Journal of Physical Education and Sport ® (JPES), Vol 19 (Supplement issue 1), Art 36, pp.242 - 248, 2019
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Model-target characteristics of physical fitness in the system of programming sports and recreational activities with adolescents

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Published online: January 31, 2019
(Accepted for publication January 11, 2019)
DOI:10.7752/jpes.2019.s1036

Abstract:
Purpose: The aim of our work is to substantiate and develop the model-specific characteristics of the physical condition on the example of 13-year-old adolescent boys who are not involved in sports. *Material:* The studies were conducted on the basis of secondary school No. 17 in the city of Kiev (Ukraine). 87 adolescent boys of 13 years old took part. *Results:* The article substantiates the models of physical characteristics of adolescents aged 13 years, which are considered quantitative criteria of physical fitness and are directly related to the functional indicators of somatic health. *Conclusions:* Target models of a proper level of physical fitness are used in the system of managing individual health of schoolchildren in the process of physical education.
Key words: physical education, adolescents, models, physical fitness, physical condition.

Introduction.

The development of statehood in Ukraine requires the development of a national system of physical education in accordance with the requirements of the renewal of our society. Specialists (Vaskov & Pashkov, 2006; Dutchak & Trachuk, 2012; Krucevich & Trachuk, 2017) identify the orientation of the program-normative bases of the physical education system of different age groups of the population on a set of indicators characterizing the amount of daily physical activity level of physical development, the state of the functional systems of the body, physical performance and physical fitness.

At school age, the goal of physical education is specified by the following health problems (Krutsevich, 2017):

1) prevention of the occurrence of priority diseases (violation of posture, viral and respiratory);
2) the harmonious development of all physical qualities, taking into account sensitive periods;
3) achieving a proper level of physical condition, ensuring a high level of physical health.

According to the scientists of the field, ensuring the implementation of the recreational function of physical education of various groups of the population requires, above all, the availability of a reliable, informative monitoring system. (Krucevich, 2000; Rikard, 2006; Vaskov, 2012; Osipov, 2018).

The state tests and standards for physical preparedness of the population of Ukraine (Zubaliy, 1995) adopted in Ukraine in 1996 were defined as the program-normative basis of the domestic system of physical education, but caused different reactions among specialists by the controversial provisions, in particular the validity of standards, compliance with age standards and like that. Over time, the position and vision regarding this problem was determined in the longitudinal dimension, in particular, through the creation and use of tests as objective and standardized measurements that are easily capable by quantitative estimation, statistical processing and comparative analysis.

Programming is one of the options for normative prediction, since the goal of physical education is the norm - achieving an optimal state of physical health due to an appropriate level of functioning of body systems (Baevsky, 1979; Krutsevich, Vorobyov, & Bezverkhnya, 2011; Platonov, 2015).

Regulatory levels of physical condition can be represented as models whose characteristics are functional indicators of the cardiovascular, respiratory, nervous systems at rest or after performing physical activity, indicators of physical performance, physical fitness, etc. (Arinchin, 1983; Baevsky, 2004).

Such models can meet the average age, due or individual norms. Following the basic control conditions, it is necessary to measure similar characteristics of a managed object, compare it with a given model, identify differences between them and the degree of remoteness from the target. Target models specify pedagogical tasks, allow you to choose the means, methods, volume and intensity of loads adequately to the individual characteristics of the student. At the same time, it is necessary to take into account the reasons for the decline in indicators - the transferred diseases, the influence of unfavorable environmental factors, detraining due to the limitation of the physical activity (Krucevich, 2000; Trachuk, 2011).

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Proper physical standards are justified by objective data, indicating that students who have complied with the established standards of physical fitness have a higher level of health, a higher body resistance to adverse environmental factors compared to those who have not fulfilled them.

Material and method.

The aim of our work is to substantiate and develop model-specific characteristics of physical fitness on the example of 13-year-old adolescent boys who are not involved in sports.

The study was conducted on the basis of secondary school No. 17 in Kiev (Ukraine), where 87 adolescent boys of 13 years old took part. In these studies, we studied 40 indicators of morphofunctional status, physical performance, physical fitness of adolescents. We used methods of bicycle ergometry (PWC-170), motor tests, copying from medical records of schoolchildren, methods of mathematical statistics, factor, cluster, correlation and regression analysis for the synthesis of predictive models of physical fitness.

Results.

