Original Article

Hardware operational control of spatial and temporal parameters of athlete's movement

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Abstract:

The paper considers the possibility of approximating the possibilities of controlling the spatial-temporal parameters of the athlete's motion using a device created on the basis of modern electronic technologies. The purpose of the work is to substantiate and implement the ability to control the spatial-temporal parameters of movements of athletes using the hardware complex created on the basis of modern electronic technologies. Acquainted with the purpose of its introduction into the training process for the timely receipt of clear objective information and operational control. This enables purposeful correction of the training process on the basis of an integrated approach to the development of physical qualities.

Key words: athlete, control, parameters, motion, electronics.

Introduction

Assessment and analysis of the system of training athletes and the results of their performances in many sports prove that certain successes have achieved the laws of growth and the formation of sports skills. Significant role in this process is played by the individual training of athletes, depending on the laws of the development of physical capabilities, the equipment of a certain sport, motor sports, physical abilities and qualities (Koryahin, et al., 2016).

One of the components of effective management of the training process in the system of multiple trainers – is the definition of important factors that have an impact on the achievement of the sport result. Identifying trends in the combination of factors of sports training allowed to make a scientific basis for a purposeful selection of means and methods of sports training in each of three times, taking into account the important level of athletic skill (Preatoni, et al., 2013).

The relevance of the study is due to the need for an analysis of the existing control system of the parameters of motion. The following observations, which in the theory and practice of sports training, related to the informativeness of the testing procedures and the dynamics of the development of spatial-temporal parameters of motion, are not sufficiently developed, which are recognized by many scholars (Clarys & Cabri, 1993; Iedynak, et al., 2017; Magill, 2007; Preatoni, et al., 2017). It has been established that there is a need to find reserves for the growth of sports achievements by improving the quality of the training process. In this case, an important aspect is the search for innovative approaches to optimizing the process of physical training and improvement of methods for managing physical training. We note that the necessity of this search is dictated by the modern high level of sports achievements, which, in turn, imposes high demands on the level of physical training of athletes.

There is a system of knowledge in the field of sports training, considered in detail in the series of studies (Iedynak, et al., 2017; Koryahin, et al., 2017; Preatoni et al., 2013; Koryahin, et al., 2019). Numerous scientific sources focus on the management of the training process based on the control of the state and level of special training of athletes. Nevertheless, this problem is still the subject of discussions. Undeniable is the fact that the basis of the growth of sports results is the improvement of means and methods of development of physical qualities, as well as the current provision of this process (Duncan Mac-Duggala et al., 1997; Koryahin, et al., 2016). To date, there are many methodological research methods based on individual diagnostics of physical training of athletes using innovative technologies. At the same time, in the work there is no single approach to

the information and technical aspect of the study of the necessary parameters of the level of physical training of athletes.

Among the necessary conditions that provide sports improvement, it is important to study the parameters of the movements of athletes and their rational use, which requires the creation of an optimal technique for their control (Duncan Mac-Duggala, et al., 1997). The development of spatial parameters of motion in studies of reputable scientists is given a great deal of attention, since they are the scientific basis for understanding and practical solution of certain issues in sports training (Edwards, 2010; Magill, 2007). In addition to establishing the general laws governing the improvement of these parameters depending on the conditions and nature of the training sessions, the coach needs to pay attention to identifying the specific features characteristic of a particular sport (Schmidt & Wrisberg, 2008).

The search for ways to improve the methods for determining the spatial-temporal parameters of the level of development of movements determined the choice of the research topic. Analysis of existing publications on this issue (Duncan Mac-Duggala, et al., 1997; Koryahin, et al., 2016; Wilson, 2001) suggests, that the solution to this problem is connected with the use of the latest technologies for obtaining urgent objective information. The technological foundations of this issue in the field of sports training require scientific refinement, which is recognized by many scientists (Clarys & Cabri, 1993; Estivalet & Springer, 2009; Haake, 1996). To date, only some of its aspects have been developed in the field of sports science, and the proposed automated monitoring approach has not been used. In this connection, further study of the effectiveness of control methods in the context of modern electronic devices should be considered relevant.

