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Kvach O.
assistant teacher at a preschool
Oak Ridge School District, Tennessee, USA
coach in rhythmic gymnastics
«Nika Rhythmic gymnastics LLC», USA
https://orcid.org/0009-0000-5252-7099

BIOMECHANICAL FEATURES OF BALANCE PERFORMANCE IN YOUNG GYMNASTS AT THE STAGE OF INITIATION OF COMPETITIVE ACTIVITY

Kvach O. Biomechanical features of balance performance in young gymnasts at the initial stage of competitive activity. The article presents the results of a study on the biomechanical features of balance performance in young gymnasts aged 5–9 years at the initial stage of competitive activity, as well as spatial–coordination changes in the movement structure of balances during targeted preparation for first competitions. The relevance of the study is determined by the need for scientifically grounded formation of postural control and technical repeatability in beginner athletes, since these characteristics largely determine the quality of balance execution in a competitive context. The research was conducted at the Nika Rhythmic Gymnastics club (Oak Ridge, Tennessee, USA): the overall beginner group comprised 12 children aged 4–9 years, while biomechanical analysis and comparison of two time points were carried out in a subgroup of 9 gymnasts aged 5–9 years preparing for their first competitions. The performance of basic balance elements (passé, balance with the leg abducted, and balance with trunk inclination) was analyzed using a set of indicators including trunk sway, stability of the supporting leg, shoulder girdle symmetry, coordination between upper and lower body segments, and technical repeatability. Quantitative results of repeated assessment demonstrated positive dynamics between the early and later stages: trunk sway decreased from 3.2 to 1.9 (–1.3), supporting-leg stability increased from 2.4 to 3.6 (+1.2), shoulder girdle symmetry from 2.6 to 3.8 (+1.2), coordination of upper and lower segments from 2.3 to 3.5 (+1.2), and technical repeatability from 2.5 to 3.9 (+1.4). Taken together, these changes indicate a reduced reliance on compensatory strategies for maintaining posture and the formation of a more controlled, coordinated, and repeatable movement structure of balances during preparation for first competitions.

Keywords: *young gymnasts, rhythmic gymnastics, balance, biomechanical analysis, postural control.*

Квач О.О. Біомеханічні особливості виконання рівноваг у юних гімнасток на етапі початку змагальної діяльності *.У статті подано результати дослідження біомеханічних особливостей виконання рівноваг юними гімнастками віком 5–9 років на етапі початку змагальної діяльності та просторово-координаційних змін рухової структури рівноваг у процесі цілеспрямованої підготовки до перших стартів. Актуальність роботи зумовлена потребою науково обґрунтованого формування постурального контролю й відтворюваності техніки в дітей-початківців, оскільки саме ці характеристики визначають якість виконання рівноваг у змагальному контексті. Дослідження проведено на базі клубу Nika Rhythmic Gymnastics (Oak Ridge, Tennessee, USA): загальний контингент початкової підготовки становив 12 дітей віком 4–9 років, а біомеханічний аналіз і порівняння двох часових зрізів виконано в підгрупі з 9 гімнасток 5–9 років, які готувалися до перших змагань. Проаналізовано виконання базових рівноваг (passé, рівновага з відведеною ногою, рівновага з нахилом корпусу) за комплексом індикаторів: коливання корпусу, стабільність опорної ноги, симетрія плечового пояса, узгодженість верхніх і нижніх ланок, повторюваність техніки. Кількісні результати повторного оцінювання засвідчили позитивну динаміку між раннім і пізнішим зрізами: коливання корпусу зменшилися з 3,2 до 1,9 (–1,3), стабільність опорної ноги зросла з 2,4 до 3,6 (+1,2), симетрія плечового пояса – з 2,6 до 3,8 (+1,2), координація верхніх і нижніх ланок – з 2,3 до 3,5 (+1,2), повторюваність техніки – з 2,5 до 3,9 (+1,4). Сукупність цих змін вказує на зниження потреби в компенсаторних стратегіях утримання пози та на формування більш керованої, узгодженої й відтворюваної рухової структури рівноваг у процесі підготовки до перших змагань.*

Ключові слова: *юні гімнастки, художня гімнастика, рівновага, біомеханічний аналіз, постуральний контроль.*

Problem statement. The state of postural control in preschool and early school-age children is increasingly considered an integral indicator of the maturity of the musculoskeletal system, coordination capabilities, and the ability for conscious organization of movements. Under conditions of a modern lifestyle, in which children's spontaneous motor activity is limited, the formation of stable skills for maintaining body position in space becomes particularly significant for preserving physical well-being and ensuring further motor development. Body posture in balance reflects not only the morphofunctional state of the musculo-ligamentous system but also the level of sensorimotor integration and movement regulation, which is directly related to the quality of motor performance in sport and everyday activity [1].