As the main concept characterizing the approach to the issue under study, we have adopted the state of an individual's bioenergy as a criterion for the perfection of growth and development. The dynamics of the functional reserve of bioenergy in ontogenesis is characterized by a variation in the average value of energy consumption at rest and a significant increase in this level during exercise in absolute terms (Apanasenko, 2011).

In early childhood, insufficient functional maturity of the musculoskeletal, cardiovascular and respiratory systems limits the adaptive possibilities of increasing energy metabolism during physical exertion (Bar-Or & Rowland, 2009; Potop, Grigore & Moraru, 2014). It is noted that the maximum level of energy consumption, produced by aerobic metabolic reactions, depends on the length, weight and surface of an individual's body, as well as on the degree of his physical fitness. This indicator increases with age in proportion to the length and body weight of the child, reaching a maximum by the age of 18-20. Thus, the relative (per 1 kg of body weight) indicators of the functions of a growing organism (at rest) that provide oxygen transport remain unchanged (Apanasenko, 1992; Sapin & Sivoglazov 2002; Bar-Or & Rowland, 2009).

The indicator of the physical condition, according to the chosen concept and the results of the factor analysis, was the power of the second stage of the bicycle ergometric load (x_{13}). As it was determined by many authors, the greatest dependence of the aerobic power of the load is determined by the variable length and body weight of adolescents (x_2 and x_3). The task of selecting base variables was solved by cluster analysis of indicators characterizing the morphological status of schoolchildren (10 variables), which led to the formation of the boundaries of three non-intersecting clusters of schoolchildren who clearly differ in length and body weight (Table 1).

Table1. The content of clusters on the plane (body length (x_2) - body mass (x_3))

Number of cluster	Number of members in clusters	Contribution, %	Cluster center coordinates	
			x_2	x_3
1	53	60,9	156,8	44,9
2	14	16,9	140,6	37,9
3	20	22,2	168,2	57,9

The arrangement of clusters on the plane is shown in Fig. 1. The largest number of schoolchildren as objects of study (60.9%) was concentrated in the first cluster, the coordinates of which are close to the average values of body length (x_2) and body weight (x_3) of the entire sample, respectively 156.8 cm and 44.9 kg The coordinates of the second cluster (16.9% of the sample) characterize schoolchildren as short, whose body weight is only slightly inferior to the mass of schoolchildren of the first cluster. In the third cluster, which includes 22% of the sample, were tall students with a body weight that was 13 kg higher than the average in the sample.

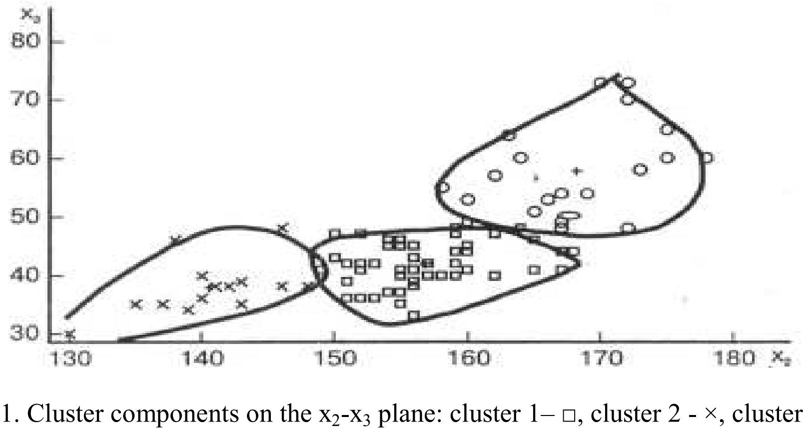

Fig. 1. Cluster components on the x_2-x_3 plane: cluster 1– □, cluster 2 - ×, cluster 3– o, centers - +

Characteristically, such a distribution occurred in a group of one chronological age - 13 years (a total of 87 subjects), which indicates the group's heterogeneity in biological age and the possibility of using length and body weight indicators as characteristics of physical development rates (Rebrova, 2006).

The predictive model of physical performance (Wpr) is synthesized taking into account the nonlinear nature of the dependencies of the variable length (x_2) and mass (x_3) of the body, which led to the introduction of their squares (x_2 x_2, x_3x_3) and works (x_2x_3) as candidates to regressors. The result is a predictive view model.

$W_{pr} = PWC_{170} = 0{,}769x_3 – 0{,}0048(x_2)^2 – 0{,}057(x_3)^2 + 0{,}036x_2x_3$ (1)

A visual representation of the surface structure can be obtained from Fig. 2, on which lines of constant power level are constructed as a function of body length and its mass.

