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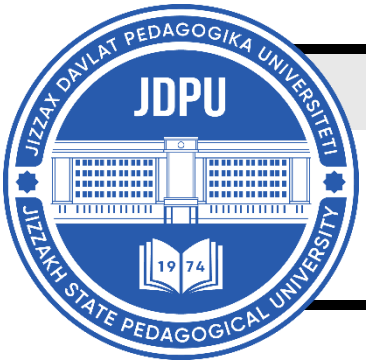

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STUDYING THE FEATURES OF THE TECHNIQUE OF PERFORMING THE YURCHENKO TYPE VOUCH USING THE METHOD OF KINEMATIC ANALYSIS IN ARTISTIC GYMNASTICS

Ilyas Tadjimatov
Uzbekistan State University of Physical Education and Sport
Tadjimatov.ilya@gmail.com
Chirchik, Uzbekistan

ABOUT ARTICLE

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Abstract: The article examines the issues of the biomechanical kinematic structure of the Yurchenko type vaults, which are a fundamental element of competitive programs in artistic gymnastics, as well as the development and creation of model characteristics of basic vaults based on an analysis of their execution by highly qualified gymnasts.

Introduction. Artistic gymnastics is one of the sports that requires a high level of technical complexity, precision, and harmonious coordination of movements. The exercises performed in this sport, particularly vaults, demand not only strength and speed from athletes but also advanced coordination abilities, spatial orientation, and precise control of movements within limited time intervals. The effectiveness of vault performance largely depends on biomechanically grounded technique, and taking into account the leading biomechanical parameters within the structure of motor actions is one of the most important conditions for achieving high-quality execution.

As athletes' skill levels improve, the requirements for the technical execution of movements increase accordingly. At the initial stages of preparation, the formation of general motor skills is considered a priority, whereas at the stages of sports improvement and elite athletic mastery, identifying the most effective and rational variants of each technical element becomes critically important. Therefore, determining the leading indicators of sports

movement techniques, scientifically analyzing them, and implementing the results into practice constitute one of the most pressing issues in modern artistic gymnastics. The study of kinematic parameters of movements during the execution of acrobatic and vaulting exercises is a necessary condition for effective management of the training process. Kinematic analysis makes it possible to determine temporal characteristics, velocity, acceleration, joint angles, ranges of motion, and the spatial trajectory of the body. This information allows for an in-depth analysis of athletes' motor activity, identification and correction of technical errors, and planning of the training process with consideration of individual characteristics.

In this regard, special importance is attributed to the study of basic acrobatic vaults performed by highly qualified athletes. It is precisely in the performances of elite gymnasts that the most rational and biomechanically optimal variants of technique are manifested. On this basis, it becomes possible to develop model characteristics of vaults and acrobatic elements and to introduce them into the educational and training process according to age and qualification levels. Model indicators serve as an important scientific and practical tool for coaches and specialists in evaluating technique, identifying errors, and improving athletes' preparedness.

Vault exercises in artistic gymnastics are characterized by a complex coordination structure and consist of several interrelated phases. The run-up, takeoff from the springboard, hand support on the vaulting table, push-off from the support, flight phase, and landing are closely interconnected, and the effectiveness of each phase directly influences the quality of the subsequent phase. Among vaults, Yurchenko-type vaults are distinguished by their high execution speed, complex rotational movements, and increased demands on spatial orientation.

Yurchenko-type vaults are currently considered one of the most commonly used and fundamental vaults in artistic gymnastics. They are widely applied by athletes from the stage of sports improvement through to the stage of elite athletic mastery. Successful execution of this vault depends on several factors, including run-up speed, accuracy of the round-off and back handspring, power of the push-off from the vaulting table, and the ability to control body position during the flight phase. For this reason, scientifically grounded investigation of the technique of performing this vault is of great importance for improving athletic performance.

