BIOMECHANICAL ASSESSMENT OF JAVELIN THROWING TECHNIQUE

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Анотації:

The relevance of research related to search for the optimality of motion technology in various phases of javelin throwing. The questions of biomechanical parameters of javelin throwing are considered at different stages of sports actions in the article. The aim of the work was determination of the rational structure of motor actions in various phases of javelin-throwing. The research was carried out on the basis of an analysis of 764 training and competitive attempts of javelin throwers. The videograms were analyzed using the software «KinoVea». Along with the phase structure of the javelin throwing, the main positions are highlighted, including initial, final and a number of intermediate provisions. To assess the movement, a number of animation positions are highlighted in the main elements of the movement. As the studied parameters were defined time parameters, angular speeds of movement of body parts, moments of inertia and radius of the moment of inertia motion, angular positions in the joints and trajectories of changes in the center of mass of links relative to the general center of mass. The research revealed kinematic and dynamic parameters of the phase structure of javelin throwing. The ranges of angular positions of the body links are revealed in various phases of throwing action. The parameters of the moment and radius of inertia positions of the body links are determined, relative to the common center of mass in different phases of motion, that allows you to predict deviations from the rational trajectory of technology and prevent the possibility of injury. The sequence of movements of the body's links is studied, taking into account the influence of kinematic and dynamic parameters of movement. The findings of research contribute to the selection of the most rational summing training exercises. In addition, it will help reduce the load on the joint and ligamentous apparatus of the thrower.

Keywords:
phases of motion, kinematic and dynamic characteristics, range of angular movements.

Біомеханічна оцінка техніки метання списа. ***Бондаренко Костянтин, Примаченко Прасковья, Врублевський Євген***

Актуальність дослідження пов'язана з пошуком оптимальності техніки руху в різних фазах метання списа. У статті розглянуті питання біомеханічних параметрів метання списа в різних стадіях спортивного дії. Метою роботи послужила визначення раціональної структури рухових дій в різних фазах метання списа. Дослідження виконувалось на підставі аналізу 764 тренувальних і змагальних спроб метальників списа. Відеограми аналізувалися за допомогою програмного забезпечення «KinoVea». Поряд з фазової структурою метання списа, виділені основні позні положення, що включають початкові, кінцеві та ряд проміжних положень. Для оцінки руху виділено ряд мультиплікаційних положень в основних елементах руху. Як досліджуваних параметрів визначалися часові параметри, кутові швидкості руху частин тіла, моментів інерції і радіуса моменту інерції руху, кутові положення в суглобах і траєкторії зміни центру мас ланок щодо загального центру мас. Проведене дослідження виявило кінематичні і динамічні параметри фазової структури метання списа. Виявлено діапазони кутових положень ланок тіла в різних фазах метальної дії. Визначено параметри моменту і радіусу інерції положень ланок тіла відносно загального центру мас в різних фазах руху, що дозволяє спрогнозувати відхилення техніки від раціональних траєкторій і запобігти можливості отримання травми. Вивчено послідовність переміщень ланок тіла з урахуванням впливу кінематичних і динамічних параметрів руху. Отримані дані дослідження сприяють підбору найбільш раціональних підвідних тренувальних вправ. Крім того, це буде сприяти зниженню навантаження на суглобово-зв'язковий апарат метальника.

фази руху, кінематичні і динамічні характеристики, діапазон кутових переміщень

Биомеханическая оценка техники метания копья. ***Бондаренко Константин, Примаченко Прасковья, Врублевский Евгений***

Актуальность исследования связана с поиском оптимальности техники движения в различных фазах метания копья. В статье рассмотрены вопросы биомеханических параметров метания копья в различных стадиях спортивного действия. Целью работы послужила определение рациональной структуры двигательных действий в различных фазах метания копья. Исследование выполнялось на основании анализа 764 тренировочных и соревновательных попыток метателей копья. Видеограммы анализировались с помощью программного обеспечения «KinoVea». Наряду с фазовой структурой метания копья, выделены основные позные положения, включающие начальные, конечные и ряд промежуточных положений. Для оценки движения выделен ряд мультипликационных положений в основных элементах движения. В качестве исследуемых параметров определялись временные параметры, угловые скорости движения частей тела, моментов инерции и радиуса момента инерции движения, угловые положения в суставах и траектории изменения центра масс звеньев относительно общего центра масс. Проведённое исследование выявило кинематические и динамические параметры фазовой структуры метания копья. Выявлены диапазоны угловых положений звеньев тела в различных фазах метательного действия. Определены параметры момента и радиуса инерции положений звеньев тела относительно общего центра масс в различных фазах движения, что позволяет спрогнозировать отклонения техники от рациональных траекторий и предотвратить возможность получения травмы. Изучена последовательность перемещений звеньев тела с учётом влияния кинематических и динамических параметров движения. Полученные данные исследования способствуют подбору наиболее рациональных подводящих тренировочных упражнений. Кроме того, это будет способствовать снижению нагрузки на суставно-связочный аппарат метателя.