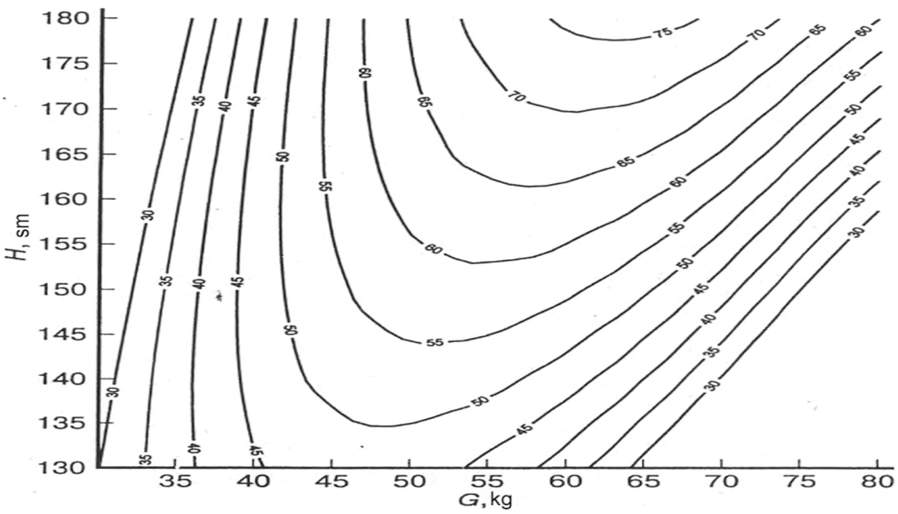

Fig. 2. Lines of constant power level Wpr = const on the plane of mass (G) and body length (H) parameters

This figure is used as a nomogram to determine the minimum predicted power level of physical activity for an individual without testing.

The predicted level of physical performance is a function of indicators, 70-80% of genetically determined and little manageable in the process of physical education.

The criteria for regularization in the selection of models were the minimum number of control variables, the minimum values of the standard error of the estimate and the average absolute error, as well as the maximum attainable values. The base variables were allocated x 25 - long jump from the spot (cm), x27 - hand strength (kg), x 34 - shuttle run 10 × 5 m (s).

The model is described by the equation of multiple linear regression.

$x_{39} = 0{,}1145x_{25} + 1{,}1551x_{27} – 0{,}3847\,x_{34}$ (2)

Since the estimated significance of P is less than 0.01, equation (2) as a whole is statistically significant with a confidence level of 99%. Statistics show that the model explains 99.6% of the variance of the variable Wpr (x_{39}).

The analysis of the basic variables of the functional model of physical performance - power, speed and speed-power qualities - shows that the skeletal muscle power, reflecting the tone and activity of muscle tissue that absorbs oxygen, makes a significant contribution to ensuring aerobic power.

The rule of "skeletal muscles" by I. A. Arshavsky is based on the derived physical laws - the motor activity of the living system is a factor in the functional induction of excess anabolism. There are two forms of excess anabolism. The first is represented in the antenatal and early postnatal periods with gradual attenuation and is expressed in excessive accumulation of protoplasmic mass, which causes an increase in the linear and weight characteristics of the organism. The second form is manifested in the excessive accumulation of structural-energetic potentials in the muscles of the skeleton, increasing their working abilities.

The excessive anabolism induced by functional activity is the leading mechanism underlying the processes of growth and development. Inadequate stimulation of excess anabolism during the period of growth and development, when there is the greatest susceptibility to the influence of the environment, associated with the restriction of motor activity, contributes to their restriction and incomplete use of the genetic stock.

Fundamental research (Krucevich, 2000; Apanasenko, 2011). the significant correlation of the hand strength indicators with the physical health indicators of a children's contingent not involved in sports is confirmed.

The strength of the hand is closely interrelated with the results in motor tests: pulling up on a crossbar, raising the body from a position on a back, a jump in length and a height from a place, and also with a becoming force (Fig.3). This indicates the possibility of using the power of the hand as an indicator of the development of skeletal muscles. However, the local development of hand strength does not lead to an increase in all the above indicators, i.e. feedback is not observed. This explains the opinion of some authors about the lack of informativeness of the index of hand strength when testing power qualities. With the targeted development of the strength of individual muscle groups in sports training (weightlifting, bodybuilding, athletics, etc.), this relationship with the indicator of hand strength and physical health can be broken. The essence of the system of physical training resources management is that the equation of the predictive model (2) can be directly used when programming control actions in order to achieve the desired level of physical performance.

