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BIOMECHANICAL CRITERIA FOR SELECTION AND MONITORING IN THE SPORTS RESERVE SYSTEM

Abstract. The theses examine the role of biomechanical criteria in the selection and ongoing monitoring of young athletes. Modern instrumental methods for assessing motor characteristics are analyzed: force plates, IMU sensors, and machine learning algorithms. The feasibility of an integrated approach combining anthropometric, kinematic, and dynamic indicators is substantiated.

Key words: biomechanics, sports reserve, selection, force plate, IMU sensors, countermovement jump, youth athletes.

Анотація. *Біомеханічні критерії відбору та контролю в системі спортивного резерву.* Кокарев А.Б., Азербасев Д.Н., Кокарев Б.В. У тезах розглянуто роль біомеханічних критеріїв у системі відбору та поточного контролю юних спортсменів. Проаналізовано сучасні інструментальні методи оцінювання рухових характеристик: силові платформи, IMU-датчики та алгоритми машинного навчання. Обґрунтовано доцільність комплексного підходу, що поєднує антропометричні, кінематичні та динамічні показники.

Ключові слова: біомеханіка, спортивний резерв, відбір, силова платформа, IMU-датчики, контрстрибок, юні спортсмени.

An effective sports reserve preparation system requires scientifically grounded criteria for selecting and monitoring the development of young athletes. Traditional pedagogical observation and subjective coaching assessments are today increasingly supplemented by instrumental methods that enable objective measurement of biomechanical movement parameters. Research over the past decade convincingly demonstrates that biomechanical indicators – joint kinematics, force-profile characteristics, and neuromuscular efficiency – are informative predictors of athletic potential [1, 2].

At the same time, researchers emphasize the risks of a one-dimensional approach to talent identification: focusing solely on current performance without accounting for maturation rates and individual developmental trajectories leads to systematic selection errors [3]. Accordingly, defining a set of biomechanical indicators suitable for integration into scientifically grounded selection and ongoing monitoring systems is a pressing task.

Among biomechanical testing methods, assessment of jumping characteristics using force plates occupies a leading position. The countermovement jump (CMJ) is the most valid and reliable test of lower-limb explosive strength and is widely used in sports selection systems [4]. A study by Aničić et al. (2023) showed that of 45 calculated CMJ indicators, only 24 demonstrate an acceptable level of

reproducibility ($CV \leq 10\%$), with the most informative being performance-component indicators (jump height, relative peak power) and eccentric-component indicators (braking-phase loading) [4]. This is fundamentally important when constructing profiles of young athletes: not all CMJ metrics are equally suitable for screening, and the choice of indicators must be scientifically grounded.

A study by King et al. (2024), conducted within the Scottish Performance School programme ($n=90$ players, 11.3 ± 0.4 years), established that selected and non-selected players differ significantly in speed-strength qualities (CMJ, 20 m sprint, 5-0-5 agility test) and technical characteristics determined by inertial sensors during play [5]. In particular, selected players demonstrated higher running speed with the ball and a greater frequency of touches in decision-making situations. This underscores the value of combining biomechanical testing with game context.

Alongside force plates, wearable technologies based on inertial measurement units (IMU), electromyography (EMG), and pressure sensors are advancing rapidly. Alzahrani and Ullah (2024), in a cross-sectional study, demonstrated that IMU sensors allow field-based measurement of joint angular displacements (mean: 112.3° , SD: 6.8), muscle activation, and ground reaction forces, forming a comprehensive real-time biomechanical profile of the athlete [6]. This approach overcomes the limitations of laboratory research and enables assessment directly during training sessions and competitions.

A review by Rebelo et al. (2023), encompassing 21 primary studies (2008–2023) across various sports, confirmed that triaxial accelerometers were used in 67% of studies, GPS technologies in 52%, and force plates in 33% [7]. Combining these methods provides the foundation for objective monitoring of training load, injury risk, and recovery dynamics in young athletes. The application of machine learning algorithms to analyse large data sets collected by wearable devices is a particularly promising direction [1].

Analysis of contemporary research convincingly indicates that an effective sports reserve system cannot be built on isolated biomechanical indicators. Carvalho and Gonçalves (2023), in a theoretical paper, note that discrepancies between current developmental level and athletic potential stem from neglect of biological maturation when assessing motor characteristics [3]. In particular, athletes in the post-pubertal phase are frequently overrated, while athletes with delayed maturation – who may possess higher ultimate potential – are systematically eliminated.

The Chilean selection programme (CPAP), described by Baraga et al. (2025) on a sample of 3,060 schoolchildren, demonstrates the successful integration of biomechanical tests (standing long jump, 30 m sprint, T-agility test) with consideration of sex, age range, and maturation stage [2]. The programme's results are impressive: 23% of former participants were included in the main squad for the 2023 Pan American Games, and their share of the national team's medal tally reached 40.5%. This example illustrates the effectiveness of systematic, scientifically grounded selection incorporating biomechanical criteria.

Multidimensional and longitudinal approaches to talent identification are recognised as the most effective in the systematic review by Mulder et al. (2024), which covered 32 studies in racket sports [8]. The authors established that most studies focus on physiological characteristics (n=28), while technical (n=16) and psychological (n=4) parameters are covered considerably less. Accordingly, a promising direction is the expansion of test batteries to include technical and biomechanical indicators using portable instrumental tools.

Conclusions.

1. Biomechanical criteria – in particular CMJ indicators, joint kinematics, and force profile – are valid and reliable tools for the objective selection and monitoring of young athletes, provided that metrics are chosen on a scientifically grounded basis [4].

2. Wearable technologies (IMU, EMG, GPS) expand the possibilities for field-based fitness monitoring, which is fundamentally important for the practical implementation of a sports reserve system [6, 7].

3. Maximum effectiveness of biomechanical diagnostics is achieved through the integration of diverse indicators (anthropometric, kinematic, dynamic) with consideration of biological maturation stage and longitudinal monitoring [2, 3, 8].

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