At the age of 4–9 years, intensive growth is combined with relative functional immaturity of stabilizing muscular chains, as a result of which balance maintenance mechanisms remain labile and sensitive to external influences. In the absence of systematic pedagogical support, disturbances in the spatial organization of the body tend to become fixed and may complicate the acquisition of more complex motor forms in the future [11]. At the same time, this age period is characterized by high plasticity of neuromuscular mechanisms, which creates favorable conditions for the targeted development of postural control and the formation of basic balance skills [12].

Sports activity is considered one of the most effective means of influencing the development of balance abilities; however, its effect is not universal and is largely determined by the specificity of the motor content of training. Generalization of the results of children's participation in various types of motor activity indicates that positive changes in postural status are primarily characteristic of those forms of activity that require systematic control of body position, symmetry, and precision of movements [3].

In this context, rhythmic gymnastics occupies a special place, since balance elements are one of its basic structural components and are formed already at the initial stage of training. The performance of balances in rhythmic gymnastics requires coordinated work of stabilizing muscles, precise control of the position of the center of mass, and a high level of intermuscular coordination. Participation in rhythmic gymnastics at a young age contributes to the development of movement culture, plasticity, and spatial organization of movements, creating prerequisites for harmonious physical development [2].

Modern approaches to the analysis of motor activity, in particular those using biomechanical and instrumental monitoring technologies, demonstrate the high demands of this sport on body stabilization in static and quasi-static positions [17]. At the same time, the vast majority of research in the field of rhythmic gymnastics focuses on issues of sports performance, whereas the features of balance formation in children at the stage of initiation of competitive activity remain insufficiently studied.

An equally important factor in the effectiveness of learning motor actions in childhood is the motivational component. The regularity of training sessions and the quality of exercise performance largely depend on the emotional attractiveness of the training process, the pedagogical stance of the coach, and parental support [4; 8]. For children who are only preparing for their first competitions, a positive motivational background serves not only as a condition for maintaining interest in training but also for the formation of an adequate motor stereotype when performing technically complex elements, in particular balances.

Pedagogical experience in the use of rhythmic gymnastics means in work with young children confirms their appropriateness for the development of coordination abilities and basic motor skills [9]. Similar patterns are observed in studies devoted to educational and postural gymnastics, where specially organized exercises have a positive effect on the stability of body position and children's spatial orientation [10; 12]. At the same time, analysis of the practice of initial sports training indicates the absence of a clearly structured biomechanical approach to teaching balances to beginner children, especially during the period of preparation for the first competitions.

Thus, despite the availability of substantial theoretical and applied groundwork, the problem of biomechanical features of balance performance in young gymnasts aged 4–9 years at the stage of initiation of competitive activity remains insufficiently systematized. This determines the relevance of research aimed at analyzing the spatiotemporal and coordination

characteristics of balances in beginner children, taking into account age-related features, pedagogical training conditions, and the specificity of rhythmic gymnastics as a sport.

Purpose of the study is to investigate the biomechanical features of balance performance in young gymnasts aged 5–9 years at the stage of initiation of competitive activity and to determine the nature of spatiocoordinational changes in the motor structure of balances in the process of targeted training preparation.

Research methods: theoretical analysis and synthesis of scientific and methodological sources on the issues of postural control and technique learning in rhythmic gymnastics; pedagogical observation of the training process in an initial training group; biomechanical (qualitative–quantitative) analysis of the performance of basic balance elements with fixation of spatial position characteristics (support stability, trunk axis, shoulder girdle symmetry, intersegmental coordination, repeatability) and repeated assessment at two time points of training; methods of descriptive statistics for summarizing and comparing indicators between the assessment stages.

Presentation of the main research material. Observation of balance performance was conducted in September 2025 at the Nika Rhythmic Gymnastics club (Oak Ridge, Tennessee, USA), when the training regimen had already become regular and beginners' technique had acquired more defined and repeatable features. The overall initial training group included 12 children aged 4–9 years; for the biomechanical analysis of balances, 9 gymnasts aged 5–9 years were selected, who were in the phase of preparation for their first competitions, that is, under conditions of increased demands for stability and repeatability of element performance.

Within this stage, basic balance elements that constitute the technical framework of initial routines prove to be the most informative: single-leg balance of the passé type, a variation with the leg abducted, and balance with trunk inclination. It is precisely in these positions that the integrity of postural organization can be assessed: the ability of the supporting segment to bear load without excessive foot corrections, maintenance of the trunk axis, stabilization of the shoulder girdle, and control of the projection of the center of mass within the support area.

