

Modern methods of monitoring and evaluating the current functional state of athletes in various types of martial arts

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Purpose: development of a contactless real-time monitoring system of the athlete's current functional state.

Material & Methods: analysis of scientific and methodological literature on the problems of ongoing research; biomechanical analysis of the kinematic and dynamic characteristics of the athlete's motor actions when performing competitive exercises; methods of mathematical statistics; computer mathematical modeling.

Results: the existing methods for assessing the functional state of the body during the training and competitive activities of the athlete are reviewed and analyzed, on the basis of which the requirements for the construction of a method of contactless monitoring of the athlete's functional state are determined.

Conclusions: the functional state of martial arts athletes is currently monitored by modern equipment with a high degree of accuracy and speed of information processing, but only in contact mode, which excludes the possibility of operational monitoring of the athlete's current state during the fight. The study of the biomechanics of the motion of the kinematic links of the limbs and the static working pose based on the materials of the video recording of the athlete's movements made it possible to establish the dependence of the flow of dynamic forces that determine the speed of movement of the biokinematic pairs, which formed the basis of the developed non-contact method for assessing the measure of athlete fatigue directly during the fight. Modern techniques of video recording, computer support and established patterns of kinematic movements at various static stresses of the working pose allowed us to achieve our goal.

Keywords: athletes, martial arts athletes, contactless control, static stress, dynamic efforts.

Introduction

The development of a large number of various types of martial arts, representing various schools, involving in their classes an extensive and extremely diverse contingent of people of different age, sex, constitutional structure of somatotypes, requires deep theoretical studies that determine the acceptable norms of physical activity, the construction of optimal training process modes, assessment appropriate motor talent for practicing a specific type of martial arts aimed at achieving a high level of sports about mastery. This type of research suggests the need to solve quite serious and voluminous organizational tasks for monitoring the contingent of people who wish and are already engaged in the chosen sport.

In recent decades, this problem has become characteristic of many sports, but there are no sufficiently substantiated theoretical developments in this direction. One of the most important tasks, the solution of which is of paramount importance, is to determine the allowable loads based on the individual biological age, which reflects the ripening time of the morphological and functional systems of the body [14]. The essence of the problem is that the observed anatomical and morphological aspects of changes in the body under inadequate loads ultimately affect the reproductive function of the body, which entails the health problem of the next generation [2; 4].

The lack of fundamental systematic research in this area determines the relevance of the search for solutions to problems aimed at studying adaptation processes for both high achievement sports and practical healthcare.

Purpose of the study: to develop a non-contact system for monitoring the current functional state of athletes in situational sports.

Material and Methods of the research

Materials: data of video filming of fights by performances of athletes of various qualifications involved in martial arts.

Research methods: analysis and synthesis of scientific and methodological literature; biomechanical analysis of video materials of sports fights of athletes, a method of mathematical computer approximation of the kinematic movements of the centers of mass of individual parts of the body and the general center of mass of the body; graphical construction of research results in semantic attribute spaces with a single measure of comparable characteristics introduced into them; method of clinical anthropometry according to M. Ya. Breiتمان.

Results of the research

The organization of selection for the purpose of long-term

long-term planning involves mandatory certification of an individual's physical development, physical condition, true biological age, chronological age, individual structural features of the somatotype, prenosophical predisposition to the corresponding constitutional diseases, phylogenetic predisposition to certain forms of motor activity and the level of competitive reliability.

The compilation of such a passport of martial arts people became possible thanks to the methods developed at the Kharkov State Academy of Physical Culture and found their application in ongoing dissertation research [1; 5; 11].

Based on anthropometric data and their subsequent processing, special attention was paid to the weight of the individual referred to the population average statistical indicator for each specific age. In all types of martial arts, this task is greatly simplified due to the presence of weight categories in these sports, which made it possible to collect from 30 to 100 examined athletes from each weight category.

The availability of data on the weight of the athlete and his data on the biokinematic characteristics of the structure of the somatotype structure allows you to accurately determine the total center of mass of the body, the center of mass of each biokinematic link, which makes it possible to determine the energy costs of the athlete with modern computer technology, the necessary video processing programs and modern video recording technology. to perform motor activity immediately at the time of the fight. A characteristic feature of the kinematics of motion is that as fatigue increases, the inaccuracy of the technique of the techniques performed in terms of temporal, spatial and power characteristics is observed.

The rate of development of these changes depends on the initial state, which determines the potential abilities of the athlete, and the intensity of his physical activity. These characteristics are of a general nature of their course in all athletes, but have strictly individual isolation in each of them.

To build a method of remote contactless monitoring of the current state of a martial artist, it is necessary to establish regularities of the individual manifestations of the dynamics of the course of fatigue as a factor in temporarily reducing performance from the nature of its performance when it is certified for physical development and physical condition. Any motor act is associated with the mandatory presence of such constituent components as the physical stress of the static force that determines the working position, and dynamic forces that provide the kinematics of the performed locomotion.

