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Original Article

Systemic approach and mathematical modeling in physical education and sports

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Abstract.
The purpose of the work is substantiation of systemic approach and mathematical modeling methodology in studying of processes in physical education and sports. *Material:* The researches were conducte as per factorial experiment of 2^2 type plan. In the research 92 gymnasts of age 7-10 years and 78 junior gymnasts of age 11-13 years participated. Models of junior gymnasts" trainings at initial and basic stages have been worked out. For study system's transition to other level discriminant analysis was used. Assessment of 6-10 years boys' motor fitness was carried out by results of motor tests. The participants were: 6 years age boys (n=48), 7 years' - (n=45), 8 years' - (n=60), 9 years' - (n=47) and 10 years' age boys (n=40). *Results:* mathematical modeling, alongside with physical and live experiment, is one of main means for obtaining new knowledge in different spheres of natural sciences. Its importance will grow further but not replace physical and live experiment, because experience always is the base of any research. In physical education the objects of mathematical modeling include: age dynamic of cardio-vascular system's functional state and children's and adolescents' motor fitness; modes of physical exercises' fulfillment and their influence on efficiency of motor functioning; motor training of adolescents and children. For receiving models the following can be used: full factorial experiment of 2^k type (models of training impacts), logistic function (determination of training process and motor abilities' growth periods) and discriminant function (pdagogic control over fitness level). *Conclusions:* at present stage of science development modeling is one of the most efficient and promising tools for study complex phenomena and processes. All methods of scientific researches base on idea of modeling: theoretical (with the help of different abstract models); experimental, based on subjective models. Modeling method is an effective tool for study laws of adolescents' and children's motor training and working out of program for it.
Key words: systemic approach, mathematical modeling, biological, natural and pedagogic systems, physical education.

Introduction

Modeling, with systemic approach in its base, is an important method of any research (Blauberg, Sadovskij, & Iudin, 1969; Blauberg & Iudin, 1976). In systemic approach th object of study is regarded in its interconnection with its surrounding; the reasons of its appearing, development and sources of being are cleared up. In general-theoretical aspect systemic approach was implemented in theory od systems; in applied aspect – in systemic analysis [Ludwig Von Bertalanffy, 1972).

In opinion of Blauberg, Sadovskij and Iudin (1969) creation of statistic methods completed the first stage of systemic approach pre-conditions' formation: the stage, on which principles of approach to objects of sientific study were formed and filled with exact meaning. However, Blauberg and Iudin (1973) do not tend to firmly connect realization of systemic approach (or principle) with *mathematical methods'* usage. It is connected with the fact that application of mathematical models (and more widely – formal) methods becomes effective only on the base of solution of methodological task, in which object is regarded as system. Kacenelinbojgen (1970) notes, that mathematic in natural sciences plays a triple role: discription of an object; solution of a task (its qualitative analysis); the receive in the task's solution mathematical results sometimes stimulate scientists for their interpretation. It permits to rvel important phenomena, which characterize the nature of this object. Mathematical methods of analysis can be used for prove the task's feasibility and, thus, for confidence in practical realization of this task. Це дає можливість розкривати важливі явища, що характеризують природу даного об'єкта. However, mathematical methods of solution are not sufficient for proving such realization. It is necessary to clear up the completeness of the set task (i.e. its correspondence to actual onditions) and realize it in the given direction and in real time (providing methods and means of its solution). Tiukhtin (1988) points that

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special knowledge can to one or another extent (depending on theoretical maturity of science and development of mathematic itself) mathematized. Concrning any empiric fields, applicability of mathematical conceptions is of potential (not actual) character. In spite of gneral character of any mathematical structure, for description of any empiric field one or other kind of structures are used (or their combinatiopns). Mathematical coneptions and structures, in respect to empiric phenomena, have general and sunthetic character , including all variety of classes, sub-classes of different mathematical structures.