The purpose of the work is to substantiate and implement the ability to control the spatial-temporal parameters of movements of athletes using the hardware complex created on the basis of modern electronic technologies.

Material & methods

To solve the research tasks used the methods of comparing and contrasting are used and analysis, synthesis, abstraction, formalization and scientific modelling.

Results

To determine the spatial-temporal parameters of the movements of an athlete during their exercise, we developed an electronic system for monitoring movements of his body (arms, legs, and head). Such a system belongs to the class of virtual reality devices that have recently been widely used in means of remote control of robots and manipulators, in simulators, means of treatment and rehabilitation, video animation, ergonomic research.

Our analysis showed that sensors on optical, magnetic, capacitive, inductive, ultrasonic, electromagnetic, and strain gauge transducers (Hotra, et al., 2010; Zordan & Hodgins, 1999) are used to implement systems for measuring spatial and temporal motion parameters. The choice of the type of transmitter depends on many factors: distance, measurement conditions, type of object, accuracy, etc. Optical transducers of spatial position of objects are the most universal, but their use is associated with some problems, including the complexity of the procedure for identifying an object and determining the distance to it, the need to constantly maintain an object in the field of view of video cameras, high price, especially in real-time measurement tasks. The advantage of magnetic, capacitive and inductive converters is the ease of signal processing and the ability to accurately measure even very small distances.

Modern work carried out in the field of magnetic sensors is, for example, the creation of transducers for simultaneous measurement in three coordinates X, Y, Z (3-D sensors) (Baxter, 1997). Among the new developments in the field of inductive transducers can be noted ultrasonic, electromagnetic and strain transducers, as well as combinations of several types of transducers (Bracke, et al., 2007). However, a common drawback of all these converters is the impossibility of measuring large distances (the maximum measured distance does not exceed a few centimeters). Ultrasonic and electromagnetic transducers can function at large distances to the object. Among them, the most developed ultrasound. Their advantage is the high accuracy of the distance measurement. However, like optical transducers, ultrasonic transducers cannot function when "shading" objects. In addition, they have a very low noise immunity, which is caused by the presence of echo signals from foreign objects. Electromagnetic transducers partially solve the problem of a "gray" object (provided that electromagnetic oscillations do not attenuate in the barrier), however, noise immunity is insufficient for accurate measurement of their distance. Their problem is also the dependence of the signal on the angle of rotation of the transducer, which makes it impossible to directly measure the distance to an object and, when moving, changes the angle of inclination. Strain gage transducers are used when there is a mechanical connection with the object. An example of the successful use of modern flexible strain-gage transducers is the CyberGlove® glove for controlling virtual reality applications. The informative parameter in devices of this type is the magnitude of the bend of the strain-resistive transducer. However, the use of strain gauge transducers to create a system for measuring the spatial position of an athlete's body is associated with the problem of the impossibility of

precisely fixing these transducers on all moving parts of the body. This, in turn, causes significant errors of such measurements.

Some measuring devices use combinations of several types of transducers or controls of computer devices (Estivalet & Springer, 2009). For example, a combination of ultrasonic and electromagnetic (microwave) transducers provides increased sensitivity and stability of operation in the presence of destabilizing factors (Hotra, et al., 2010). However, the use of existing systems for determining the characteristics of spatial movements does not meet the requirements for physical training. Firstly, such systems are rather cumbersome, in particular, sensors placed on the athlete's body create inconvenience and limit its movement. Secondly, the prices of existing systems for determining the spatial parameters of motion are tens of thousands of US dollars, which limits their use in sports training.

The hardware system for determining the spatial parameters of movements of athletes developed by us uses spatial position sensors based on electromagnetic transducers of the audio (several kHz) frequency range. Such frequencies of electromagnetic waves are reproduced by traditional sound sources – speakers. Electromagnetic type speakers are used in household radio equipment, music players, headphones, and therefore the question of the influence of electromagnetic waves in the kilohertz frequency range on the human body is well studied. We can assume that these waves do not have any negative impact on the human body. In addition, the radiation power does not exceed 0.1 W, that is, is scanty in comparison with the typical power of electromagnetic waves of sound frequencies of household sound sources.

