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THE ROLE AND SIGNIFICANCE OF BIOMECHANICAL APPROACHES IN DEVELOPING THE PHYSICAL PREPAREDNESS OF TAEKWONDO ATHLETES DURING THE TRAINING PROCESS

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Abstract

This article provides a scientific analysis of the role and importance of biomechanical approaches in shaping the physical preparedness of taekwondo athletes during the training process. Biomechanical indicators such as kicking velocity, joint angles of lower limbs, force moments, and body mass distribution are examined in terms of their integration into training methodology. Modern technological tools (motion capture cameras, force platforms, 3D motion analysis) for biomechanical diagnostics are also reviewed. This biomechanical approach offers a scientific foundation for coaches and researchers to enhance the training efficiency of taekwondo practitioners.

Keywords: Taekwondo, biomechanics, physical preparedness, movement technique, striking power, balance, sensor analysis.



Introduction

O'QUV MASHG'ULOT BOSQICHIDA TAEKVONDOCHILARNING JISMONIY TAYYORGARLIGINI SHAKLLANTIRISHDA BIOMEXANIK YONDASHUVLARNING O'RNI VA AHAMIYATI

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Annotatsiya:

Maqolada o'quv mashg'ulot bosqichida taekvondochilarning jismoniy tayyorgarligini shakllantirishda biomexanik yondashuvlarning roli va ahamiyati ilmiy tahlil qilinadi. Biomexanik ko'rsatkichlar — kick tezligi, bo'y va oyoq segmentlarining harakat burchaklari, kuch momentlari va tana og'irligi taqsimoti — ta'lim va mashg'ulot jarayonlarida qanday qo'llanilishi mumkinligi muhokama etiladi. Shuningdek, zamonaviy texnologik vositalar (kapturli kameralar, kuch plitalari, 3D analiz) yordamida biomexanik diagnostika usullari ko'rib chiqiladi. Bu yondashuvlar murabbiylar va olimlar uchun taekvondochilarning samarador tayyorgarligini yuqori darajaga olib chiqishda ilmiy baza beradi.

Kalit so'zlar: taekvondo, biomexanika, jismoniy tayyorgarlik, harakat texnikasi, zarba kuchi, muvozanat, sensor tahlil.

АННОТАЦИЯ

В статье проводится научный анализ роли и значимости биомеханических подходов при формировании физической подготовленности спортсменов таэквондо на этапе учебно-тренировочного процесса. Рассматриваются биомеханические показатели — скорость удара, углы суставов нижних конечностей, величины моментов сил, распределение массы тела — и способы их интеграции в тренировочный метод. Также обсуждаются современные технологические средства, такие как камеры захвата движения, силовые платформы и 3D-анализ, применяемые для



биомеханической диагностики. Данный подход представляет собой научную основу повышения эффективности подготовки таэквондистов для тренеров и исследователей.

Ключевые слова: тхэквондо, биомеханика, физическая подготовка, техника движений, сила удара, равновесие, сенсорный анализ.

INTRODUCTION

In taekwondo, the effectiveness, accuracy, and speed of strikes delivered to the opponent play a decisive role in achieving competitive success. The harmony between an athlete's physical preparedness and the biomechanical structure of technical movements is a key factor determining performance efficiency. The training phase is the foundational stage where an athlete's core readiness is developed, and if biomechanical approaches are systematically integrated during this stage, it becomes possible to achieve higher performance outcomes while simultaneously minimizing the risk of injuries.

Biomechanics is the science that analyzes human movement through mechanical principles. It includes two main components — kinematics, which examines the geometric characteristics of motion (trajectory, velocity, angle), and kinetics, which studies the forces and torques that generate and control movements. In taekwondo, every strike — particularly leg techniques — involves a complex sequence of muscle activity, joint movement, and coordinated body segment interaction, all of which must operate in precise synchronization with physical conditioning.

The purpose of this article is to explore the role and practical significance of biomechanical approaches in shaping the physical preparedness of taekwondo athletes during the training process, to identify methodological features, and to propose applicable recommendations for optimization.

The research seeks to address the following core questions:

– Which biomechanical parameters of taekwondo strikes are most directly linked to an athlete's physical preparedness?



– How can biomechanical diagnostic methods be effectively integrated into training sessions?

– In what ways can biomechanical monitoring contribute to the enhancement of athletic performance and injury prevention?