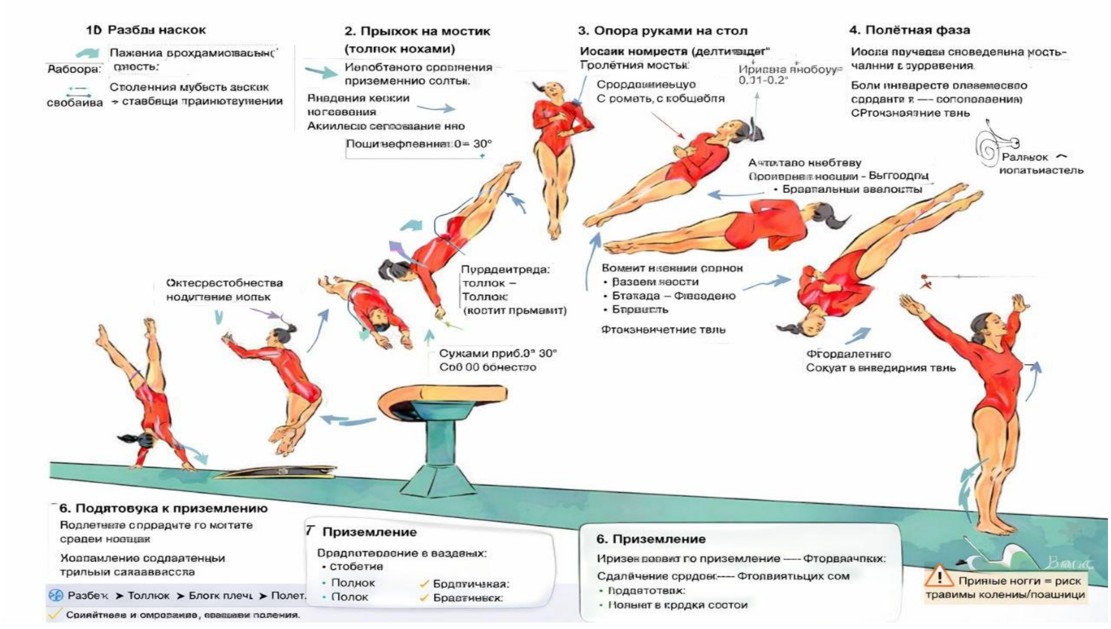
To master a rational technique, an athlete must know when, how, and within what limits changes should be introduced into movements. Adapting movements to external conditions as well as to individual physical and psychophysiological characteristics allows for further improvement of technical preparedness. In this process, kinematic analysis plays a key role as

an objective scientific source of information for both coaches and athletes. Using kinematic analysis methods, it is possible to determine temporal indicators, velocity dynamics, joint angles, and spatial body positions during the execution of the Yurchenko-type vault. Based on these indicators, the athlete's technical level can be assessed, optimal and inefficient movement patterns can be compared, and errors occurring during training can be identified. As a result, opportunities are created for scientifically grounded management and individualization of the training process.

Within the framework of this study, the movement structure of the Yurchenko acrobatic vault (round-off–back handspring–layout salto) performed by highly qualified female gymnasts aged 14–16 is analyzed. This age period represents a crucial stage for the refinement of technically complex elements, during which the correct formation of movement technique largely determines the success of future athletic performance. The results of the study make it possible to identify leading kinematic indicators of this vault, assess their interrelationships, and develop model characteristics.

Therefore, the present research is aimed at studying the kinematic characteristics of the technique of performing the Yurchenko-type vault in artistic gymnastics, identifying leading biomechanical parameters, and developing scientifically grounded practical recommendations for improving the training process. The findings of the study are of practical significance for coaches, sports specialists, and researchers, contributing to the improvement of athletes' technical preparedness, reduction of injury risk, and achievement of high sports performance.

The purpose of the present study was to determine the kinematic characteristics of the technique of performing the Yurchenko vault (Figure 1, Table 1).



