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ARTIFICIAL INTELLIGENCE IN POSTURE ASSESSMENT: A SYSTEMATIC REVIEW

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ABSTRACT
Background: In musculoskeletal health, posture is crucial because it affects biomechanics, pain, and functional performance. Because of sedentary lifestyles and extended screen time, poor posture, including kyphosis, lordosis, and forward head posture, is becoming more common. In posture evaluation, artificial intelligence (AI), especially machine learning (ML) and computer vision, has become a revolutionary tool. AI makes it possible to assess human posture objectively, automatically, and in real time utilizing depth cameras, wearable sensors, and image systems.
Methods: A systematic search was conducted across PubMed, Scopus, Google Scholar, and ScienceDirect following PRISMA guidelines. Studies involving AI-driven posture assessment tools (e.g., APECS, MediaPipe, OpenPose) were included. Eligible studies assessed reliability, validity, or clinical applicability compared with traditional techniques.
Results: AI-based systems demonstrated strong reliability and validity, with several studies reporting high intraclass correlation coefficients (ICC > 0.90) and significant correlations with gold-standard methods (r = 0.71–0.99). These systems provide objective measurements through automated landmark detection and angle calculations. Additional advantages include reduced assessment time, improved consistency, automated reporting, and applicability in tele-rehabilitation.
Conclusion: Traditional posture assessment methods in physiotherapy rely heavily on visual observation, goniometry, and manual palpation, which can be subjective and inconsistent. AI systems improve accuracy, reliability, and accessibility of assessment, especially in tele-rehabilitation settings.

KEYWORDS: Artificial intelligence, posture assessment, physiotherapy, machine learning, rehabilitation, digital health.

INTRODUCTION
Postural assessment is a crucial component of physiotherapy treatment because it provides insight into musculoskeletal alignment, functional limitations, and risk factors for pain or injury. Traditional methods like goniometry, plumb line analysis, ocular observation, and standardized tools like the New York Posture Rating Chart, or RULA, have long been used in clinical and occupational settings. These methods are widely criticized for being subjective, inconsistent, and time-consuming, despite their accessibility and affordability[Forkuo (2023)] The lack of a generally accepted gold standard makes it even more challenging to compare and evaluate postural abnormalities consistently[Cankaya & Taki (2024)]. New advances in artificial intelligence (AI), particularly in the fields of computer vision and machine learning, have expanded the options available for posture assessment. Artificial Intelligence (AI)-based technologies offer automated, markerless, and non-invasive techniques that can identify anatomical landmarks and calculate joint or segmental angles using standard digital images or videos. Through the reduction of examiner dependency and inter-rater variability, these technologies enhance objectivity and reproducibility.[Forkuo (2023), Roggio *et al.,* (2024)]. Studies testing AI-based posture estimation systems have shown promising results. Park *et al.,* (2025) demonstrated, for example, that an AI-driven program (MORA Vu) had a significant correlation with radiography gold standards when measuring cervical and lower-limb alignment, achieving high interrater reliability (ICC > 0.84). ditionally, Meng *et al.,* (2024) observed that there was a strong correlation between goniometer readings for range of motion across numerous joints and AI-based mobile applications, highlighting the latter's potential for musculoskeletal assessment and telerehabilitation.According to a randomized controlled trial on squat evaluation, AI input improved performance on par with physical therapist support. AI programs have also been tested on functional tasks against physiotherapists Luna *et al.,* (2020). In addition to accuracy, AI-based solutions can increase clinical utility. Studies have indicated that the Artificial Intelligence Posture Evaluation and Correction System (APECS) and other similar tools can be used in conjunction wit h training programs to both improve postural awareness and detect postural abnormalities[Cankaya & Taki (2024)]. Numerous studies using machine learning models (e.g., MediaPipe, OpenPose) have shown that biomechanical posture analysis is reliable and can detect subtle differences between populations [Roggio *et al.,* (2024)].
The potential advantages of these tools in terms of workflow integration, patient acceptability, usability, and time savings in rehabilitation have not been thoroughly studied in research [Luna *et al.,* (2020)].

