Individual optimization of the repulsion biomechanism When jumping up

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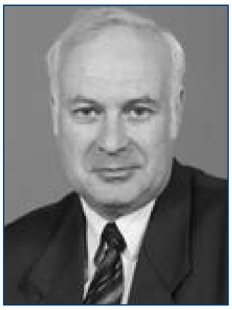

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Abstract

Objective of the study was to find the optimal repulsion technique depending on the individual characteristics of the athlete.

Methods and structure of the study. The research procedure included performing an upward jump on a dynamometer platform and analyzing the vertical component of the support reaction.

Results and conclusions. As a result, according to the information received about the height and efficiency coefficient of each of the jumps performed using various techniques, the most rational individual movement stereotype of repulsion from the support is determined when the subject performs a series of jumps. The efficiency coefficient quantitatively assesses the quality of the organization of the jumping movement with the possibility of operational control of various variants of the repulsion biomechanism.

In the aspect of improving biomechanical analysis: the proposed research methodology implements one of the possible approaches to studying the operation of open biomechanical systems, in contrast to the previously used point mass models.

The results of the study will help to gain knowledge about the biomechanics of repulsion and form an individual technique based on operational feedback.

Keywords: *repulsion biomechanics, upward jump, efficiency coefficient.*

Introduction. Jumping up from a place from a regular stance according to the Federal standards is included in the standards of general and special physical fitness for enrollment in training groups at all stages of training in many types of sports games, first of all, as an indicator of a person's speed-strength abilities, taking into account specialization, skill level , age, anthropometry and more.

This test is a multicomponent one that assesses the level of development of complex coordination abilities of a person. With its help, a number of indicators are diagnosed: the strength of the leg muscles when jumping from a squat of different depths, the frequency of jumps, their type (with the swing of the arms or rotations around the vertical axis) and other manifestations of physical qualities.

In practice, many coaches still use the Abalakov tape drive mechanism to assess jumping ability, which significantly reduces the accuracy of measurements, and also gives an incomplete picture of the jumping capabilities of athletes. Much more accurate information about the jumping ability of an athlete can be obtained by measuring the time of the flight phase, which allows, according to the laws of kinematics for uniformly accelerated movement in the earth's gravity field, to calculate the height (h) of the rise of the common center of mass (CCM) of the body. It is possible to fix the flight time in hardware as a phase of the unsupported position by various methods, including light motion sensors, contact or force measuring systems. The main condition for the standard height measurement procedure is landing without cushioning on relatively “straight” legs, which, otherwise, allows you to get a “height gain” of up to 10-15 cm. However, an analysis of the athlete’s potential, taking into account the quality of the repulsion biomechanism, even when using powerful measuring complexes are not carried out, which prevents the convergence of the scientific theory of movements with the practice of specialists who teach a person to record jumps.

The work of internal mechanical forces in each jumping movement of a living object gives different efficiency for various reasons, reflecting the anthropometric, physical, age characteristics of a person, his level of qualification, the state of the properties of the movement apparatus. A special role is played by the technical rationality of the movement itself and the positive individual deviations of the movement object from the average (model) value. These features in the form of factors influencing the effectiveness of "jump work" are trying to be found by coaches when educating champions blindly without an appropriate theory.

A new approach to the analysis and evaluation of the "jump up from a place" test. A priori, when determining the height of the jump by the time of the flight phase, it was assumed that the calculations are valid for the motion of point masses of the mechanical system and, accordingly, the common center of mass (CCM). This cannot be done in a living system, since it is necessary to take into account the work of all elements of a mechanical system, because interelement connections can change in it in terms of kinematics and dynamics, affecting the total height result. If we compare jumps with different techniques and the contribution of internal forces to the height of the jump, then there will be an extremely large number of options for movements, which was noticed in the 70s by A.V. Zinkovsky, Yu.A. Gagin, N.B. Kichaikin, and in 2004 a group of mechanics showed the contribution of “biomechanical energy” to the total kinetic energy during a jump [4].

To assess the quality of the repulsion biomechanism, one can use the approach known in biomechanics [9], namely, to determine the height of the jump in two ways. The first, described above, allows you to calculate the real height of the jump from the time of the flight phase, the second, based on the calculation of the expended impulse of force from the repulsion dynamogram, determines the ideal, a kind of "model" height of the jump. Comparison of the "real" and "model" heights for each individual jump makes it possible to assess the fact how efficiently the athlete's energy potential is used in organizing the biomechanism of the jump, that is, how much the reserves of the living system are used in achieving the target setting. At the same time, it is inappropriate to determine the economy, that is, the costs of a living system per unit height of a single jump, as well as to evaluate the quality of sprinting by its energy indicators or efficiency.

Traditionally, studying the dynamogram of a jump, we found the impulse of the repulsive force, the take-off speed and hence the “model” height of the general center of gravity (GCG), which, with the ideal organization of the motor action and in the absence of losses, should tend to the “real” one. It is possible to quantify the quality of the organization of real jumping movements, in particular, with the help of the efficiency coefficient introduced and patented by us - k [3], which is equal to the ratio of the "real" height to the "model" one.