Morozov (2016) points that mathematical modeling is considered to be a justified tool for study different aspects of biological evolution and bio-systems' adaptation. Theoretical models and computer modeling are regarded, at present, as additions to empiric researches, but modeling often can even ensure alternative for biological and pedagogic experiments (Arziutov, Iermakov, Bartik, Nosko, Cynarski, 2016; Khudolii, Ivashchenko, Iermakov, & Rumba, 2016; Kozina, Repko, Ionova, Boychuk, & Korobeinik, 2016; Morozov, 2016; Pomeshchikova et al., 2016).

Concerning biological and natural objcts and processes, models shall include characteristics of surrounding, influence and system's typical reaction to irritation (Lopatiev, Dziubachik, & Vinogradskij, 2004; Lopatiev, 2007; Lopatiev, Dziubachik, & Smil'nianin, 2009; Khudolii, 2005, 2010, 2011; Vlasov, Lopatiev, Vinograds'kij, & Demichkovs'kij, 2010; Khudolii & Ivashchenko, 2014; Pjanylo & Pjanylo, 2014).

Thus, substantiation of systemic approach and mathematical modeling methodology in study physical education and sports processes is rather relevant.

The purpose of the work is substantiation of systemic approach and mathematical modeling methodology in studying of processes in physical education and sports.

Material & methods

The tasks of the research:

Classification of general conceptions in systemic approach theory of modeling.

Adaptation of general-systemicc terminology to mathematical modeling requirements.

Determination of methodological approaches to modeling in physical education and sports.

The methods and organization of the research: for solution of the set tasks we used the following: dialectic method (principle of system, principle of causuality); systemic approach; modeling; generalization, analysis, synthesis; pedagogic experiment; methods of mathematical planning of experiment; testing.

Application of systemic approach permitted to find integrative, systemic characteristics of the object of our research, as well as determine the modeling methods, which can be used as information support of motor abilities' training and in general, adolescents' and children's training.

The researches were conducte as per factorial experiment of 2^2 type plan. The received materials were used for modeling of junior 7-13 years' age gymnasts' training. At initial stage we analyzed 530 trainings. In the research 92 gymnasts of age 7-10 years participated. At basic stage we analyzed 580 trainings. In the research 78 gymnasts of 11-13 years' age participated. The research resulted in working out the models of junior gymnasts' trainings at initial and basic stages. For determination of different training modes' influence on cardio-vascular system's functional state and training effectiveness we conducted five-year' longitudinal studies. 60 junior gymnasts participated in them. In the experiment we registered heart beats rate after every attempt on gymnastic apparatus. Assessment of training effectiveness we registered the level of exercise's mastering. The level of exercise's mastering was determined as relation of successfully fulfilled exercises to their general quantity. System's transition to other level was studied with the help of discriminant analysis. Motor fitness of 6-10 years' boys was estimated by motor tests' results. The participants were: 6 years age boys (n=48), 7 years' - (n=45), 8 years' - (n=60), 9 years' - (n=47) and 10 years' age boys (n=40).

The study protocol was approved by the Ethical Committee of University. In addition, children and their parents or legal guardians were fully informed about all the features of the study, and a signed informed-consent document was obtained from all the parents.

Results

Classification of mai conceptions in systemic approach: let us regard dynamic systm, consisting of three elements-sub-systems:

- Object- interaction- medium, where: objects is stable in time and restricted in space creature, regarded in its correlations as a single unit – system's element;
- Interaction – contimuous process of interconnected by cause-and-effect linkage of object- medium transformation;
- Medium – arbitrary combination of objects, which can influence on the studied object.

All interactions can be understood as informational, as far as in every of them interacting objects realize controle over each other. Then it would be purposeful to regard interaction as a trine: material; not material; material-not material, whn one of interacting parts is material and the other – not material.

Any interaction between objects (elements of arbitrary system or systems), in the process of which one object transmits some essence and other objects receive this essences we shall call informational interaction.

Accordingly, the transmitted esence will be called information. Two the most general properties of information are: information can not xist out of objects' interaction, i.e. information is a process; in the frames of closed system information can not be lost and is kept within this system.