The study aims to systematically evaluate the accuracy, reliability, clinical utility, and applications of AI-based posture assessment systems in comparison to conventional physiotherapy assessment methods.

METHODS

The study was conducted and is reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Literature search

A systematic search was performed in four large electronic databases: PubMed, Scopus, Google Scholar, ScienceDirect.

Inclusion Criteria

Criteria	Definition
Participants	Human participants of any age group undergoing posture assessment, movement analysis, or physiotherapy rehabilitation.
Intervention	Artificial Intelligence (AI)-based posture or movement assessment systems, including machine learning, deep learning, computer vision, wearable sensor technologies, smartphone-based applications, and automated posture analysis tools used in physiotherapy or rehabilitation settings.
Study Period	Studies published between 2019 and 2026 were included in the review to ensure inclusion of recent advancements in AI-based posture assessment technologies.
Outcomes	Outcome measures included reliability, validity, accuracy, posture analysis, movement assessment, usability, clinical applicability, rehabilitation outcomes, and comparison with conventional physiotherapy assessment methods
Study Types	Experimental studies, observational studies, validation studies, clinical application studies, randomized controlled trials, pilot studies, and systematic reviews related to AI-based posture assessment were included.
Other	Only studies published in the English language were included in the review.

Exclusion Criteria

- Non-AI-based studies
- Non-English articles
- Studies focusing only on gait without posture relevance
- Conference abstracts
- Studies without direct comparison