Objective of the study was to find the optimal repulsion technique depending on the individual characteristics of the athlete.

Methods and structure of the study. The procedure includes performing an upward jump on a dynamometer platform and analyzing the vertical component of the support reaction - curve P (t) (Figure 1) [5].

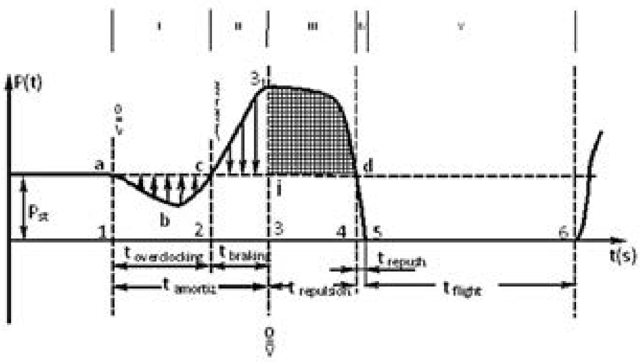

Figure 1. *Vertical component of the support reaction when jumping up*

It is especially important to note that the analysis of the repulsion biomechanism according to the dynamogram of the vertical component of the support reaction (Fig. 1) should be carried out using the system-structural model, and not the traditional point model using the concept of CCM, which allows us to explain the presence of an additional impulse, which we called the impulse "push" (section IV on the interval between points 4-5), which plays an important role in the structure of the movement.

An additional contribution to the impulse of the repulsive force, which was not previously included in the motion analysis program, is realized due to plantar flexion of the rigidly tense muscles of the ankle joint and joints of the foot after the start of the rise of the common center of mass and the fall of the support reaction below the level of the weight force Pst (point «d» in Fig. 1). A similar effect was experimentally noticed by us and analyzed in the dissertation of N.V. Makarov [8] when studying trampoline jumping, where the masters, during high jumps, additionally pressed their feet on the extremely stretched trampoline net to control the height of the jump, doing the work of the “pushing” force in order to increase the flight height.

Simultaneously with the performance of the jump, the height (h) and the efficiency coefficient (k) of the jump are calculated according to the dynamometer chart:

$$h = \frac{g t_{пол.}^{2}}{8}, \qquad k = \left(\frac{P_{ст.} t_{пол.}}{2S}\right)^{2} 100\%,$$

where: h is the height of the jump; g = 9.81 m/s2 – free fall acceleration; tflight - the time of the flight phase, determined by the dynamometer; k is the jump efficiency coefficient; Pst. - the weight of the subject; S is the impulse of the repulsive force, determined by the dynamometer.

As a result, according to the information received about the height and efficiency coefficient of each of the jumps performed using various techniques, the most rational individual movement stereotype of repulsion from the support is determined when the subject performs a series of jumps. The efficiency coefficient quantitatively assesses the quality of the organization of the hopping movement with the possibility of operational control of various variants of the repulsion biomechanism [3].

Theoretical and practical significance. When searching for the most rational individual technique of repulsion, it is important to create conditions under which a living system can find its own reserves, for this, according to N.A. Bernstein [2], it needs to be “let it try out” in order to form the best jumping stereotype. The so-called efficiency coefficient (k), equal to the ratio of the “real” jump height (h), calculated from the time of the flight phase, to its idealized, “model” value, determined by the impulse of the repulsion force, can serve as a quantitative criterion for the correct organization of repulsion. This coefficient shows the potential reserves of a living system and how effectively the repulsion biomechanism is organized in a jumper. The greater the value of the repulsion efficiency coefficient, the better the living system works and the more rational individual technique a person can find, taking into account the characteristics of his own organism and the tactical tasks set.

The leading components of achieving a high result are the coincidence of the frequency properties of the organization of the musculoskeletal system and the external environment when controlling the rigidity properties of interacting systems and their phase composition, which should provide bioresonance in the "man-environment" system [1, 6, 7, 9]. These components are constantly variable, so the living system selects and adjusts them during long training sessions, and with the help of the repulsion efficiency coefficient k, these indicators can be quickly controlled.

Conclusions. The proposed research methodology allows to significantly expand the understanding of the theory of movement as a system of moving links, where, thanks to training, a person finds the best individual option for his jump with an accurate quantitative assessment of the quality of its performance by quickly calculating the parameters of each jump. Operational control of the jump parameters by force impulse and jump height allows to obtain an objective quantitative assessment of the quality of the athlete's work, which is so important for the coach. In the aspect of improving biomechanical analysis: the proposed research methodology implements one of the possible approaches to studying the operation of open biomechanical systems, in contrast to the previously used point mass models.

The conducted research shows the knowledge on the basis of which an athlete can realize his potential motor abilities.

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