A substantial body of scientific research has been conducted at the intersection of biomechanics and taekwondo. For instance, Jia and colleagues (2024) analyzed the correlation between the biomechanical characteristics of bilateral roundhouse kicks and the electronic scoring system, identifying the importance of maximal linear velocity in distal lower-limb segments. Other researchers have emphasized the proximal-to-distal motion pattern in elite-level kicks — where the movement is initiated from the core and upper body, transferring momentum to the lower limb for maximum impact.

Hong and collaborators at the Hong Kong Sports Institute studied taekwondo kicking techniques through biomechanical analysis and introduced training modifications based on their findings. Similarly, the work “Biomechanics of the Taekwondo Axe Kick” by Mailapalli et al. examined optimal joint angles and safety considerations in neryo chagi execution. A recent scoping review further highlighted the importance of biomechanical analysis in enhancing performance and preventing injuries.

Moreover, Guan et al. (2024), in their study titled “Effects of Core Muscle Stability on Kicking Performance,” demonstrated a strong correlation between core stability and strike efficiency, confirming that targeted core training can significantly improve taekwondo kicking performance.

Ojeda-Aravena (2025) has identified a significant correlation between high-intensity kicking performance and change-of-direction (COD) ability with key parameters of physical preparedness in taekwondo athletes, emphasizing the role of neuromuscular reactivity and explosive power development in optimizing combat efficiency.

In a broader perspective, unique kinematic and kinetic datasets provide a deeper understanding of taekwondo striking mechanics, allowing coaches to construct more precise and individualized methodological frameworks for training optimization and performance enhancement.



A comprehensive review of the literature indicates that contemporary research increasingly seeks to associate parameters such as segmental velocity, torque production, body mass distribution, and center of mass (CoM) dynamics with the athlete's biological readiness. However, biomechanical control and real-time monitoring systems are still rarely implemented during the training phase — addressing this methodological gap is therefore considered highly relevant and practically necessary.

Ojeda-Aravena (2025) identified that force plates allow the measurement of ground reaction forces, force vectors, and vertical components at the moment of impact, making this method directly relevant to the kinetic parameters of the strike.

Kinetic and kinematic analysis software is used to calculate parameters such as segmental velocity, joint angles, torque generation, and energy transfer.

Electromyography (EMG) is applied to detect muscle activation during specific movement phases and to analyze optimal muscle engagement. Although this method is less frequently used in studies, it can play an important role in comprehensive biomechanical analysis. In some studies such as “Biomechanical Analysis of Taekwondo Kicking Technique,” EMG has been integrated as part of the evaluation process.

Integration of biomechanical approaches into the training phase

Diagnostic phase. At the beginning of training, athletes undergo biomechanical tests (kick tests, segmental velocity tests, torque tests), and the results are used as a baseline to develop individualized training plans.

Individualized training programs. Specific segmental weaknesses — for example, insufficient torque in the lower limb — are identified, and targeted strength and speed exercises (such as plyometrics and eccentric strength training) are incorporated to optimize strike execution.

Monitoring and reevaluation. After each specific cycle (e.g., every 2–3 months), biomechanical tests are repeated to monitor progress. If segmental parameters do not meet the target, the training strategy is revised.



Modern technologies and real-time integration. Markerless systems and real-time movement analysis tools (such as live tracking cameras and software) provide immediate feedback during training sessions, allowing coaches to analyze the athlete's movements instantly.

Conclusion

This article scientifically examined the role of biomechanical approaches in developing the physical preparedness of taekwondo athletes during the training phase. Key biomechanical parameters — including segmental velocity, torque generation, joint angle dynamics, center of mass control, and muscle activation — and their relationships with physical readiness were identified. In addition, practical applications of biomechanical diagnostics — such as motion capture systems, force plates, kinematic/kinetic analysis software, and EMG — were outlined.

From an integration standpoint, the importance of using biomechanical testing as a diagnostic foundation, incorporating it into individualized training programs, conducting systematic monitoring and reevaluation, and utilizing real-time analysis technologies was emphasized. These approaches can support coaches and researchers in enhancing movement efficiency, reducing injury risk, and optimizing training strategies.

In the future, within the context of Uzbekistan, it will be crucial to widely implement biomechanical approaches by strengthening national laboratories, digital systems, and sports science infrastructure. This will significantly increase the international competitiveness of national taekwondo athletes.

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