The main conceptions in theory and practice of objects', procsses' and phenomena's modeling are system and model. In scientific-methodic literature on systemic researches great attention is paid to main conceptions of systemic approach (Akoff & Emeri, 1974; Blauberg et al., 1969, 1973; Sadovskij, 1974).

Term "system" has been existing for more than two thousand years, though different researchers determine it differently and as on to day there is a number definitions of term "system". However, using any of them it is necessary to consider the tasks to be solved. For all definitions the general is: system is a holistic complex of interconnected elements with certain structure and interaction with medium.

In systemic studies one has to divide object into finite quantity of parts. With it, relations between them are considered, which characterize their interaction. This is exactly the start of interpretation of the studied object as complex systenm and its components – as sub-systems. If some sub-systems turns out to be too complex, it can be subdivided (preserving all linkages) into a number of sm,aller sub-systems. The procedure of sub-systems' dividion can be continued until components become sufficiently simple and convenient for direct description. Just such subsystems are called elements of complex system: they can not be divided further.

Medium is a combination of outide world elements, which are not componentsof system, but influence on its bihaviour and properties. Sytem is open, if it is influenced by medium. Linkages are very important in systems. All problems, which are characteristic for systemic approach, are grouped around this conception. Linkage is correlations between system's components, based on interdependence and inter-conditioning. From formal point of view, linkage is restriction of system components' freedom.

We determined corelations between objects in the following way: bewteen two objects there is linkage if (with the absence or presence of some properties) we can cvonclude about absence or presence of other object's properties (appearing and disappearing of objects we can regard as specific case). Linkage is characterized by direction, strength and character (kind). By this property linkages are divided into oriented and not oriented. By other property, they are strong and weak. Sometimes, scale of linkage strength is used for definite task. By character (kind) there are linkages of obedience, genesis, indifferent, controlling. Some of these classes can be divided more specifically: for example, linkages of obedience can be of type "part- the whole"; genesis linkages can be of type "cause – effect". Linkages can be classified also by place of location (internal and external), by orientation of processes in system in general or in separate sub-systems (direct and reverse) and by other more specific properties. Linkages in some systems can be characterized by several of the mentioned properties.

The system's structure we interpret as combination of internal stable and substantial links between elements, which determines the most substantial relations between objects. "Knowledge of system's structure is knowledge of law, as per which system's elements and relkations between them appeared". These relations form just those system properties, which determine existance and functioning of system and nsure preservation of its main properties under different external and internal changes.

Let us pay attention to difference betweenconception "structure" and "system". Sructure is understood as a net od interconnected elements, whose qualitative nature is not onsidered. With it, main attention is paid to their linkages. System is an object in the whole with all characteristic for it internal and external links and properties. With it attention is accented on qualitative specifics of elements, which determine the wholeness of object. Accordingly to it, system can be defined, turn by turn sorting its elements and all possible pairs of linkages bewteen them. However, it is difficult, if the quantity of elements is big. For understanding such system it is necessary to address conception of structure – partially ordered elements or correlations between them by certain property.

The purpose of the system is often defined as its desirable future status. Depending on the stage of the object's cognition, stage of systemic analysis this term is interpreted differently: from ideal strives, expressing active conscious of some persons or social systems to specific targets-results. In the first case targets, achievement of which can be impossible, can be formulated, but to which it is possible to reach infinitely. In the second case targets are feasible within certain time interval and are formulated sometimes even in terms of final product of activity. Often there are subjective and objective targets. Subjective target is subjective opinion of a researcher at desirable future status of system. Objective target is future real status of system, i.e. the state, to which system can transit under given external conditions and controlling influences.