For the majority of the observed attempts, a balance-maintenance strategy characterized by increased co-contraction at the ankle and knee joints was typical: the position was stabilized mainly through generalized tension rather than precise dosing of muscular effort, which is consistent with age-related compensatory mechanisms of postural control [1]. Against this background, even when the position is formally maintained, small oscillations of the trunk in the frontal and sagittal planes persist—as a regular accompaniment of quasi-static maintenance, when the stabilizing capacities of the trunk are still developing and sensorimotor coordination does not always ensure fine positional correction [12]. In rhythmic gymnastics, such deviations become more noticeable due to the increased demands on body geometry in space, symmetry, and precision of spatial orientation [17].

The most characteristic deviations at the stage of preparation for the first competitions exhibit pronounced repeatability and form a typical configuration of technical limitations. First, these include trunk oscillations during the phase of entering the position, when trunk stabilization is implemented with a temporal delay relative to assuming the posture, which reduces stability. Second, shoulder girdle asymmetry reflects insufficient segmental stabilization and disrupts the "line" of the position. Third, insufficient fixation of the supporting foot and small corrective movements at the ankle joint increase performance variability. Finally, there is excessive involvement of the upper limbs as a compensatory mechanism: arm movements are used for stabilization rather than solely for shaping the position, which increases overall muscle tension and reduces efficiency.

From a pedagogical perspective, these manifestations are typical for beginners and are consistent with data on the expediency of using rhythmic gymnastics means for the formation of movement culture and coordination at a young age, while simultaneously emphasizing the need for targeted instruction in the mechanics of balance rather than only the external form of the position [9]. The generalized biomechanical characteristics of the performance of basic balance elements are systematized in Table 1.

Table 1

Main biomechanical indicators of balance performance in young gymnasts (5–9 years)

Type of balance	**Stability of the supporting leg**	**Trunk position**	**Maintenance of the center of mass**	**Characteristic deviations and errors**
Single-leg balance (passé)	Average	Slight forward inclination	Within the support area with oscillations	Trunk oscillations, shoulder tension
Balance with the leg abducted	Low–average	Disruption of the vertical axis	Partial displacement beyond the support area	Shoulder girdle asymmetry
Balance with trunk inclination	Average	Inclination in the sagittal plane	Compensation through the use of the arms	Excessive tension of the upper limbs

Source: created by the author based on own research.

The data in Table 1 show that the most controllable balance for gymnasts aged 5–9 years is the basic single-leg balance (passé): support stability is assessed as average, and the center of mass is generally maintained within the support area, although with noticeable oscillations, manifested as trunk sway and increased tension of the shoulder girdle. Complication of balance conditions through leg abduction is accompanied by a decrease in stability to a "low–average" level,

disruption of the vertical axis of the trunk, and partial displacement of the center of mass beyond the support area; a typical marker of technical instability is shoulder girdle asymmetry, which indicates insufficient segmental stabilization and attempts to compensate for deficient control through the trunk.

Balance with trunk inclination retains an "average" level of supporting leg stability, but this is achieved at the cost of pronounced compensation via the upper limbs: excessive arm tension is recorded, indicating the dominance of a compensatory strategy rather than economical stabilization of the trunk and pelvic girdle. Overall, the obtained data reflect a pattern typical of the initial stage of competitive preparation—a transition from relatively controllable basic positions to technically more risky variants, in which stabilization of the trunk axis and shoulder girdle symmetry become the main limiting factors.

To trace changes in the spatiocoordinational quality of balances within the preparatory cycle, a comparison of two time points was organized: an early stage (at the beginning of preparation) and a later stage (at the pre-competition phase). Performance assessment was carried out in the same group of young gymnasts (n = 9, aged 5–9 years) who were preparing for their first competitions within the club program.

At each time point, the performance of basic balances typical for the initial level (passé, balance with the leg abducted, balance with trunk inclination) was recorded, after which key spatiocoordinational characteristics of technique were compared: the magnitude of trunk oscillations during position maintenance, stability of the supporting segment, preservation of the trunk axis and shoulder girdle symmetry, the nature of upper limb involvement in stabilization, as well as repeatability of performance within the same type of element. Such a scheme makes it possible to interpret the observed changes as the result of targeted preparation for competitions, since the comparison is conducted under identical conditions at two time stages within the same training cycle. The generalized indicators of balance stability and coordination quality at the early and later stages are presented in Figure 1.

