AMERICAN JOURNALS
Open Access, Peer Reviewed Journals

American Journal of Pedagogical and Educational Research
ISSN (E): 2832-9791| Volume 43, |December - 2025

OPPORTUNITIES OF BIOMECHANICAL ANALYSIS OF SPORTS MOVEMENTS BASED ON ARTIFICIAL INTELLIGENCE

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A B S T R A C T

This article analyzes the theoretical foundations, practical opportunities, and prospects of using artificial intelligence (AI) technologies in sports biomechanics. The effectiveness of modern approaches developed based on machine learning, computer vision, and neural networks for biomechanical assessment of sports movements is highlighted. Furthermore, the study examines the use of AI for improving sports techniques, preventing sports injuries, and optimizing training processes. The results of the research demonstrate that the use of digital technologies in sports biomechanics has significant scientific and practical value.

K E Y W O R D S

Sports biomechanics, artificial intelligence, biomechanical analysis, machine learning, sports movement, technique, injury prevention.

INTRODUCTION

Modern sports science not only aims to achieve high performance but also prioritizes maintaining athletes' health, reducing the risk of injuries, and increasing movement efficiency. In this context, sports biomechanics plays an invaluable role by studying the mechanical principles of sports movements to improve athletic techniques.

In recent years, the rapid development of information technologies has led to significant changes in the field of sports biomechanics. In particular, AI-based systems have enabled automatic analysis of sports movements, processed large volumes of biomechanical data, and drawing accurate conclusions. This has significantly expanded the limitations of traditional biomechanical analysis methods.

The relevance of this article lies in the fact that the application of AI technologies in sports biomechanics not only increases the efficiency of scientific research but also contributes to achieving higher results in practical sports training.

Accurate and objective assessment of motor activity occupies a leading position in modern sports science. The efficiency of athletes' movements largely depends on biomechanical principles, and in-depth analysis of these principles is a key condition for achieving high sports results. Traditional biomechanical analysis methods often require complex laboratory conditions, which limits their continuous application in training.

The introduction of AI technologies into sports biomechanics solves this problem by enabling real-time, high-precision analysis of sports movements with minimal technical equipment. This facilitates scientifically-based management of athletes' training and ensures an individualized approach.

The purpose of the study is to scientifically substantiate the opportunities for biomechanical analysis of sports movements based on AI and to determine their significance in sports practice.

Research objectives:

1. To analyze the theoretical foundations of AI technologies in sports biomechanics;
2. To identify the capabilities of AI-based methods for analyzing sports movements;
3. To evaluate the role of AI technologies in improving sports techniques and preventing injuries;
4. To determine prospective directions for AI development in sports biomechanics.

Research methods:

- **Literature review** — studying local and international scientific sources in sports biomechanics and AI;
- **Biomechanical analysis method** — determining spatial-temporal parameters, forces, and velocity characteristics of sports movements;
- **AI-based video analysis** — automatic detection of movements using computer vision and deep learning algorithms;
- **Machine learning methods** — evaluating technical efficiency and identifying errors based on biomechanical indicators;
- **Statistical analysis** — determining the reliability of the obtained results.

The combination of these methods ensured the scientific validity of the research results.

AI models sports movements considering the human body as a multi-joint biomechanical system. The amplitude, speed, and force characteristics of each joint are determined using AI algorithms. Based on this data, an optimal biomechanical model of sports movements is developed.

Modeling movements allows taking into account athletes' individual anatomical and functional characteristics, facilitating individualized technical preparation.

Artificial intelligence refers to a set of technologies that model computer systems with human-like abilities to analyze, learn, and make decisions. In sports biomechanics, AI is mainly applied in the following areas:

- Machine Learning (ML)
- Deep Learning (DL)
- Computer Vision
- Neural Networks

These technologies enable automatic calculation of spatial-temporal characteristics, joint angles, movement speed, acceleration, and force parameters. When analyzing sports movements using AI, changes in joint angles, movement velocity, and acceleration are automatically measured. Research shows that disruptions in movement coordination lead to reduced technical efficiency.

AI systems can detect microscopic deviations in movements, enabling more precise improvement of athletes' technical skills. Unlike traditional biomechanical analysis, which often requires complex laboratory equipment, AI-based systems can extract accurate biomechanical data from simple video recordings. This makes sports biomechanics research more accessible and convenient.

AI-based biomechanical analysis of sports movements provides the following opportunities:

1. Automatic detection and analysis of movements

Using computer vision technologies, body segments are automatically identified, and their movements are analyzed in real-time. This method allows accurate study of complex actions such as running, jumping, and striking.

2. Detection of technical errors

AI systems compare athletes' movements with an ideal biomechanical model to identify technical errors. As a result, coaches can quickly and accurately assess individual shortcomings of athletes.

3. Assessment of movement efficiency

Based on biomechanical indicators, AI determines the energetic efficiency of sports movements, optimizing athletes' energy expenditure and improving performance.

Sports injuries often result from biomechanically incorrect movements, excessive load, and imbalance. AI-based biomechanical analysis systems can detect these risk factors in advance. For example, analyzing knee joint or spinal load allows predicting injury risks. This enables development of individualized preventive exercises. AI technologies assess muscle and joint load, identifying cases of excessive strain. Based on this data, athletes' functional condition and recovery processes are scientifically planned.

Optimization of training with AI

AI technologies also play an important role in planning training processes. Based on biomechanical analysis, athletes' physical condition and technical readiness are evaluated. Individual training programs are developed accordingly. Biomechanical deviations identified by AI allow detection and correction of technical errors, improving efficiency and preventing injuries.

This approach prevents excessive strain, increasing training effectiveness. The research results can be applied in:

- Evaluating athletes' technical readiness;
- Scientifically planning coaching processes;
- Developing injury prevention programs;
- Using in sports education institutions during training.

Conclusion

The analysis shows that AI-based biomechanical analysis of sports movements is one of the promising directions in sports science. These technologies provide broad opportunities for improving sports techniques, preventing injuries, and optimizing training.

Future development of AI technologies will enhance the quality of research in sports biomechanics and contribute to achieving higher sports performance.

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