Methods of control of vertical jump distance in sports

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Abstract

Objective of the study is to evaluate the degree of reliability and appropriateness of using methods for determining the jump height of athletes based on theoretical analysis and generalization of practical experience.

Methods and structure of the study. A theoretical review of the available literature was conducted, as well as pedagogical testing: measuring the vertical jump height of forty athletes specializing in various team sports. In addition, dynamometric measurements of jump characteristics were carried out using a computerized data processing system synchronized with high-speed video recording.

Results and conclusions. The variety of existing methods for determining jump height indicates their applicability in various sports disciplines, since each of them meets the needs of a specific sport. However, comparing the results obtained in different sports areas seems unjustified without unifying the measurement methods. The difference in accuracy due to the use of different methods can reach 30-40%.

Due to the lack of uniform standards for determining jump height, in practice jumping ability is often assessed as a specific skill characteristic of a certain sports specialization, and not as a general physical characteristic. The most accurate and objective way to determine the true jump height is dynamometry, which allows excluding the influence of specific skills and abilities inherent in specific sports.

Using only age, gender and qualification standards is insufficient due to the significant variability of this indicator within homogeneous groups of athletes. When monitoring and assessing jumping ability, it is advisable to take into account the anthropometric data of athletes, in particular their height, as well as their playing role, as is customary in some team sports.

Keywords: *jump height assessment, agility, speed-strength abilities, standardization of measurement method.*

Introduction. The “Upward Jump” test is included in the Federal Standards in many sports. Considering the importance of monitoring speed-strength abilities, a number of sports theorists, in particular, Yu.V. Verkhoshansky, more than 50 years ago proposed to consider jumping ability as an independent sixth physical quality, compatible with the five generally accepted in the theory and methodology of physical education [3, 5].

In practice, most often it is not the height of the rise of the GCM (general center of mass) of the human body that is measured, which follows from the definition of potential energy in classical physics, but the ability to reach the highest point in a jump is assessed. In this version of measurement, in addition to speed-strength abilities, special jumping agility also acquires special significance.

Even in track and field, where the problem of standardizing the measurement of jump height has been solved today, and is determined by the height of the bar that the athlete has overcome, it is impossible to attribute the abilities of an athlete only to speed-strength, since the special gift of the jumper to “flow around” the bar plays a huge role. A striking example of this is the Fosbury Flop jump, where the trajectory of the athlete’s body center of mass passes below the height of the bar.

In most cases, when determining the “jump height”, the measurement method is not specified, but only the

regulatory requirements for the test results are given, which does not allow for an objective comparison of the test results of athletes, especially for different sports specializations. Many researchers have drawn attention to this problem, and the discrepancy in the measurement results associated with the use of different methods reaches 30% [6].

The complexity of the situation is that sports theorists do not have a consistent understanding of the most important characteristics of athletes' jumping ability, especially in different sports. In addition, the standards do not provide uniform requirements for the methods of measuring the most important characteristics of a jump. As a result, jumping ability, in our opinion, should be interpreted as a complex specific skill that is qualified by the ratio of a number of components in a complex interaction: strength, speed, endurance and special agility.

The purpose of the study is to evaluate the degree of reliability and feasibility of using methods for determining the height of jumps of athletes based on theoretical analysis and generalization of practical experience.

Methodology and organization of the study. Theoretical analysis of information sources, pedagogical testing (assessment of the height of jumps of 40 athletes involved in various types of sports games), dynamometric studies of jumps using a computerized information processing system with accompanying high-speed video filming were conducted.

Results of the study and conclusions. The considered variety of methods for measuring jump height indicates that they all have a right to exist, since they reflect the needs of a particular sport, but conducting a comparative analysis of test results in different sports specializations becomes incorrect without standardization of methods for measuring jump height. The fundamental measurement error by different methods can reach 30-40%. The lack of standards for the method of measurement leads to the fact that in sports practice jumping ability is most often measured as a special skill inherent in a certain sports specialization, and not what is called "jump height". The most reliable and fundamentally correct method for determining the jump height is the dynamometry method, which allows you to exclude specific skills and abilities of various sports specializations.

The height of the rise of the GCM from the standpoint of classical physics is an indicator reflecting the reserve of potential energy of the body. According to this classical definition, the jump height is estimated by the value of the change in the vertical coordinate of the GCM of the athlete's body from the position of the main stance to the highest point of the trajectory of its movement.

The obvious difficulty with this approach is due to the fact that the human body cannot be modeled by a point mass, and the GCM of the body is a virtual point, the position of which depends on the pose and on the mass-inertial characteristics of the links of the human body when performing a jump.

Today, depending on the technical support and preferences of sports practitioners, at least seven approaches or methods are used to determine the jump height, which have their own characteristics.

Video recording. Allows to determine the value of vertical movement of a certain reference point (marker). The method is labor-intensive, requires qualified personnel and compliance with a number of conditions for high-quality video filming. The fundamental disadvantages of this method can be considered the displacement of markers due to the mobility of the skin of the body or clothing of the athlete, and the main disadvantage is the impossibility of accurately determining the true position and corresponding movement of the body's CM, which is only indirectly related to the position of the markers on the body.