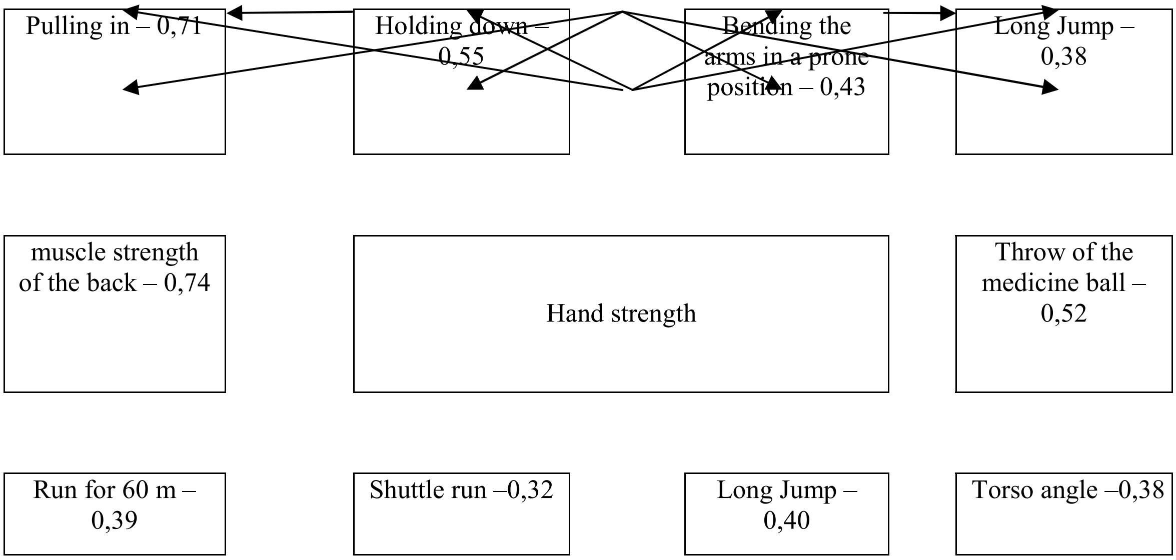

Fig. 3. Correlation of hand strength with motor test results

The target model of physical performance combined the components of the power of work performed. Comparison of individual indicators involved with the model provides an opportunity to specify the objectives, focus and ratio of funds in the coaching programs. The strength of the hand is an integral indicator of the skeletal muscles. Due to the lack of specialized sports activities, a significant correlation ($p < 0.01$ - 0.001) of hand strength with back force, strength and speed-strength tests (Fig. 3) is observed in the surveyed contingent, which makes it possible to include in the training programs and harmonious development of muscle strength in adolescents.

The formation of the aerobic component of physical performance is also associated with the development of general endurance, which is determined by the time to overcome the distance of 1500 m (x_{36}).

Applying a similar approach, we derived a predictive model for the average power of the ergometric load (x39) with an average absolute error of 17.1 s.

$$x_{36} = 515–1,108x_{39} \qquad (4)$$

This made it possible to determine the proper result at 1500 m, which corresponds to a high power level of the bicycle ergometric load (75 W), equal to 431.9 s ± 17.1 s, i.e. 7 m 22 s ± 1.17 s.

This result is characterized by an average speed of running through the distance of 3.4–3.6 m s – 1. Translated into metabolic units, this corresponds to 13–14 MET with VO2 50–52 ml•min^{-1}•kg^{-1} which, according to many authors, is the norm for adolescents and characterizes a safe level of somatic health (Apanasenko, 1992; Bar-Or , Rowland, 2009).

This was taken into account when developing standards for physical fitness of schoolchildren (m) of 13 years in the system of new tests and standards for assessing the physical fitness of different groups of the population of Ukraine (2016). (On approval of tests and standards for the annual assessment of physical fitness of the population of Ukraine, 2016). A high level of evaluation (5 points) corresponds to a running time of 1500 m 405 ± 20 s., And a proper level of 440 ± 20 s..