баскетбольная команда, специфические коэффициенты, технико-тактические действия, модельные показатели, игровые амплуа

Problem statement. Biomechanical evaluation of sports exercises is designed to identify the main qualitative and quantitative parameters of not only the entire action, but also its individual parts. Earlier attempts were made to determine kinematic and dynamic parameters, movement parameters in the javelin throwing, however, they considered mainly the nature of the interaction «spear-thrower's hand». As part of the state research program «Convergence-2020», we have attempted to identify biomechanics of all elements of the thrower movement, their relationship and impact on the final result.

Analysis of recent research and publications. The construction of a rational movement requires knowledge of the relationship of the body's links and the ability to transmit an impulse quickly from one part of the body to another [2]. This relationship is provided by model motion parameters [1, 12]. The authors show in various researches, how optimal trajectories are provided based on the determination of kinematic parameters of motion, and as a result, achieving the best results in a competitive exercise [6, 8, 10, 15, 18, 19]. The rationality of the trajectory, in many cases, depends on the functional state of the skeletal muscles, which ensure not only the creation of the necessary effort, but also effectiveness of multiple execution of motor actions [5, 6, 16]. It should be noted that the ability of the skeletal muscle to maintain its functionality depends on the volume and intensity of the work performed, and depends on the speed of recovery processes and the associated accumulation of trace fatigue [7, 9, 10, 13]. Choosing the most optimal modes of training loads contributes to the correct selection of training tools and methods of mastering and improving the structural elements of movement [3, 14]. Lack of necessary biomechanical control of movement, or ignorance of biomechanical nuances of motor action, increases the risk of excessive tension of skeletal muscles and joint-ligamentous apparatus and can lead to injury [4, 11, 17].

The purpose of the research was rationalization of the structure of motor actions in various phases of javelin throwing.

Research materials and methods. Analysis of biomechanical parameters of javelin throwing in various phases of movement was performed in the research laboratory of physical culture and sports of the Francisk Skorina Gomel State University. The biomechanical analysis was based on videos of 764 training and competitive attempts of Belarusian javelin throwers. The videograms were analyzed using software «KinoVea». As the studied parameters were determined time parameters of movement, angular velocities of movement of body parts, moments of inertia and radius of the moment of inertia movement, angular positions in joints and trajectories of changes in the center of mass of links relative to the General center of mass.

The results of the research and their discussion. Javelin throwing can be divided into the run-up phase, cross steps, final effort, and deceleration. Each phase is characterized by a sequence of structural elements of movement and a range of joint positions. Along with the phase structure of javelin throwing, we have identified their main postures, including initial, final and a number of animated positions.

The run up phase is characterized by a gradual set of movement speed over five running steps. A feature of the phase is its tempo-rhythmic structure with a sequential increase in the step length (table 1).

Table 1

Range of running steps in the run-up phase of the javelin throw

Initial position	Animated position 1	Animated position 2	Animated position 3	Final position
109,1-132,2 cm	129,6-164,2 cm	170,8-193,6 cm	186,7-198,0 cm	195,3-215,8 cm

The speed of the athlete depends on the length of the steps, as well as on the anthropometric data of the athlete.

The transition to crossing steps is characterized by a change in the position of the body in space, different from the position in the run-up. This position is characterized by turning the body in the direction of throwing.

The character of movement is determined by the range of angular positions between the links of the body in the phase of the final effort. It's noteworthy, the character of changes in motor actions aimed at the effectiveness of projectile release. In particular, at the beginning of the phase, the range of angular positions between the hip and the lower leg is within 115 – 119 degrees, between the shoulder and the forearm – 142-147 degrees, and the shoulder and the trunk 84-88 degrees. When performing the movement, the moment of inertia of the shoulder relative to the total center of mass of the body (GCMB) composes 0,036 ± 0,007 kg*m^2, forearms – 0,015 ± 0,006 kg*m^2, thighs – 0,2175 ± 0,0004 kg*m^2.

When placing the foot on the support in the ankle and knee joints, there is a tension. The value of the reference reactions related to the possibility of injury to the cruciate ligament of the knee joint and Achilles tendon. When the threshold force tendon is equal to 500 N in the Achilles, that is sufficient to ensure the performance of the ankle joint, the trace processes of fatigue, or insufficient recovery, it can lead to injury to the tendon and at lower stress parameters.