Abalakov's method (mechanism). A widely known method based on the use of a measuring tape and a device for unwinding/holding it. The fundamental disadvantages of this method include: low measurement accuracy, possible displacement of the fixing belt on the athlete, to which one end of the measuring tape is attached, the need to control the verticality of the jump, and most importantly - the impossibility of determining the true vertical movement of the body's CM.

"Marking on the wall". A fairly simple and well-known method based on measuring the distance between marks left by an athlete on the wall with an arm extended upwards, while in the basic stance and at the top of the jump. The method is characterized by low accuracy, dependence of the result on the flexibility of the body, the tilt of the body towards the wall, and the impossibility of determining the true vertical movement of the body's CM.

Stance with shifting plates (Vertek's method). This is a specific testing method widely used in team sports. The method is characterized by low accuracy, dependence of the result on the degree of joint mo-

bility, the tilt of the body and the professional skills of the athlete, therefore, the possibility of determining the true vertical movement of the body's CM is also excluded.

"Light crossbar" (Meskin's method). The testing method resembles "marking on the wall", but the measurement process is automated due to vertically located optocouplers, for example, OptoJump-next rails. The athlete jumps in the crossbar between the emitter and the receiver. The method is characterized by low measurement accuracy determined by the discreteness of the optocouplers' arrangement. The test result depends on the mobility of the joints and the professional skills of the athlete, and also excludes the determination of the true vertical movement of the body's CM.

Measuring the flight phase time. The measurement method is widely known and is characterized by high efficiency, allows testing not only single jumps, but also measuring jumping endurance by the parameter of decreasing the height of continuous jumps as fatigue occurs. The fundamental disadvantages of the measurement method include the requirement to land strictly on straight legs, and this testing method does not take into account the individually variable height of the rise on the toes, which does not allow monitoring the true vertical movement of the body's CM.

Dynamogram of the support reaction when performing an upward jump from a stationary platform. The method is also widely known and has been developed in detail in sports pedagogy. This is the only method that allows objectively monitoring the jumping ability of an athlete, since the testing measures the true vertical movement of the athlete's body's CM regardless of any external factors.

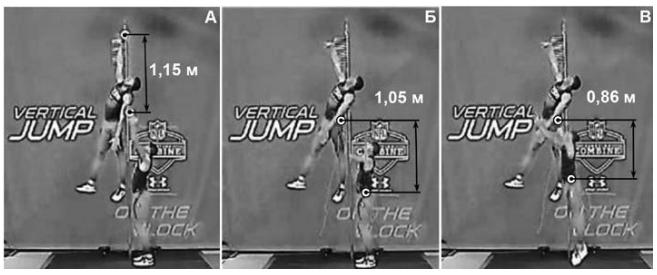

Illustration of different ways to measure jump height [2]

Evaluation of possible methods for monitoring jump height. The difference in measurement results is clearly illustrated by the analysis performed by A. Bulakhov [2], where the author describes in detail the "errors" in measuring the jump height of the NBA league leader, basketball player Byron Johnson, during the course of the next pre-draft tests.

The figure shows the following options for measuring jump height:

A – the athlete reaches for the plates installed on the stand with an outstretched arm (Vertek method); the movement of the arm from the position of the main stand to the highest point of the arm's movement trajectory is measured;

B – the athlete performs a jump similar to option A, but the movement of the marker installed on the point of the conventional CM of the human body is measured, which eliminates the additional error (10 cm) associated with the mobility of the shoulder girdle;

B – the athlete performs a vertical jump, and the time of the flight phase is measured, which begins with the "raised toes" position, which conditionally reduces the jump height by another 19 cm.

How can the true jump height be measured and how can the resulting fundamental errors be eliminated?

It was noted above that the only fundamentally correct way to determine the magnitude of the displacement of the human body's CM from the basic stance position to the point of maximum rise of the CM's trajectory is to analyze the repulsion dynamometer, which allows one to determine the maximum potential energy characterizing the jump height. This method is significantly complicated by the fact that the human body cannot be represented as a point mass, since it is a multi-link system with variable elastic connections and the presence of internal forces that change the configuration and shape of the body [1].

Any vertical component of the repulsion force, which according to the third law of mechanics is registered by the dynamo platform as a vertical component of the support reaction force, increases the jump height. The mechanisms of the increase in the height (vertical displacement) of the body's CM lift above the support are different: lifting the head, shoulder girdle and arms in the push-off phase "raises" the CM position relative to the vertical coordinate in the main stance by 10-15 cm, lifting the body onto the toes at the end of the push-off "shifts" the CM even higher up to 20 cm, therefore the flight phase of the jump begins with an "elevation" caused by a change in the configuration and shape of the human body, which we called the pedestal [4].

The dynamometer chart gives a more reliable accuracy of determining the vertical coordinate of the CM departure before the body's take-off (the height of the pedestal) than the previously discussed methods, where there were many more random causes. In flight, a freely flying body is taken as a point mass and the vertical displacement is calculated in accordance with the laws of classical physics for uniformly accelerated motion in the Earth's gravitational field.

Conclusions. Based on the analysis of possible methods for assessing jump height, significant discrepancies in the indicators (up to 40%) were revealed depending on the measurement methods.

In order to optimize the control of athletes' jumping ability and increase the accuracy of assessing this quality, which is important for many sports, it is necessary to standardize the procedure for measuring jump height.

It seems advisable to take into account not only the age, gender, and qualification characteristics of athletes, but also the methods for assessing jump height when developing regulatory requirements for various groups.

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