Continuing the study of this issue, we turned to the incidence rates of schoolchildren during the calendar year, which are characterized by the number of diseases (x) and the total number of days missed due to illness (x_{38}). The study of the relationship between the x_{38} variable and the 1500m run time (Fig. 4) made it possible to determine that to reduce disease by 1 day, a student from the contingent to be examined must, according to his functionality, run 1500m distance by 15.5 s faster than his personal result . The predictive morbidity model (x_{38}) with total endurance (x_{33}) is:

$$x_{38}= -19,48 + 0,064x_{36} \qquad (5)$$

Having checked the derived standard in the 1500 m run (415-449 s), we can predict that a teenager has a chance to get sick from 7 to 9 days during the year, which is an episodic disease. If, having reached this standard, he got sick once a year with an acute viral and infectious disease, then in order to increase the reserves of the body's resistance, he needs to either train purposefully to improve overall endurance, or include other physical education tools in the training program. strength properties that stimulate the functional reserves of the body.

Out of 16 motor tests have been allocated (except for physical performance and overall stamina) a few more tests, interconnected with the incidence of teens that has enabled the synthesis of predictive models and the development of proper regulations for this cohort of students.

Thus, a model linking morbidity with the strength of the hand (x_{27}), which has the form

$$x_{38} = 24{,}05+0{,}356x_{27}, \quad (6)$$

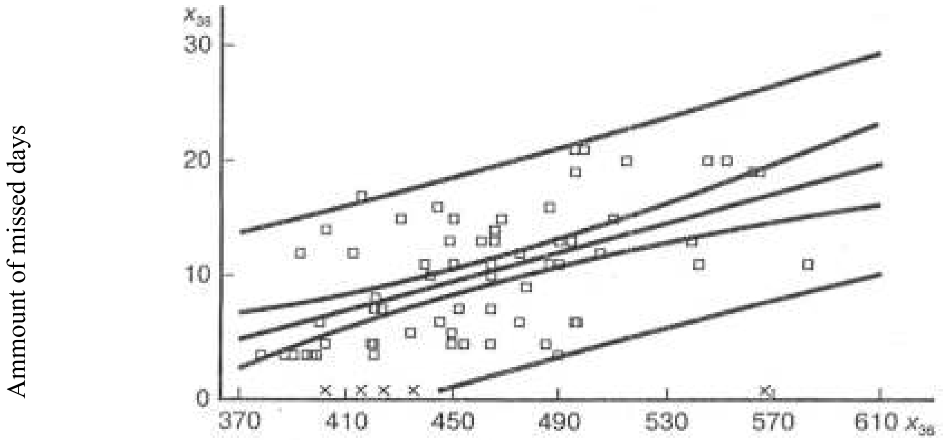

Fig. 4. The statistical relationship between the incidence (x_{38}) and the running time at 1500 m (x_{36})

This model is statistically significant as a whole with a confidence level of 90 %. The steepness of the obtained dependence is such that on one day of increasing the incidence there is 2.8 kg of the hand dynamometry effort. The following are models linking incidence with test results:

pull up on the bar (x_{21})

$$\mathbf{x_{38} = 17{,}37+1{,}04}x_{21}; \quad (7)$$

flexion and extension of the arms in the supine position (x_{24})

$$x_{38} = 17{,}04+0{,}31x_{24}; \quad (8)$$

long jump (x_{25})

$$x_{38} = 27{,}2+0{,}1x_{25}; \quad (9)$$

high jump (x_{26})

$$x_{38} = 22{,}2+0{,}33x_{26}; \quad (10)$$

running for 60 m (x_{33})

$$x_{38} = -56{,}7 + 6{,}63x_{33}. \quad (11)$$

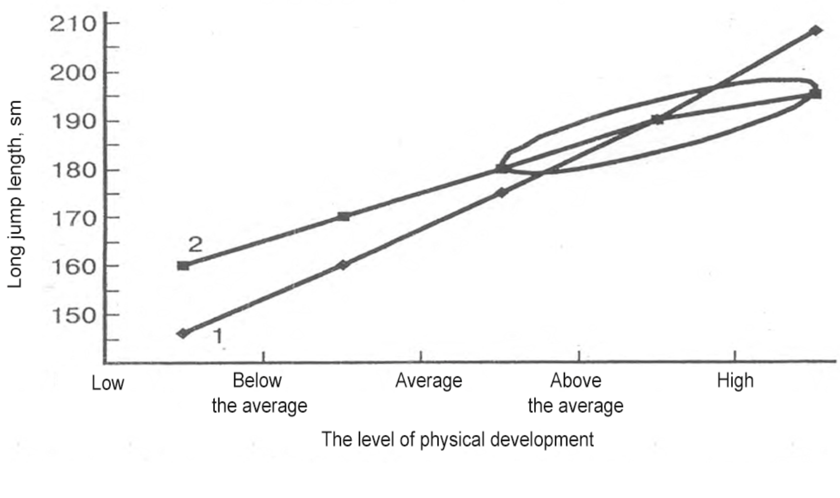

Fig. 5. Standards of the long jump for 13-year-old boys in the system of state tests (1, 1995) and "proper" standards of physical condition (2)

This makes it possible to carry out the correction of the model of the appropriate level of physical fitness of the individual, depending on the number of days of acute respiratory viral infectious diseases during the year. So for the standards of the long jump the proper standard in 2016 is the result of 170-185 cm.