Knowing the mass of the body and its location in the process of performing the movement of the body, the work performed on its movement is determined. Direct calculations show that the work performed is less than the actual expenditure of energy potential, which reflects the measure of the athlete's current loss of performance. This fact is explained by the fact that a significant amount of energy loss is spent on static voltage, which ensures the working pose of the performed locomotion. This expenditure of potential energy supply includes the cost of present emotional stress. Separate differentiation of these losses in the studies was not carried out. The main goal was to develop a method for assessing the athlete's contactless remote current state.

This fact is explained by the fact that in preserving the working posture a simultaneous balanced tension of the muscles, both their synergists and antagonists, is manifested. The kinematics in this balanced static stress is determined by the boundaries of its velocity pulsation and its duration. A processing program for this material was developed at the Kh-SAPC and was used in previously published works [6; 7; 10]. It is based on: the use of special semantic spaces with a single measure introduced in them, ensuring the construction of a scale of relations of the compared indicators, reflecting the dynamics of their course during the performance of a specific work. These regularities of the relationship between the current static stress depend on the angle of extension between the biokinematic links, which determine the structure of locomotion construction and the speed of their flow.

Any motor act is necessarily associated with the presence of static muscle tension of antagonists and synergists, providing a working pose for the exercise. The fulfillment of the motor act is possible provided that the voltage between the synergists and antagonists changes in a certain range, sufficient for the full implementation of its kinematic movement. In turn, the act of movement itself is characterized by the speed of movement of the biokinematic parts of the body. From what has been said, it follows that the structure for constructing the necessary semantic space with the unified measure of comparable characteristics introduced in it consists of equal static muscle tension of antagonists and synergists, from their minimum value to the maximum possible at the moment. The movement itself is carried out at a certain voltage range between synergists and antagonists. These characteristics can be represented in a Cartesian rectangular coordinate system, where the axes will reflect the voltage of "synergist antagonists". Naturally, this is a unit square, since the voltage varies from 0 to 1. Its diagonal reflects changes in equal forces of the "antagonist-synergist", the ratio of which is equal to 1 on the entire diagonal. The plot of moving the value on the coordinate axes relative to its projection onto the diagonal is $\sqrt{2}$ smaller than on the diagonal.

If we draw a perpendicular straight line with respect to the diagonal of the square, on which the "antagonist-synergist" voltage ripple zone will be reflected, then with the exception of the "time" parameter, the necessary phase semantic space will be constructed with a single measure for all the mentioned characteristics. Its peculiarity lies in the fact that the current value of the state is simultaneously on all four scales and is projected into a generalized section of two-unit squares, which are rotated at 45° relative to each other, which is shown in the figure.

By virtue of the distribution theorem of Archimedes, Cantor and the Dedekind randomness theorem in the generalized zone of the constructed semantic space, a measure of the normal distribution law in fractions of signal deviations is introduced, which is presented on all coordinate axes. In the generalized zone, a plot of the integral curve enclosed in the range $\pm\delta$ deviations from the zone of maximum density of the frequency of occurrence of interdependent observed deviations (Figure).

This task is reduced to determining the derivative of a complex function that describes the dependence of the change in the developed force on the regime of changing the angle of extension of the biokinematic pair, i.e. $\frac{dF}{dt}$, as a complex func-

tion $\frac{dF}{d\varphi} \cdot \frac{d\varphi}{dt}$ or $\frac{dF}{dt} = \frac{dF}{d\varphi} \cdot \frac{d\varphi}{dt}$, where $\frac{dF}{d\varphi}$ defines the boundary conditions, and $\frac{d\varphi}{dt}$ initial conditions of the movement.

The main task in forming the physical development passport and assessing the current functional readiness was to determine the individual nature of their manifestation. The establishment of the fact of the potential energy supply consumption in two components – on static voltage and dynamic forces – drew attention to the need to study the nature of the manifestation of static forces from the angle of extension of the biokinematic pair, which is defined as the first derivative $\frac{dF}{d\varphi}$.

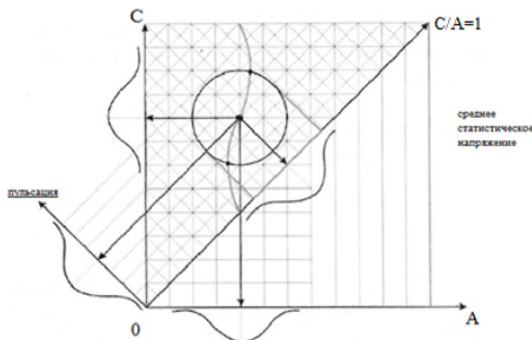


Fig. The regularity of the movement of the common point of the ripple indicator of the energy potential in its ordered representation in semantic semantic space with its arbitrary manifestation in the naturally occurring process of a single combat combat:

C – reflects the magnitude of the synergistic efforts (*C*) in the relationship of potential opportunities with its antagonist *A* in ensuring equal statistical stress, which is represented by the *C/A* ratio, equal in all cases 1, as the coefficient of constant statistical stress ratios (*C/A*), which is the diagonal coordinate system, where the coordinates of the *C* axis; *A*. Orthogonal to the diagonal *C/A=1* ripple relative to the coefficient (*C/A=1*), which make up the space having a common beginning with the space *C*; *A* turned by an angle $\alpha=45^\circ$. The zone of joint intersection of these spaces is an area that reflects the behavior of a common point, combining the interaction of all 4 parameters that generate a logical analytical relationship of their interdependent relationships.