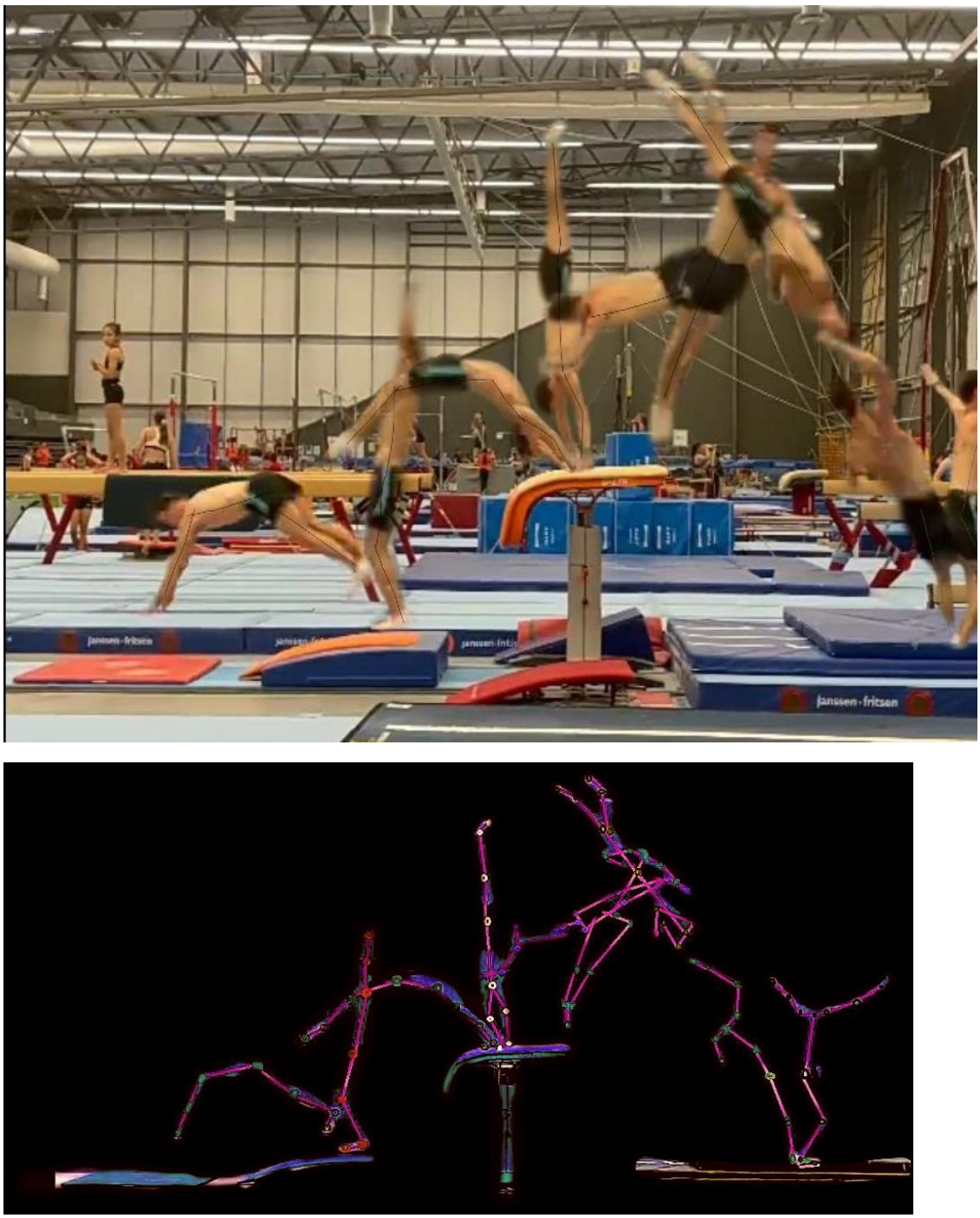


Figure 1. Kinematic sequence of the Yurchenko vault

Table 1.