Comparison of the predicted indicators of "due" norms and existing standards in state tests (Fig. 5, 6), which were previously in Ukraine from 1995 to 2006, allows us to make a conclusion about their inconsistency. The range of due values is in the zone from the average result to the high, and the high level in the state tests lies above the optimal result, which ensures a high level of physical condition. The method of predictive modeling used by us allows us to correct the norms of physical fitness depending on the purpose of physical education of schoolchildren.

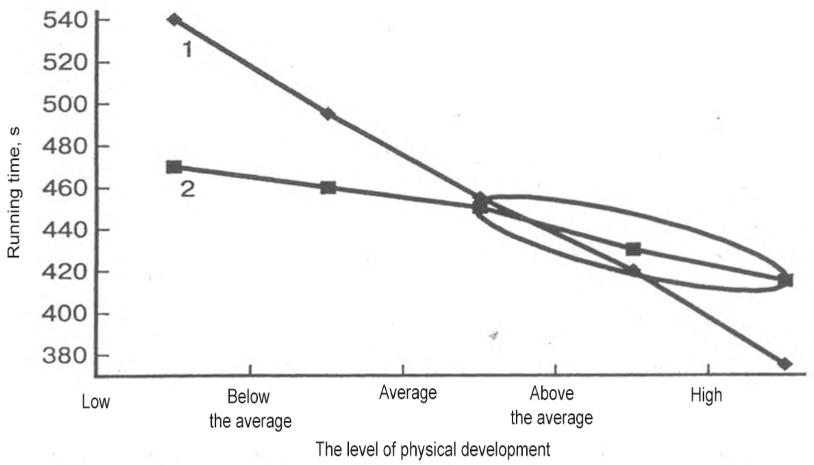

Fig. 6. Standards in the 1500 m race for 13-year-old boys in the system of state tests (1, 1995) and "proper" standards of physical condition (2)

The quantitative criteria of a “safe level of health” (Apanasenko, 1992, 2011) were determined based on the results of physical tests for endurance, strength, and speed, reflecting the qualitative level of functioning of the body of adolescents during physical exercises, which provide the minimum risk of acute respiratory viral infectious diseases throughout the year and endogenous risk factors.

Discussion.

According to Apanasenko G.L., it is the maximum oxygen consumption that is the criterion for the distribution of healthy and sick people to different levels of physical health, which are based on the amount of bioenergy reserves. The simplest and most accessible criteria for characterizing the energy reserve is the results of physical performance testing, since only general endurance characterizes the individual’s maximum aerobic capacity. As a test for general endurance for children of 7–16 years old, the authors recommend running at 1,500 m, the 12-minute Cooper test, and an ergomegric load consisting of several steps (PWC-170).

The above models help to adjust the proper standards for a particular student, selecting a variety of means of influence for the development of strength, speed, speed-strength qualities, general endurance, using those types of exercises that cause interest in adolescents. Regulatory models of physical condition and models of management of the process of physical education make it possible to develop computer programs of classes taking into account the age and individual characteristics of the students, which facilitates the work of a teacher of physical education and increases the health-improving efficiency of physical education classes.

Conclusion.

This approach in the development of target models provides an opportunity to substantiate and develop standards when testing physical fitness of various age groups of the population, taking into account the feasibility and achievements, depending on the objectives of physical education.

Thus, the developed models of the physical condition of adolescents have a quantitative characteristic, which is expressed by indicators of physical performance, individual indicators of physical fitness, which are directly related to the functional characteristics of somatic health, determining the energy potential of a biosystem. And this, in the context of physical development and physical fitness, will allow to orient the program basis of physical education towards the achievement of proper standards, namely, high and above average levels of physical health of those involved, which will contribute to improving the level of physical health and safe life of the young generation.

Conflict of Interest. The authors declare that there is no conflict of interest.

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