through telerehabilitation, and the Meus et al. found technology-supported HIT programs to be a feasible intervention. The Abdelhady et al. study uses machine learning to find key predictive features and optimize treatments.

Challenges and Limitations:

Despite the promising advancements, several challenges persist: It is important to consider the limitations of these studies. The Villatoro-Luque et al. study acknowledges that their results may not generalise to the entire LBP population due to their focus on chronic NLBP patients. The Neto et al. study was a pilot test with a limited sample size. The Meus et al. study also had a small sample size and lacked a control group. The Abdelhady et al. study acknowledges the need for larger datasets. These limitations highlight the need for further research to validate and expand upon these findings.

-Data Quality and Availability: The effectiveness of AI algorithms hinges on the quality and quantity of training data, which can be scarce in the context of LBP.
-Interpretability: Many AI models, especially deep learning algorithms, function as "black boxes," making it challenging for clinicians to comprehend and trust their recommendations.
-Ethical and Privacy Concerns: The integration of AI in healthcare brings up issues related to data privacy, algorithmic bias, and the risk of becoming overly dependent on technology.

Future Directions:

The integration of AI into physical therapy for low back pain (LBP) presents significant opportunities, but additional research is essential to tackle current challenges. Future directions include:
- **Multimodal AI Systems**: Merging data from various sources (such as imaging, wearables, and patient-reported outcomes) to create more holistic models.
- **Explainable AI**: Creating interpretable AI models to build clinician trust and encourage adoption.
- **Longitudinal Studies**: Implementing long-term studies to assess the effectiveness of AI-driven interventions in enhancing patient outcomes.

Conclusion:

In conclusion, the research highlights the transformative potential of AI in physiotherapy and low back pain management. From advanced diagnostic systems and innovative motion-detecting applications to machine learning models for recovery prediction, AI-driven solutions have demonstrated superior accuracy, efficiency, and clinical outcomes compared to traditional methods. These findings underscore the importance of integrating AI technologies into physiotherapy practices, offering more personalized, effective, and accessible care for patients with LBP. Future research and larger-scale trials, such as those involving the SelfBACK app, will be crucial to further validate these advancements and expand their application in clinical settings. Overall, AI holds great promise for revolutionizing the evaluation, treatment, and self-management of LBP, paving the way for improved patient outcomes and enhanced rehabilitation strategies.

Data Sharing Statement: not applicable
Disclosure: no conflicts
Funding: no funding
Informed Consent: Nil

References:

1-WHO. “Low back pain. Word Health Organization; 2023”. Available at: https://www.who.int/news-room/fact-sheets/detail/low-back-pain (Accessed: 5 May 2024).
2-GBD. “GBD 2019: Global burden of 369 diseases and injuries in 204 countries and territories, 1990-2019: A systematic analysis for the global burden of disease study 2019. GBD; 2019”. Available at: https://vizhub.healthdata.org/gbdresults/ (Accessed: 5 May 2024).
3-GBD 2021 “Low Back Pain Collaborators. Global, regional, and national burden of low back pain, 1990-2020, its attributable risk factors, and projections to 2050: A systematic analysis of the global burden of disease study 2021”. Lancet Rheumatol. 2023:5(6):e316-29. https://doi.org /10.1016/S2665-9913(23)00098-X PMid:37273833
4-Dzakpasu FQS, Carver A, Brakenridge CJ, et al. “Musculoskeletal pain and sedentary behaviour in occupational and non-occupational settings: A systematic review with meta-analysis. Int J Behav Nutr Phys Act”. 2021;18(1):159. https://doi.org/10.1186/s12966-021-01191- y PMid:34895248 PMCid:PMC8666269
5- Dziedzinski AT, Johnston C, Zardo E. “Perfil epidemiológico dos pacientes com dor lombar que procuram o serviço de traumatologia e ortopedia do Hsl-PUC-RS [Perfil epidemiológico dos pacientes com dor lombar que procuram o serviço de traumatologia e ortopedia do HslPUC- RS]”. Rio Grande Sul. 2005;13(12):453-8

6- Belfin RV, Shobana AJ, Manilal M, Mathew AA, Babu B. “A graph based chatbot for cancer patients. 2019 5th International Conference on Advanced Computing and Communication Systems”, ICACCS 2019; 2019:717–721. doi: 10.1109/ICACCS.2019.8728499.

7- Hauser-Ulrich S, Künzli H, Meier-Peterhans D, Kowatsch T. “A smartphone-based health care chatbot to promote self-management of chronic pain (SELMA): pilot randomized controlled trial”. JMIR mHealth uHealth. 2020;8(4):e15806. doi: 10.2196/15806

8-Meskó B, Görög M. “A short guide for medical professionals in the era of artificial intelligence.” NPJ Digit Med. 2020;3(1). doi: 10.1038/S41746-020-00333-Z

9-Huber S, Priebe JA, Baumann KM, Plidschun A, Schiessl C, Tölle TR. Treatment of low back pain with a digital multidisciplinary pain treatment app: short-term results. JMIR Rehabil Assist Technol. 2017;4(2):e11. doi: 10.2196/REHAB.9032

10-Anan T, Kajiki S, Oka H, et al. “Effects of an artificial intelligence-assisted health program on workers with neck/shoulder pain/stiffness and low back pain: randomized controlled tria”l. JMIR mHealth uHealth. 2021;9(9):e27535. doi: 10.2196/27535

11-Whittaker R, Mcrobbie H, Bullen C, Rodgers A, “Gu Y. Mobile phone-based interventions for smoking cessation”. Cochrane Database Syst Rev. 2016;4(4). doi: 10.1002/14651858.CD006611.PUB4