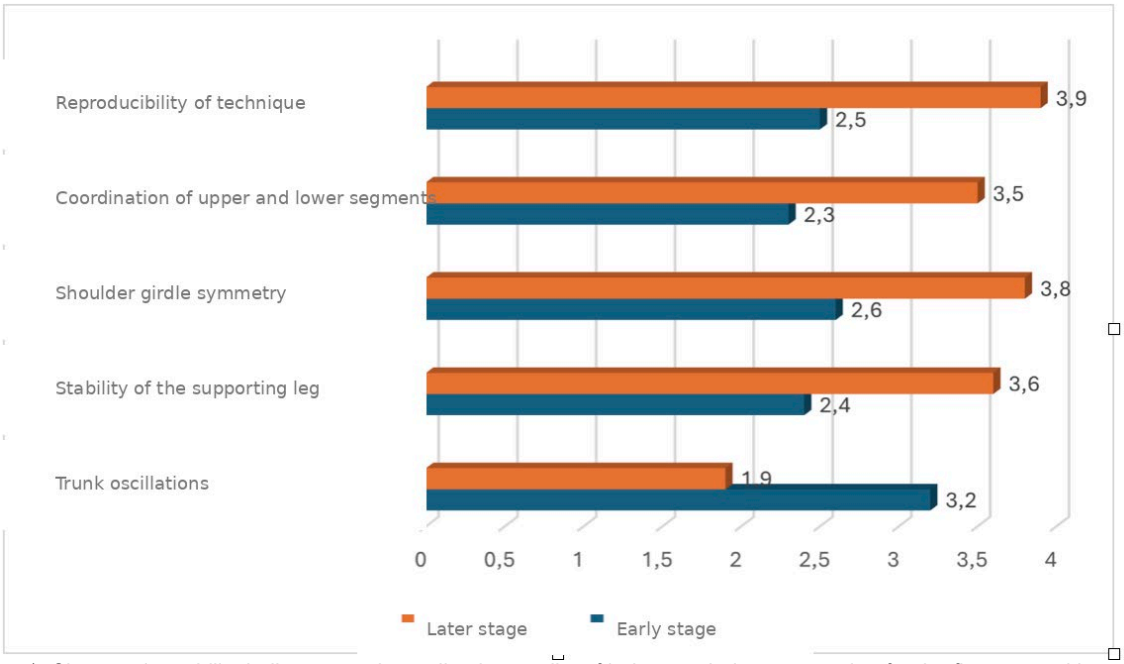


Figure 1. Changes in stability indicators and coordination quality of balances during preparation for the first competitions (early vs later stage).

Source: created by the author based on own research.

At the same time, the stability of the supporting leg increases substantially: from 2.4 to 3.6 arbitrary units (+1.2 units; approximately +50%). This dynamics is interpreted as a decrease in the frequency of small corrective actions in the ankle and knee joints and more reliable fixation of the supporting foot. In balance technique, this creates prerequisites for more stable maintenance of the projection of the center of mass within the support area and, accordingly, for more accurate preservation of the element's form without excessive corrective movements.

Changes in the shoulder girdle confirm this trend: shoulder girdle symmetry increases from 2.6 to 3.8 arbitrary units (+1.2 units; about +46.2%). In practical terms, this reflects more stable maintenance of the "line" of the position and alignment of the trunk axis. In rhythmic gymnastics, this indicator is of fundamental importance, since shoulder girdle symmetry simultaneously ensures mechanical stability and meets the requirements for visual accuracy of body position, reducing the need for compensatory movements of the upper limbs.

The dynamics of coordination between the upper and lower body segments is also pronounced: the indicator increases from 2.3 to 3.5 arbitrary units (+1.2 units; approximately +52.2%). This means that at the later stage of preparation, the movements of body segments in balance become more coordinated, and stabilizing work is distributed more rationally: the supporting segment ensures reliability of support, the trunk provides axis stabilization, and the upper limbs primarily maintain the заданую positional configuration. Such coordination is a criterion of transition to a more technically mature performance model in which stability is achieved not through generalized tension but through coordinated interaction of segments.

The greatest increase is observed in technique reproducibility: from 2.5 to 3.9 arbitrary units (+1.4 units; about +56%). In pre-competition preparation, this indicator is of particular importance, as it reflects reduced performance variability within the same type of balance: key positional features (trunk axis,
shoulder girdle stability, and the nature of support stabilization) are reproduced more consistently from attempt to attempt, indicating the formation of a more reliable technical stereotype for competitive conditions.