When placing the left foot on the support, the movement is performed from the heel, in a top-down direction to increase the stiffness in the skeletal muscle when it is stretched. The momentum of movement in the direction of the supporting leg is transmitted through the bent right hip with a forward movement relative to the axis of the trunk with a turn of the pelvis inward. Reverse loop-like movement of the left hand, with pulling it up to the body determines the nature of the throw, to exclude the possibility of interaction «athlete-projectile».

When moving the left leg to the support, the angular position between the hip and the lower leg of the right leg was in the range of 107-111 degrees, in the knee joint – 177,5-179 degrees, between the shoulder and the forearm of the throwing hand – 143 – 146 degrees, between the trunk and the shoulder 84,5-88,5 degrees. The moment of inertia relative to the GCMB for the shoulder in our study was 0,031 ± 0,006, the forearm – 0,016 ± 0,006, the hip – 0,223 ± 0,001 kg*m^2. The step length in this phase position was 181,41 ± 2,69 cm. The center distance between the knee joints was in the range of 68 – 71 cm.

Twisting the body at the moment of turning the right hip in the direction of the throw creates tension in the hip joint, increasing the risk of injury when overtaking links. The tension of the throwing arm muscles is provided in the subsequent action is provided by an active turn-and-extension movement of the right side of the trunk from the foot to the shoulder girdle muscles. The study revealed the ranges of angular positions between the hip and lower leg, which were 118,5-121 degrees, the shoulder and forearm of the throwing hand – 136-139 degrees, the shoulder and trunk – 86-89 degrees. The moment of inertia of the shoulder relative to the GCMB is 0,031 ± 0,008, the forearm is 0,017 ± 0,005, and the hip is 0,161 ± 0,001 kg*m^2. Under the influence of inertia of movement on the support, the step length increased to 219,4 ± 2,99 cm.

The lashing motion of the throwing arm with the release of the projectile is performed by sequential braking from the proximal to distal links of the arm. In this position, the ratio of the body links to the projection of the support is important. The projection of the torso beyond the acceptable range of deviation can lead to injury in the joints. The revealed ranges of angular positions between the hip and the lower leg of the right leg were 122,5-127 degrees, left – 154-156,5 degrees, between the shoulder and the forearm of the throwing hand – 131,5-136 degrees, the shoulder and the trunk – 92-95 degrees. When turning the shoulder, the moment of inertia was 0,028 ± 0,004, the forearm – 0,013 ± 0,005, the hip – 0,167 ± 0,001 kg*m^2. The next rotation inward in the shoulder joint with a horizontal orientation involves the elbow joint in the motor chain and, due to the subsequent flexion in the wrist joint, provides the release of the projectile. In this case, just before the release of the projectile, there is a sharp turning of the trunk to the left, with a valgus movement in the knee joint when turning the hip. The transfer of the General center of mass to the left leg does not make it possible to perform the locking movement in full, so that the knee joint does not unbend and is in the range of 160-164 degrees. The angular range of position between the shoulder and forearm of the throwing arm was 125,5-128 degrees, and between the shoulder and torso – 93-99 degrees.

The moment of inertia of the shoulder relative to the GCMB is within 0.024 ± 0.007, the forearm – 0,013 ± 0,004 and the hip – 0,134 ± 0,001 kg*m^2. The end of the final effort phase is characterized by the release of a projectile over the shoulder of the throwing hand. The moment of movement is determined by creating maximum tension in the joints of various parts of the body. In particular, a deviation from the optimal trajectory of movement in the shoulder joint creates a great strain on the articular ligamentous apparatus and can lead to injury to the articular bag of the shoulder joint. Stopping movement of the leg with the straightening of the knee joint can lead to injury if the interaction is incorrect under the influence of the force of inertia of the hip joint and the supporting position of the foot. The joint tension in the shoulder and elbow joints increases when a twisting moment occurs in the shoulder and elbow joints. As a result of this strain the elbow collateral ligament and rotator cuff of the shoulder joint may be injured.

The ranges of angular positions at the time of projectile release in our study were: between the hip and the Shin – 103-107 degrees, between the shoulder and the forearm – 132-135 degrees, between the shoulder and the trunk – 107-110 degrees.

The moment of inertia of the shoulder relative to the GCMB was 0,025 ± 0,004 kg*m^2, the forearm – 0,014 ± 0,007 kg*m^2, the hip – 0,283 ± 0,001 kg*m^2.

The final movement in the javelin throw is the deceleration phase, aimed at «extinguishing» the inertia of movement and decelerating the links of the body. Options for how to perform the action in this phase differ, as a result, the range of angular movements increases significantly. In our study, it was: between the shoulder and the forearm – 129-147 degrees, between the shoulder and the trunk – 80-103 degrees, between the hip and the Shin – 100-140 degrees.