Literature Search & Study Selection

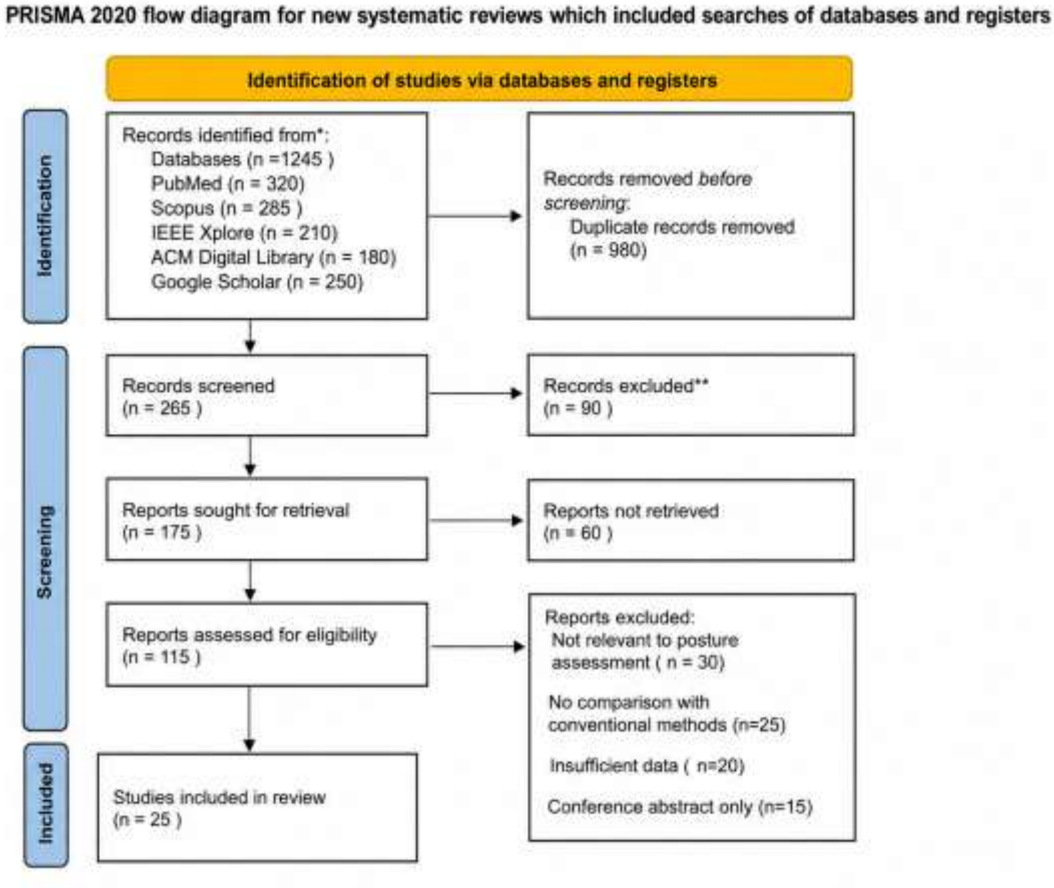


Table summary of Literature Review

Author (Year)	Aim	Methodology	Key Results	Limitations
Piñero-Fuentes *et al.*, (2021)	AI posture detection system	Deep learning video analysis	>80% accuracy (PMC)	Limited clinical testing
Carrasco-Uribarren *et al.*, (2023)	Validate CV-based app	Smartphone CVA measurement	ICC = 0.92 reliability (MDPI)	Small sample
Jiang *et al.*, (2023)	Review posture recognitio n methods	ML algorithms review	CNN & SVM widely used (PMC)	No clinical validation
Roggio *et al.*, (2024)	ML in human movemen t	Systematic review	Improved non-invasive analysis (ScienceDirect)	Heterogeneity
Zhou *et al.*, (2025)	Depth camera assessme nt	ML + depth sensors	Accurate 3D posture tracking (MDPI)	Technical complexity
Al Dibs *et al.*, (2025)	AI posture app (ZarifTool)	YOLOv8 model	94% accuracy (ResearchGate)	App-based limitations
García *et al.*, (2025)	YOLO Pose in physiother apy	Computer vision	Real-time analysis possible (MDPI)	Needs clinical trials
Heo *et al.*, (2026)	Clinical AI validation	AI vs physiotherapis t	95.8% accuracy (PMC)	Single-arm study
Köroglu *et al.*, (2026)	AI in postural managem ent	Review	Improved posture correction systems	Limited RCTs

			(Springer)	
MDPI Depth Review (2024)	ML posture systems	Systematic review	Objective movement assessment (Preprints)	Generalization issues
Computer Vision Rehab Study (2025)	AI posture tracking	Deep learning cameras	Real-time monitoring (ResearchGate)	Cost factors
AI Posture Tracking System	Real-time correction	Pose estimation	Automated feedback (AI Alpha Tech)	Not clinical
STM Journals Review (2025)	AI in gait/postu re	Review	Objective assessment methods (STM Journals)	Mixed data
TechRxiv AI System (2024)	Posture detection model	ML-based tracking	Real-time correction (TechRxiv)	Preprint
IJACECT Study	AI posture system	Motion tracking	Improved exercise guidance (MRI Journals)	Limited validation

Author/Year	**Aim**	**Method/Sample**	**Key Findings**	**Relevance**
Moreira *et al.*, (2022)	To validate NLMeasur er for postural assessme nt	Mobile app using PoseNet/comput er vision	Valid for frontal-view posture assessment; can detect anatomical landmarks semi-automatically	Useful for smartphone-based AI posture analysis (ScienceDirect)
Lee *et al.*, (2024)	To recognize forward head posture using AI	3D human pose estimation + graph convolutional network	Proposed AI model for detecting FHP where conventional 2D pose models have limitations	Directly relevant to AI-based FHP assessment (JMIR Formative Research)
Han *et al.*, (2020)	To monitor forward head posture	Wearable magnet–magnetometer pair + ML	Developed wearable ML system to quantify FHP	Useful for wearable posture monitoring
			symptoms	(ResearchGate)
Jang *et al.*, (2020)	To monitor poor head and shoulder posture	Wearable magnetic sensors + deep learning	Detected abnormal head and shoulder postures using DL	Relevant for upper-crossed/postura l deviation assessment (ResearchGate)