The advantages of the kHz-frequency band of electromagnetic waves in spatial position detectors are:

- minimal attenuation in living tissue (human body), which, in addition to high noise immunity, provides minimal effect of radiation on the human body;
- the possibility of using high-precision and highly stable signal converters of the correlation type (in particular, sync detectors), and, therefore, ensuring high accuracy and noise immunity;
- good compatibility with frame antennas, which have advantages when placed on the human body;
- ensuring a sufficiently high speed converters;
- the absence of prohibitions on the use of radiating devices in industrial applications.

The spatial position sensor contains a transmitting antenna (Transmitter), emitting electromagnetic waves, and a receiving antenna (Receiver), receiving these waves, and turns them into an informative signal about the distance L and the angle of inclination. A typical characteristic of a pair of electromagnetic transducers, representing the dependence of the output voltage V on the distance L between them for different angles of inclination, is shown in Fig. 1.

Fig. 1. The dependence of the output voltage on the distance between a pair of electromagnetic converters

The best possible placements on the surface of the athlete's body are converters in the form of compact frame antennas. However, the radiation pattern of such antennas is of low informational content. The case of changes in spatial position. The receiving antenna relative to the transmitting signal is a function of at least five parameters – the distance (vector) between the centers of these antennas, two angles of inclination of the vector to the plane of the transmitting antenna, and two angles of inclination of the plane of the receiving antenna to the specified vector.

To increase the information content, we have proposed new designs of three-coordinate transmitting antennas and flexible receiving antennas, the appearance of which is shown in Fig. 2. An example of a variant of receiving antennas on a hand is shown in Fig. 3. An electronics unit measuring 10 cm x 10 cm x 5 cm is placed on the athlete's belt. It amplifies, switches and transmits antenna signals by a wireless communication channel. To implement a wireless communication channel, the ISM standard (Industrial, Scientific, Medical) is used, which is implemented on the TRF6900 radio transmitter (Application Report, 2001).

Fig. 2. Appearance of three-coordinate transmitting (a) and flexible (b) receiving antennas

Fig. 3. Placement of antennas on hand

To visualize the spatial parameters of the movement of athletes developed the original software, the view of the main windows of which is shown in Fig. 4.

Considering the large amount of information accompanying the monitoring of the dynamics of the space-time parameters of the athlete's movements, we consider it appropriate to automate this work based on the use of modern electronic technology for statistical processing of results. Based on this, we can assume the effectiveness and feasibility of using certain means of sports training and carry out the correction of the training process to achieve the highest possible result.

Fig. 4. View of the main windows of the software component for calculating and visualizing the movement of athletes

Dicussion

Improving the quality of the training process is possible through the development and implementation of special electronic-technical devices for the implementation of automated monitoring of spatial and temporal parameters of motion (Clarys & Cabri, 1993; Iedynak, et al., 2017; Koryahin, et al., 2016; Koryahin, et al., 2018; Magill, 2007; Preatoni, et al., 2013).

An objective assessment of the dynamics of the development of movement parameters allows you to comprehensively solve issues of current control, make timely adjustments during classes according to the characteristics of the movement and, thus, ensure the selection of the optimal strategy of the training process due to the targeted implementation of the principles of the formation of spatial-temporal parameters of movement sports (Edwards, 2010; Koryahin, et al., 2019; Magill, 2007; Preatoni, et al., 2013).

The introduction and use of modern electronic technologies in the training process is a powerful methodological basis for its continuous, scientifically based targeted correction based on an integral approach to the development of physical qualities, which makes it possible to achieve a qualitative improvement in the training process (Edwards, 2010; Estivalet & Springer, 2009; Haake, 1996; Duncan Mac-Duggala, et al., 1997).

Conclusions

One of the promising directions for improving the quality of the training process of athletes is the development and implementation in this process of special technical devices for testing, which should provide objective results.

Positive characteristics of using the device offered by us based on the latest electronic technologies are: accuracy of testing; urgent receipt of the result; the possibility of automatic receipt of results in the form of an electronic record.

The attached value of the device presented in the work is due to the proposed specific management organization methods that allow to objectively characterize the state of fitness of athletes during the training process.

Conflict of interest. The authors state no conflict of interest.

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