The summary of the repeated assessment data confirms a unidirectional positive dynamic for most parameters of the technical quality of balances: against the background of reduced trunk oscillations, an increase in the stability of the supporting leg, improved shoulder girdle symmetry, enhanced intersegmental coordination, and the most pronounced increase in technique reproducibility are recorded. In the context of the study, the obtained data characterize the effectiveness of targeted preparation for the first starts under club conditions, since the changes involve not a single isolated indicator but an interrelated комплекс of stabilizing and coordination characteristics that determine the quality of balance performance in young gymnasts.

Conclusions. The obtained data indicate that the performance of basic balance elements in young gymnasts aged 5–9 years at the stage of initiation of competitive activity is characterized by a typical set of biomechanical features: insufficient stability of the supporting segment, trunk oscillations, disturbances of the axis and shoulder girdle symmetry, as well as increased involvement of the upper limbs as a compensatory mechanism for position stabilization. Comparison of the early and later stages of preparation revealed unidirectional spatiocoordinational changes: a reduction in trunk oscillations and an increase in support stability, shoulder girdle symmetry, coordination of upper and lower body segments, and technique reproducibility, which reflects the formation of a more controllable and repeatable motor structure of balances in the process of targeted preparation for the first competitions.

Prospects for further research. It is advisable to expand the sample and move from a условно-point scoring assessment to an instrument-based quantitative analysis of balances (video analysis, oscillation parameters, duration of stable maintenance, indicators of repetition variability), as well as to compare the dynamics of technique across different age sub-stages of initial training.

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Tymchyk S. G.
Lecturer at the department of health and sports technologies,
National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"
https://orcid.org/0000-0002-1916-3008

INNOVATIIVE FORMAT OF PHYSICAL EDUCATION CLASSES AT A TECHNICAL UNIVERSITY.

The article substantiates the relevance of implementing integrated formats of physical education and intellectual classes and competitions in higher education institutions using the example of a combination of powerlifting, strength training and checkers. It is noted that higher education students demonstrate a decrease in motivation for traditional forms of physical education, which necessitates the need for innovative approaches capable of combining physical development, intellectual activity and competitive attractiveness. The purpose of the study is to theoretically substantiate the feasibility of implementing the "Power of Mind" format as a means of increasing the interest of higher education students in strength sports and intellectual games in the university environment. The study uses theoretical methods of analysis, synthesis, generalization of scientific sources, as well as pedagogical statistical observation of the participation of higher education students in the educational and training process and competitions. The "Power of Mind" format, which involves the integration of strength sports with intellectual competitive components, is an original development for a technical university. The results show that the combination of strength exercises with checkers disciplines contributes to the comprehensive development of physical qualities, cognitive functions, volitional characteristics and stress resistance of higher education students. The format "Power of Mind" increases internal motivation for classes, forms interdisciplinary competencies and has a positive effect on social interaction in student groups. It is concluded that the integration of powerlifting, strength training and checkers is a promising direction for the modernization of physical education activities in higher educational institutions and requires further empirical research.

Keywords: *powerlifting, strength training, checkers, higher education students, motivation, physical education.*

Тимчик С. Інформаційний формат занять з фізичного виховання в технічному університеті. *У статті обґрунтовано актуальність впровадження інтегрованих форматів фізичного виховання та інтелектуальних занять та змагань у вищих навчальних закладах на прикладі поєднання пауерліфтингу, силових тренувань та шашок. Зазначається, що здобувачі вищої освіти демонструють зниження мотивації до традиційних форм фізичного виховання, що зумовлює необхідність інноваційних підходів, здатних поєднувати фізичний розвиток, інтелектуальну активність та змагальну привабливість. Метою дослідження є теоретичне обґрунтування доцільності впровадження формату «Сила розуму» як засобу підвищення інтересу здобувачів вищої освіти до силових видів спорту та інтелектуальних ігор в університетському середовищі. У дослідженні використовуються теоретичні методи аналізу, синтезу, узагальнення наукових джерел, а також педагогічного статистичного спостереження за участю здобувачів вищої освіти у навчально-тренувальному процесі та змаганнях. Формат «Сила розуму», який передбачає інтеграцію силових видів спорту з інтелектуальними змагальними компонентами, є оригінальною розробкою для технічного університету. Результати показують, що поєднання силових вправ з шашковими дисциплінами сприяє всебічному розвитку фізичних якостей, когнітивних функцій, вольових характеристик та стресостійкості здобувачів вищої освіти. Формат «Сила розуму» підвищує внутрішню мотивацію до занять, формує міжпредметні компетенції та позитивно впливає на соціальну взаємодію в студентських групах. Зроблено Висновок, що інтеграція пауерліфтингу, силових тренувань та шашок є*