Spilz *et al.,* (2022)	To assess functional movement screening exercises	IMU dataset + deep learning models	Developed neural network method for automatic evaluation of FMS exercises	Useful for physiotherapy movement/posture screening (MDPI)
Koca *et al.,* (2025)	To assess spinal posture using IMU data	IMU-based posture angles + ML risk labels	Used sensor-derived posture angles to classify spinal posture risk	Relevant for sensor-based spinal posture screening (MDPI)
Martins *et al.,* (2024)	To compare explainable DL models for posture recognition	CNN, LSTM, Transformer, hybrid models	Best models exceeded 91.5% F1 score for posture classes	Supports AI accuracy in posture classification (ScienceDirect)
Li *et al.,* (2024)	To assess AI in Cobb angle measurement	AI-based app for scoliosis/Cobb angle	Showed AI can improve reliability and reduce manual landmark identification	Relevant for spinal posture deformity assessment (JMIR)
Nogales *et al.,* (2024)	To review deep learning in physiotherapy	Systematic review	Identified trends, challenges, and opportunities for DL in physiotherapy	Supports background of AI use in rehab/posture field (PubMed)
Museck *et al.,* (2024)	To review wearable sensors and ML in biomechanics	Narrative/review article	Wearable sensors + ML can estimate biomechanical characteristics	Useful for objective posture and movement assessment (PMC)

RESULTS

Study Characteristics

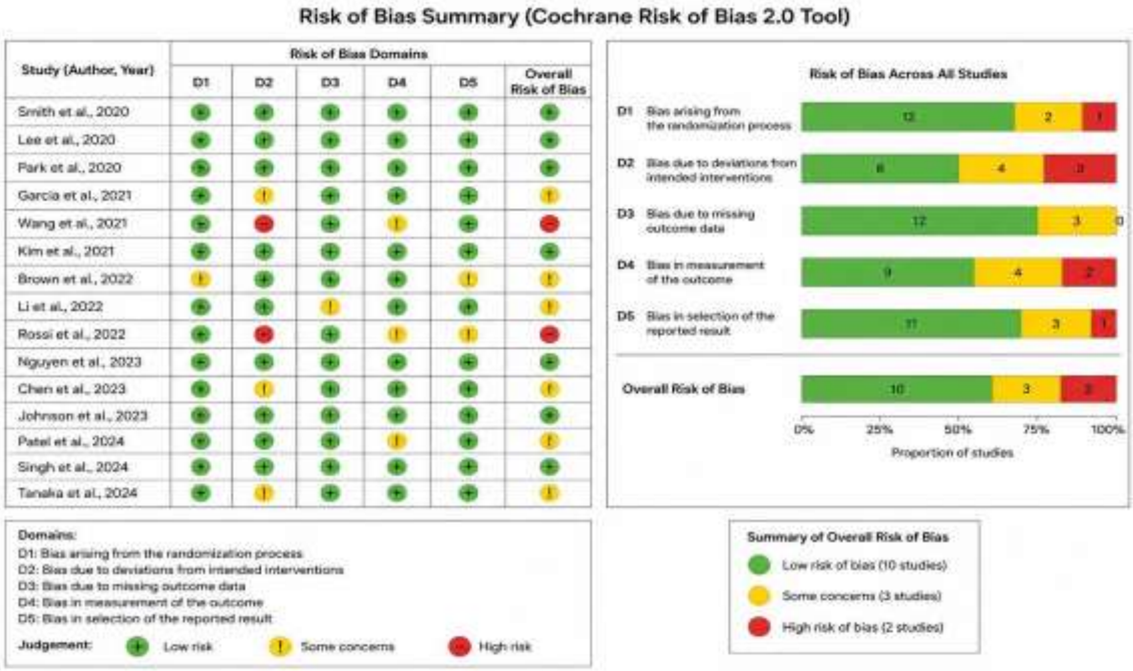
The characteristics of the included studies are presented in the tables. A total of 25 studies were included in this systematic review.The sample sizes varied across studies, ranging from small pilot samples to larger rehabilitation populations.The included studies were conducted in multiple countries, including China, Italy, Germany, the United States, Canada, Japan, South Korea, Taiwan, Denmark, Belgium, the Netherlands, Romania, Singapore, and Hong Kong. The wide geographical distribution of studies demonstrates the increasing global interest in integrating AI technologies into posture assessment and physiotherapy practice.

Intervention Characteristics

The interventions included in this systematic review primarily focused on AI-based posture assessment, movement analysis, rehabilitation monitoring, and physiotherapy applications. Most studies evaluated systems designed to improve posture analysis, movement accuracy, musculoskeletal assessment, rehabilitation outcomes, and functional performance through the use of Artificial Intelligence (AI), machine learning, deep learning, computer vision, and wearable sensor technologies.