Structural–phase model of the kinematic parameters of the Yurchenko-type vault technique

Стадии	Аккумуляция				Рабочая	Реализация				Амортизация		
Фазы	В-1	В-2	Разгон перед Наскок на мост	Наскок на мост	Отталкивание толчком двумя	Полет				Приземление	Остановка	Фиксация позы
	2 шага	Вальсет				Восходящая Траектория на опорный стол	Отталкивание толчком двумя руками	Максимальная высота	Нисходящая траектория			
Граничная поза	Тело под наклоном	Тело прямок	Тело слегка наклонена в перед	Тело наклонено вперёд с постепенным выпрямлением туловища	Ноги немного согнуты в коленных суставах	Удержание ног в месте, с активным прогибанием туловища назад с одновременным рук вверх назад	Тело прямое руки собраны ноги вместе	Вращение сохранением формы прыжка	Опускание прямого туловища	Касание опоры стопами	Опускание рук в стороны с полным выпрямлением туловища	Тело прямое руки перед собой
Ведущие действия	Разбег	Подскок за тем разбег	разбег с ускорением	Отталкивание с моста	Отталкивание с поворотом на 180	Увеличение амплитуды и высоты прыжка	Увеличение амплитуды вращения	Разведение ног в шпагат	Чуть сгибая колени, подготовка к приземлению	Пружинящее движение, ног на опоре	Снижение скорости	Сохранение равновесия

Research Methods. The main method of the study was a biomechanical analysis of the technique of performing the Yurchenko vault. The determination of the phase composition and kinematic characteristics of the vault was carried out using the Motion Capture program.

Results and Discussion. Analysis revealed temporal characteristics of movements, identified stages, determined the phase composition of the exercise, and highlighted key positions and leading motor actions.

1. Kinematics of the push-off phase from the vaulting table

Analysis showed that gymnasts maintain horizontal center-of-mass velocity upon contact with the springboard while significantly increasing vertical velocity due to torso inclination at the moment of contact. This maximizes the lifting impulse for the subsequent flight.

- Horizontal velocity slightly decreases, whereas vertical velocity increases significantly.
- The torso angle at board contact is approximately 60–90°, and effective use of the vaulting table is a key factor for achieving a high jump trajectory.

2. Energy transformations in different phases of the vault

Comparison between the Yurchenko and another style (Tsukahara) revealed that:

- The Yurchenko generates more angular kinetic energy (AKE) during the run-up and push-off phase.

- The second flight phase in the Yurchenko shows a higher overall energy level compared to the Tsukahara.
- Performing more complex variations requires slightly more AKE but does not significantly increase total energy.

3. Biomechanical load on joints and muscles

Studies indicate that during the Yurchenko vault:

- Loads on the forearms and shoulder joints are significantly high during contact with the support, especially for advanced gymnasts.
- These forces may exceed those in standard acrobatic elements and require individual analysis to prevent injury risk. Push-off technique and shoulder strength are key factors for safe energy control and body stabilization.

4. Overview of key kinematic and kinetic indicators

A systematic review showed that the Yurchenko technique critically depends on:

- Acceleration, velocity, trajectory, contact time, flight time, body deformation, angular momentum, and other parameters. These indicators are interrelated and collectively affect execution quality.

To improve technique, it is important to analyze the complete set of physical indicators rather than focusing solely on run-up speed or force.

Table 2. Kinematics and biomechanics of the vault

Jump Phase	Kinematics (Movement)	Biomechanics (Muscle Forces & Work)	Key Technical Points
1. Run-up	Linear motion, increase in CM speed	Concentric work: gluteals, quadriceps, gastrocnemius	Stable torso, consistent rhythm
2. Springboard contact	Conversion of horizontal velocity into vertical	Triple extension (ankle–knee–hip), elastic recoil of Achilles	Short contact, active feet
3. Push-off from vaulting table	Rapid upward acceleration	Maximal power of leg extensors	Take-off angle ~20–30°
4. Flight to the table	Arc of CM motion	Core stiffness maintenance	Shoulder preparation
5. Hand support (block)	Sharp change in CM direction	Isometric and concentric: deltoids, triceps, scapular stabilizers	Stiff arms, contact 0.1–0.2 s