The trajectories of movement of the body's links relative to the GCMB contribute to the development of maximum forces and accelerations in the end links. It is done with a significant strain on the skeletal muscles that provides movement.

Depending on the nature of the movement of the body's links relative to the General center of mass, the radius of inertia also changes. The efficiency of movement as a result of the inertial resistance of the body's links in the final effort phase is shown by the example of changes in their inertia radii (Fig. 1)

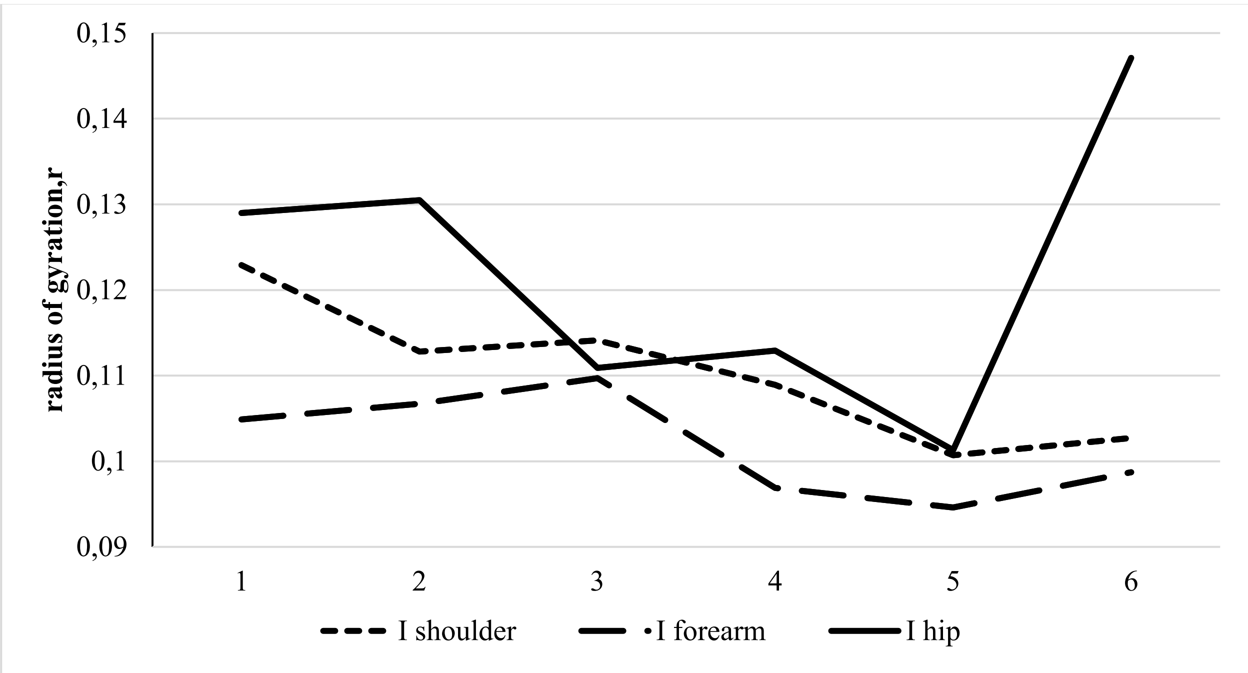

Fig. 1. The change in the radius of inertia of the links of the body in the phase of the final effort

Discussion. The determination of biomechanical characteristics allows you to structure movements and form the most rational movement technique in the phase composition of javelin throwing. Definition of moment of inertia radius of positions of the body allows to predict deviations from rational technology trajectories and to prevent the possibility of injury, relative to a common center of mass in different phases of movement. The rationality of movement of body parts contributes not only to improving athletic performance, but also to increasing athletic longevity, taking into account the influence of kinematic and dynamic movement parameters on their structure, [4, 6, 7].

The obtained research data will allow you to choose the most rational summing up training exercises [3, 13, 14, 19]. In addition, it will help to reduce the load on the joint and ligamentous apparatus of the thrower and prevent injuries to athletes. The latest is also due to the fact that coaches often spend little time in training to strengthen the shoulder muscles, as well as the elbow ligaments [10, 13]. In addition to speed and strength training of javelin throwers, you also need to develop mobility and elasticity of the muscles and ligaments through various exercises.

Conclusions and prospects for further research. The study allowed us to determine the main kinematic and dynamic parameters of movement in javelin throwing in various phases. The sequence of movements of the body's links is studied, taking into account the influence of kinematic and dynamic parameters of movement. These data can contribute not only to the quantitative reduction of injuries, but also to the selection of training tools for the purpose of injury prevention.

In the future, it is proposed to compare the biomechanical parameters of movement elements with the nature of probable injuries of the muscles and joint-ligamentous apparatus.

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