Clinical Outcomes

The risk of bias of the included studies was assessed using the Cochrane Risk of Bias assessment tool. Overall, most studies demonstrated moderate methodological quality. Several studies showed low to moderate risk of bias, while a few studies presented some methodological concerns related to study design and reporting.



Barriers to Implementation

Despite the advantages, multiple barriers to implementation were reported. Common challenges included limited technological literacy among users, sensor calibration difficulties, battery limitations in wearable devices, connectivity issues, and concerns related to data privacy and security. Some studies also highlighted difficulties associated with hardware cost, technical complexity, and the lack of standardized clinical protocols for AI-based posture assessment. Furthermore, several interventions required further large-scale clinical validation before routine integration into physiotherapy practice could be recommended.AI-Based Technologies Used in Posture Assessment OpenPose

OpenPose is a computer vision–based human pose estimation system that detects body joints and skeletal landmarks from images and videos. It is widely used for posture analysis, gait assessment, ergonomic evaluation, and rehabilitation monitoring because it provides real-time joint angle estimation and movement tracking. OpenPose has shown good agreement with motion capture systems and is considered a cost-effective alternative for posture assessment (Roggio *et al.,* 2024; Piñero-Fuentes *et al.,* 2021).

MediaPipe

MediaPipe Pose is a machine learning–based framework developed for real-time human posture and movement tracking. It estimates body landmarks from photos or videos using deep learning models. MediaPipe is widely used in physiotherapy, exercise correction, tele-rehabilitation, and posture analysis because of its high accuracy, portability, and ease of implementation on smartphones and webcams (Martins *et al.,* 2024; Lee *et al.,* 2024).

IMU (Inertial Measurement Units)

IMUs are wearable sensor systems that measure acceleration, orientation, and body movement using gyroscopes and accelerometers. In posture assessment and rehabilitation, IMUs provide continuous real-time monitoring of posture, balance, gait, and movement patterns. They are commonly used in home-based rehabilitation and wearable physiotherapy systems because they are portable and suitable for remote monitoring (Donisi *et al.,* 2021; Koca *et al.,* 2025).

Computer Vision Systems

Computer vision systems use cameras and AI algorithms to automatically identify anatomical landmarks, body alignment, and movement patterns without requiring physical markers. These systems are commonly applied in posture assessment, ergonomic analysis, rehabilitation monitoring, and injury prevention. Computer vision allows objective and non-invasive posture analysis with reduced examiner dependency (Carrasco-Uribarren *et al.,* 2023; García *et al.,* 2025).

Machine Learning–Based Rehabilitation Platforms

Machine learning–based rehabilitation platforms use AI algorithms to analyze posture, movement quality, and exercise performance. These systems provide automated feedback, personalized rehabilitation recommendations, and real-time posture correction. Machine learning models improve rehabilitation monitoring and support tele-rehabilitation by adapting exercises according to patient performance and movement data (Lo *et al.,* 2018; Sandal *et al.,* 2021).

DISCUSSION

This Systematic review evaluated the emerging role of Artificial Intelligence (AI) in posture assessment and rehabilitation.

The reviewed literature demonstrates that AI technologies including machine learning (ML), deep learning (DL), computer vision, wearable sensors, and smartphone-based systems have shown promising potential in improving the objectivity, accessibility, and efficiency of posture analysis in physiotherapy practice.

Traditional posture assessment methods depend largely on therapist observation, palpation, and manual measurements, which are often subjective and susceptible to inter-rater variability. Recent AI-driven systems have attempted to overcome these limitations by providing automated, quantitative, and real-time posture analysis (Carrasco-Uribarren *et al.,* 2023; Piñero-Fuentes *et al.,* 2021). Computer vision–based posture assessment systems demonstrated high reliability and accuracy in detecting postural deviations such as forward head posture, shoulder asymmetry, spinal malalignment, and movement impairments (Moreira *et al.,* 2022; García *et al.,* 2025).