Jump Phase	Kinematics (Movement)	Biomechanics (Muscle Forces & Work)	Key Technical Points
6. Take-off from table	Beginning of flight phase	Reactive push-off + inertia moment	Jump height and distance
7. Flight phase	Rotational body movement	Control of inertia moment (tuck/stretch)	Axis control
8. Preparation for landing	Leg extension, reduction of angular velocity	Eccentric work: core and hip extensors	Visual control
9. Landing	Vertical deceleration of CM	Shock absorption: calves → quadriceps → gluteals	Joint flexion
10. Stabilization	Static balance	Isometric stabilization	CM over support

This structured analysis highlights the complexity of movement coordination, energy management, and joint-muscle loading throughout the vault. Understanding these interactions allows coaches to improve technique, reduce injury risk, and optimize training programs.

Figure 1. Presents a comparison of angular kinetic energy (AKE) across three types of vaults

Yurchenko, Tsukahara, and Handspring (Ruchnoe Salto). The data indicate that the Yurchenko vault exhibits the highest angular kinetic energy, set as the reference at 100 conventional units. The Tsukahara vault shows a moderate level of AKE, approximately 75% of

the Yurchenko value, while the Handspring vault demonstrates the lowest angular kinetic energy, around 60% relative to Yurchenko.

This trend highlights that the Yurchenko vault generates greater rotational momentum, which is crucial for executing complex acrobatic elements during the flight phase. Higher AKE allows gymnasts to perform multiple twists and rotations with greater control, contributing to improved jump height, distance, and rotational accuracy. Conversely, vaults with lower AKE, such as Handspring, require less rotational force but may limit the complexity of aerial maneuvers.

The findings suggest that energy management during the run-up, springboard contact, and push-off phases is essential for maximizing angular kinetic energy in the Yurchenko vault. Coaches should emphasize correct torso positioning, effective push-off mechanics, and optimized take-off angles to fully utilize the rotational energy potential. This analysis further supports the conclusion that phase-specific kinematic and biomechanical optimization is critical for achieving high-level performance in elite gymnastics.

Discussion of Key Findings. Energy Efficiency – The Yurchenko vault efficiently converts horizontal momentum into vertical lift and rotational energy, producing higher angular kinetic energy than other vault types.

1. Joint Loading – High forces occur at the shoulder and wrist during block phases. Proper training and technique are required to minimize injury risk.
2. Muscle Coordination – Coordinated activation of lower limb extensors, core, and upper body muscles is critical for optimal flight trajectory and rotational control.
3. Technical Optimization – Subtle adjustments in take-off angle, torso inclination, and push-off timing significantly influence jump height, rotation, and landing stability.
4. Training Implications – Coaches can use kinematic and biomechanical analysis to provide individualized guidance, improve energy utilization, and reduce injury risks.

The integration of angular kinetic energy data (Figure 2) with phase-specific kinematics supports the conclusion that effective training for Yurchenko vaults should focus on optimizing energy transfer, rotation control, and muscular coordination. By analyzing the full set of physical indicators—rather than focusing on a single metric—performance quality and safety are maximized.

Conclusion. The biomechanical and kinematic analysis of the Yurchenko vault demonstrates the complexity of the skill and the necessity of phase-specific optimization. The study highlights:

- The importance of generating sufficient angular kinetic energy during push-off phases.
- The need for coordinated muscular activation and torso control throughout all flight phases.
- The critical role of precise timing, technique, and energy management for landing safety and execution quality.

These findings have practical applications for gymnastics coaching, including individualized technique correction, safe progression in skill difficulty, and preparation for elite-level competition. The combination of Motion Capture analysis, temporal phase assessment, and energy metrics provides a robust framework for advancing performance in young elite gymnasts.

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