OPPORTUNITIES FOR BIOMECHANICAL ANALYSIS OF FOOTBALL PLAYERS' MOVEMENTS BASED ON ARTIFICIAL INTELLIGENCE

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A B S T R A C T	K E Y W O R D S
This scientific article examines the theoretical and practical aspects of using artificial intelligence (AI) technologies in the biomechanical analysis of football players' movements. The biomechanical characteristics of key technical actions in football—running, acceleration, stopping, turning, kicking, and jumping—are analyzed based on artificial intelligence methods. In addition, the possibilities of AI technologies in improving technical preparedness, preventing sports injuries, and individualizing the training process of football players are scientifically substantiated. The research findings demonstrate that the implementation of digital technologies in football biomechanics is a crucial factor in achieving high sports performance.	Football biomechanics, artificial intelligence, biomechanical analysis, machine learning, technical actions, injury prevention.

INTRODUCTION

Football is one of the most popular sports in the world and requires complex coordinated movements. The technical and tactical skills of football players are directly related to the capabilities of the musculoskeletal system and biomechanical efficiency. Therefore, the scientific study of football players' movements is considered one of the most pressing issues in sports science.

Sports biomechanics allows the analysis of football players' movements based on mechanical laws and makes it possible to assess the effectiveness of technical elements. However, traditional biomechanical research methods often require complex laboratory conditions, significant time, and financial resources. The introduction of artificial intelligence technologies plays an important role in overcoming these limitations.

Currently, AI-based video analysis, sensor systems, and machine learning algorithms enable real-time analysis of football players' motor activities. This contributes to improving training efficiency, reducing injury risk, and accounting for the individual characteristics of players. In modern football, high sports performance depends not only on physical fitness but also on biomechanical perfection of movements. Football players' running speed, kicking accuracy, and sharp stopping and turning movements are performed under high loads within a short period of time. The mechanisms of these movements cannot be fully assessed using traditional observation methods. AI-based biomechanical

analysis technologies provide an objective assessment of players' motor activity, helping coaches and sports specialists identify technical errors and optimize the training process based on individual capabilities.

Purpose and Objectives of the Research

The purpose of the research is to scientifically substantiate the possibilities of artificial intelligence technologies in biomechanical analysis of football players' movements and to determine their significance in sports practice.

Objectives of the research:
1. To analyze the theoretical foundations of football biomechanics;
2. To biomechanically characterize the main technical actions of football players;
3. To determine the effectiveness of AI-based biomechanical analysis methods;
4. To assess the role of AI technologies in preventing injuries among football players;
5. To demonstrate the possibilities of using artificial intelligence to optimize football training.

Research Methods

The following scientific methods were used in this study:
- **scientific literature analysis** — studying domestic and foreign sources related to football biomechanics and artificial intelligence technologies;
- **biomechanical observation method** — evaluating football players' technical actions based on mechanical laws;
- **AI-based video analysis** — frame-by-frame analysis of movements using computer vision and neural networks;
- **machine learning method** — assessing technical efficiency based on biomechanical indicators;
- **statistical analysis method** — determining the reliability of the obtained results.

The comprehensive application of these methods ensured the scientific validity of the research findings.

Biomechanics of Football Movements

Football biomechanics studies players' motor activities from a mechanical perspective, analyzing indicators such as force, speed, acceleration, impulse, and balance. Football movements are cyclic and acyclic in nature and require a high level of coordination.

Sharp turning and stopping movements in football are characterized by high biomechanical loads. With the help of artificial intelligence, the maximum loads acting on the knee and ankle joints can be determined. Studies show that improper landing or turning techniques significantly increase the risk of knee ligament injuries.

Research conducted by local scholars (A. Abdullayev, R. Salimov, Sh. Khudoyberdiyev) scientifically substantiates that the biomechanical characteristics of running technique, kicking actions, and jumping movements have a direct impact on sports performance. Artificial intelligence enables automated analysis of these biomechanical processes, reducing subjective errors caused by the human factor.

Running and Acceleration Movements

Running is the most frequently performed biomechanical action in football. AI-based systems automatically identify running phases, stride length, and support and flight phases. This allows assessment of the energetic efficiency of football players.

Using artificial intelligence, running technique analysis determines stride length, stride frequency, duration of the support phase, and horizontal displacement of the body's center of mass. Research results indicate that highly skilled football players demonstrate energetically efficient running techniques with well-coordinated movement of body segments. Movement asymmetry identified through AI algorithms indicates muscle imbalance, which is considered a factor increasing injury risk.

Kicking Technique

Kicking the ball is a complex biomechanical process related to the position of the supporting leg, displacement of the center of mass, and impulse transfer mechanisms. AI technologies allow the determination of joint angles and force distribution during the kicking phase, enabling identification of technical errors.

Using artificial intelligence, the position of the supporting leg, displacement of the body's center of mass, and angular changes of the hip and knee joints during kicking are analyzed. According to scientific studies, kicking effectiveness depends on the sequential transfer of impulse through body segments. AI systems identify technical errors during the kick and provide individual recommendations for correction.

Jumping and Landing Processes

Jumping plays an important role in heading the ball and goalkeeper actions. Artificial intelligence enables evaluation of jump height, landing load, and balance, which allows assessment of injury risk. Injuries to the knee, ankle, and hip joints are common among football players. According to studies by local specialists (I. Yusupov, B. Toshpulatov), the main cause of these injuries is related to biomechanically incorrect movements.

AI-based biomechanical analysis allows:

• identification of dangerous movement patterns;

• assessment of excessive load levels;

• development of individualized preventive exercise programs.

AI-based biomechanical analysis makes it possible to predict injury risks in advance. AI algorithms detect muscle fatigue and changes in movement patterns, contributing to the development of individual recovery programs.

Optimization of Football Training Using Artificial Intelligence

With the help of AI technologies, football players' biomechanical indicators are continuously monitored. This allows coaches to:

• accurately plan training loads;

• consider players' individual capabilities;

• maintain optimal sports form.

Practical Significance of the Research

The research results can be applied in:

• scientific assessment of football players' technical preparedness;

• sports schools and professional football clubs;

• activities of sports physicians and rehabilitation specialists;

• development of injury prevention programs.

Conclusion

The research findings indicate that AI-based biomechanical analysis of football players' movements is one of the most promising directions in sports science. These technologies demonstrate high efficiency in improving technical preparedness, preventing injuries, and individualizing the training process.

In the future, the widespread implementation of artificial intelligence technologies in football biomechanics will play a significant scientific and practical role in achieving high sports performance and maintaining athletes' health.

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