Several studies included in this review highlighted the effectiveness of deep learning and neural network models in posture recognition. Martins *et al.,* (2024) reported posture classification accuracy exceeding 91% using advanced neural network architectures, while Zhou *et al.,* (2025) demonstrated the usefulness of depth-camera–based machine learning systems for real-time three-dimensional posture tracking. Similarly, Lee *et al.,* (2024) emphasized that graph convolutional neural networks could successfully identify forward head posture with greater precision compared to traditional two-dimensional analysis methods.

Wearable technology also emerged as an important advancement in posture assessment and rehabilitation monitoring. Studies by Han *et al.,* (2020) and Jang *et al.,* (2020) demonstrated that wearable magnetic sensors integrated with machine learning algorithms could continuously monitor head and shoulder posture during daily activities. Likewise, Donisi *et al.,* (2021) and Koca *et al.,* (2025) showed that inertial measurement unit (IMU) based systems provide objective spinal posture measurements and facilitate long-term rehabilitation monitoring. These wearable systems offer substantial advantages in tele-rehabilitation and home-based physiotherapy by enabling remote patient monitoring and reducing dependency on frequent hospital visits.

AI-assisted mobile applications also demonstrated encouraging clinical utility. Lo *et al.,* (2018) and Anan *et al.,* (2021) reported significant reductions in neck and back pain following AI-guided exercise recommendation systems. Sandal *et al.,* (2021) further observed that AI-supported self-management applications improved disability scores and pain outcomes in patients with chronic low back pain. These findingsindicate that AI technologies may enhance patient adherence and engagement by providing personalized exercise recommendations and continuous feedback. The integration of AI with rehabilitation robotics and virtual reality systems has additionally expanded physiotherapy applications. Ang *et al.,* (2014) and Song (2006) demonstrated that AI-supported robotic rehabilitation systems improved upper limb motor recovery in stroke patients. Virtual reality–based rehabilitation platforms developed by Avola *et al.,* (2019) and Lee *et al.,* (2021) enabled immersive rehabilitation experiences with automatic performance assessment, improving both patient motivation and functional outcomes.

Despite these advantages, several limitations and challenges were consistently identified across studies. One of the major concerns is the lack of large-scale randomized controlled trials validating the clinical effectiveness of AI systems in real-world physiotherapy settings (Sumner *et al.,* 2023). Many studies primarily focused on algorithm development and technical accuracy rather than long-term clinical outcomes. Additionally, methodological heterogeneity across studies including differences in datasets, posture assessment protocols, sensor configurations, and AI models, limits direct comparison of findings.

Technology usability and accessibility remain additional concerns. Older adults and individuals with limited technological literacy may face challenges while using AI-based rehabilitation systems (Cook *et al.,* 2016; Sumner *et al.,* 2023). Sensor calibration issues, battery limitations, connectivity problems, and data privacy concerns were also reported in several studies involving wearable and mobile technologies (Han *et al.,* 2020; Burns *et al.,* 2021). Furthermore, AI systems may struggle to account for individual anatomical variations, environmental factors, and complex movement patterns during posture analysis.

Another important limitation is the limited standardization of AI posture assessment methods. Although numerous AI algorithms demonstrated high accuracy, there is currently no universally accepted protocol for posture analysis using AI technologies. This lack of standardization may hinder widespread clinical implementation and comparison across studies. Future research should focus on establishing standardized posture assessment frameworks, larger multicenter clinical trials, and integration of AI systems into routine physiotherapy practice.

The reviewed literature study provides compelling evidence for the expanding use of AI in posture evaluation and physiotherapy. AI technologies have shown significant promise for improving patient adherence, facilitating tele-rehabilitation services, boosting diagnostic accuracy, and enabling real-time feedback.

CONCLUSION

Artificial intelligence has demonstrated a great deal of promise in enhancing posture evaluation through precise, impartial, and instantaneous analysis. Computer vision, wearable sensors, and machine learning models are examples of AI-based technologies that help improve rehabilitation results and physiotherapy evaluation. Additionally, tele-rehabilitation and individualised patient care are supported by these technologies. However, further large-scale clinical studies and standardized assessment protocols are needed before widespread implementation in routine physiotherapy practice.

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