12-Patel MS, Benjamin EJ, Volpp KG, et al. “Effect of a game-based intervention designed to enhance social incentives to increase physical activity among families: the BE FIT randomized clinical trial”. JAMA Intern Med. 2017;177(11):1586–1593. doi: 10.1001/JAMAINTERNMED.2017.3458

13-Barreveld AM, Rosén Klement ML, Cheung S, et al. An artificial intelligence-powered, patient-centric digital tool for self-management of chronic pain: a prospective, multicenter clinical trial. Pain Med. 2023;24:1100–1110. doi: 10.1093/PM/PNAD049

14-Hamid N, Portnoy JM, Pandya “A. Computer-Assisted Clinical Diagnosis and Treatment. Curr Allergy Asthma Rep. 2023;23:509–517. doi: 10.1007/S11882-023-01097-8

15-Robinson, C. L., D'Souza, R. S., Yazdi, C., Diejomaoh, E. M., Schatman, M. E., Emerick, T., & Orhurhu, V. (2024). Reviewing the Potential Role of Artificial Intelligence in Delivering Personalized and Interactive Pain Medicine Education for Chronic Pain Patients”. *Journal of pain research*, *17*, 923–929. https://doi.org/10.2147/JPR.S439452

16-Sandal, L. F., Øverås, C. K., Nordstoga, A. L., Wood, K., Bach, K., Hartvigsen, J., Søgaard, K., & Mork, P. J. (2020). “A Digital Decision Support System (selfback) for improved self-management of low back pain: A pilot study with 6-week follow-up. *Pilot and Feasibility Studies”*, *6*(1). https://doi.org/10.1186/s40814-020-00604-2

17-Wesselink, E. O., Elliott, J. M., Coppieters, M. W., Hancock, M. J., Cronin, B., Pool-Goudzwaard, A., & Weber II, K. A. (2022). Convolutional Neural Networks for the automatic segmentation of lumbar paraspinal muscles in people with low back pain. *Scientific Reports*, *12*(1). https://doi.org/10.1038/s41598-022-16710-5

18-Knoop, J., van Lankveld, W., Beijer, L., Geerdink, F. J., Heymans, M. W., Hoogeboom, T. J., Hoppenbrouwers, S., van Overmeeren, E., Soer, R., Veenhof, C., Vissers, K. C., van der Wees, P. J., Sappelli, M., & Staal, J. B. (2022). Development and internal validation of a machine learning prediction model for low back pain non-recovery in patients with an acute episode consulting a physiotherapist in primary care. *BMC Musculoskeletal Disorders*, *23*(1). https://doi.org/10.1186/s12891-022-05718-7

19-Marcuzzi, A., Nordstoga, A. L., Bach, K., Aasdahl, L., Nilsen, T. I., Bardal, E. M., Boldermo, N. Ø., Falkener Bertheussen, G., Marchand, G. H., Gismervik, S., & Mork, P. J. (2023). Effect of an artificial intelligence–based self-management app on musculoskeletal health in patients with neck and/or low back pain referred to specialist care. *JAMA Network Open*, *6*(6). https://doi.org/10.1001/jamanetworkopen.2023.20400

20-Santra, D., Mandal, J. K., Basu, S. K., & Goswami, S. (2020). Medical expert system for low back pain management: design issues and conflict resolution with Bayesian network. *Medical & biological engineering & computing*, *58*(11), 2737–2756. https://doi.org/10.1007/s11517-020-02222-9

21-Phan, T. C., Pranata, A., Farragher, J., Bryant, A., Nguyen, H. T., & Chai, R. (2022). Machine learning derived lifting techniques and pain self-efficacy in people with chronic low back pain. *Sensors*, *22*(17), 6694. https://doi.org/10.3390/s22176694

22-Park, J., Chung, S. Y., & Park, J. H. (2022). Real-time exercise feedback through a convolutional neural network: A machine learning-based motion-detecting mobile exercise coaching application. *Yonsei Medical Journal*, *63*(Suppl). https://doi.org/10.3349/ymj.2022.63.s34

23-Honcu, P., Zach, P., Mrzilkova, J., Jandova, D., Musil, V., & Celko, A. (2020).” Computer kinesiology: New diagnostic and therapeutic tool for lower back pain treatment (pilot study)”. *BioMed Research International*, *2020*, 1–10. https://doi.org/10.1155/2020/2987696

24-Neto, A. G. N., Herrera, S. D. S. C., Moura, R., Cielo, G. M., Pegoraro, F., Lira, V. F. D., Paiva, M. J. M. D., Rosa, C. G. S., Alves, R. C., & D’Alessandro, W. B. (2024). AI-driven solutions for low back pain: A pilot study on diagnosis and treatment planning. *Electronic Journal of General Medicine*, *21*(5), em601. https://doi.org/10.29333/ejgm/14934

25-Abdel Hady, D., & Abd El-Hafeez, T. (2024). Utilizing machine learning to analyze trunk movement patterns in women with postpartum low back pain. *Scientific reports*, *14*(1), 18726. https://doi.org/10.1038/s41598-024-68798-6

26-Villatoro-Luque FJ, Rodríguez-Almagro D, Aibar-Almazán A, et al. Telerehabilitation for the treatment in chronic low back pain: A randomized controlled trial. Journal of Telemedicine and Telecare. 2023;0(0). doi:10.1177/1357633X231195091

27-Meus, T., Timmermans, A., Klaps, S., & Verbrugghe, J. (2024). High-Intensity Training Telerehabilitation for Persons with Chronic Low Back Pain: A Pilot Clinical Trial. *Journal of Clinical Medicine*, *13*(24), 7599. https://doi.org/10.3390/jcm13247599