The essence of this regularity consists in recording the magnitude of the assessment of the dynamometric deadlift with different angular location of the biokinematic pair of “high-drumstick”. Presenting the results of such a measurement in the polar coordinate system, a relationship was obtained that relates the change in the angle of extension of the leg in the knee joint by the set value of degrees and the observed value of the deadlift. It was found that this dependence consists in the fact that with an increase in the angle of extension, which occurs according to the law of arithmetic progression, the corresponding developed static force flows along a geometric progression. In the polar coordinate system, this dependence is expressed by a logarithmic spiral in which the radius vector reflects the magnitude of the developed force in a given position of the biokinematic pair of “high-drumstick”.

A characteristic feature of this pattern is that, regardless of fatigue, the nature of its construction does not change. The curvature of the spiral remains unchanged, but the length of the radius vector, which reflects the magnitude of the developed static voltage, decreases. The duration of this effort is reduced. Both that and other value are reduced exponentially. Individual features of the manifestation of the described pat-

terns are that each individual has a characteristic curvature of the logarithmic spiral.

The presented analytical dependencies allow not only to reflect the current state, but also make it possible to predict its development and determine the available intensity of the work performed. The analytical apparatus and the corresponding algorithms for assessing the current state with sufficient completeness are described in previous works [2; 7]. With the full amount of passport data compiled for each individual, it is not difficult on the basis of modern computer processing systems and video recording equipment to provide current control of the athlete’s motor activity during the period of the fight.

The developed method is based on the restored physical research method, which was called the “collective photography”. The essence of the method is the multiple layering of proportionate photographs of the faces of men of the same age, as a result of which the most common features are drawn.

The method allows, without making any calculations, to obtain directly clearly expressed information about the structure of the structure of the most pronounced characteristic elements of the face.

The high cost of the method led Halton to the development of statistical research methods that successfully led to finding modal values of controlled parameters for finding their information indicators in the studied structure of the object structure. The physical research method itself has been forgotten for more than a century and a half. The presence of modern video-recording equipment and a theoretical justification for constructing semantic attribute spaces with a single measure introduced into them made it possible to restore the method of physical modeling. This method, in its modern presentation, has a high degree of solvability of complex problems inaccessible to classical research methods [12; 13].

The presence of the developed method allows us to perform the *inverse task*, which consists in determining the curvature of the logarithmic spiral based on the video data of any individual, which is of considerable interest in planning tactics for conducting a duel with an upcoming opponent. In addition, this control method allows you to isolate and analyze the most tedious and energy-intensive costs of various performed locomotion of athletes during the fight, which can be visualized in any convenient form for further analysis and construction of the training process. The objectivity of this kind of processing of the obtained data is significantly determined by the accuracy of the measurements performed in the used semantic spaces [8; 9; 14].

Thus, the established relationship between the characteristics of the kinematics of movement of body parts and the measure of fatigue made it possible to differentiate the consumption of potential energy reserves for dynamic effort and static muscle tension, aimed at maintaining the athlete’s working posture. As fatigue develops, the inaccuracy of the performed movements increases, and the rate of inertia suppression of the general center of mass of the body slows down. Angular movements between the lower leg and thigh increase. This effect is observed not only when performing dynamic efforts aimed at moving the body, but also during the athlete’s stand-up. With the same duration of static stress in the stand-up position and

the same time of active movement of the body, the resulting fatigue from “no movement” can be no less than in the active movement of the body. This is explained by the energy consumption for the reflex of readiness for the upcoming action and is characterized by tension of expectation. Changing the accuracy of the movement and the kinematics of damping the inertia of movement also allows us to estimate the energy costs of the performed techniques of both participants in the fight, which plays a significant role in the process of constructing tactics for subsequent actions. This technique of dynamic computer simulation was developed at KhSAPC on the basis of modern technology for video recording of movements and established patterns of separation of energy consumption into static tension of the working posture and dynamic forces, which provide the kinematics of angular movements between the biological links of the body.

Conclusions / Discussion

The availability of modern technical video recording tools that provide the necessary speed for recording a moving object, appropriate computer software and the necessary software made it possible to use the established patterns of the flow of biodynamic forces and static stress observed during the performance of competitive movements of martial arts, to develop a method for remote non-contact monitoring of the current state of athletes. This method opens up fundamentally new approaches to solving a number of problems that are inaccessible in their complexity when using classical methods of studying the motor activity of martial arts athletes.

Further development of this direction will be associated with its wider implementation in practical activities while ensuring the training of high-class athletes.

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