Subjective and objective targets of a system can be different. In particular they do not coincide, if system is poorly studied or, is subjecvt (who determines targets) insufficiently knows the laws of the system's functioning or ignores them. The study of systems is convenient to study in terms of processes, with which the followinf conceptions are connected: status, transition fromone state to other, event. Process is consequent change of system's states in time. The state of system is combination of its parameters (properties) in certain moment of time. It is determined either by inlet influences and outlet signals (results) or through macro-parameters and macro-properties of the system. Quantitavily any system is described by combination of values, which are divided into parameters and characteristics. Parameters describe initial properties and serve as outlet data for solution of analysis tasks. Characteristics describe secondary properties of the system and are determined by solutions of tasks and their analysis as parameters' functions.

Thus, parameters of system can be interpreted as some inlet values. Characteristics can be interpreted as some outlet values, which are dependent on parameters and are found in the process of the system's analysis. If parameters and characteristics of system and model differ they are accordingly called systemic and model . System transits from one state to other by changing the values of vaiables. The reason, conditioning such transition is called event, which is realized instantly in time.

Conception of system's (sub-system's) structure, state of element are closely connected with conception of time and with system's functioning. In the process of system's functioning its elements, sub-sysyetms and the system itself acquire the targeted state. Accordingly, system's functioning is the process, which is a consequent transition from one state to other. It is purposeful to divide functioning of system, sub-system and element into separate actions. Action is transition of element, sub-system or system from one, previous state to the next. When analyzing system it is worth to regard only those its states, change of hich changes or creates pre-conditions for change of other sub-system's or element's state. Every such consequent change shall change system's state in the whole and influence, to some extent, on realization of system's main function.

Systems do not depend on how they were created and function during some period of time. For natural, open systems there exists closed cycle "medium-system-medium", which includes three stages or phases of life cycle: exclusion of system from medium; life and co-operation with medium with certain effectiveness; loss of effectiveness and return to medium. Life cycle of artificial systems also has three stages. However, in this case it started and stops on user: "user-system-user". The system is formed in user on the base of his/her knowledge, demands. The end of the system's life also is in user, because he determines the destiny of such systems.

System's parameters can be divided into internal and external. Internal parameters include: structural parameters, hich describe the system's composition and structure; functional parameters, describing functional organization (mode of functioning). External parameters dexrcibe system's interaction with external, in repect to it, medium. The system's characteristics can be divided into global and local. Global characteristics describe system's effectiveness in general. They include: characteristics of efficiency; time characteristics; reliability characteristics, economic and etc. Local characteristics describe functioning of separate elements ot sub-systems.

Main conceptions of modeling theory: we shakk use the following dfinitions of a model, modeling, mathmatical model, mathematical modeling, oriented on studying of biological and natural objects.

General for ll models is that all of them are means of scientific cognition. Now existing models' classifications are constructed as per demands of sphere, in which researcher works. Division of models into material and ideal is traditional one. Alongside with it such division is supplemented by its dividing into subject-like and symbolic (mathematical and so on).

In the field of scientific cognition there are more specific reasons for models' classification:

- By the form of models' presentation (logical, mathematical, mechanical, physical, chemiocal and etc.)
- By the nature of phenomena, which are simulated (social, biological and so on);
- By the tasks of modeling (prognostic, heuristic and so on);
- By degree of accuracy (approximate, probable and etc.) and other.

There are two approaches for generalized definition of a model. One of them implies reflection of facts, things, relations of certain field of knowledge in the form of simple, vivid material structure of this field. Thus we mean certain structures and relations analogous to the subject of research. For scientific models characteristic is the fact that they are such substiute of the researched object, which is in such concordance with th latter. Such model permits to receive new knowledge about the object.

Modeling is defined as a method of indirect cognition with the help of artificial or natural systems, to which some features of the researched object are intrinsic. It permits to present this object in certain correlations and obtain new knowledge about it. Let us mark out mathematical models: equation or system of equations together with boundary conditions, which are a record of conditions and laws of system's functioning. General scheme of mathematical modeling is the following: real object; building of physical (biological, chemical and etc.) system on the base of conservation laws; mathematical model or reception of mathematical equations' system; solution of appropriate tasks from mathematical physics; model's verification and results' analysis.

Mathematical modeling is opening and profound study of phenomena's mechanisms as well as their parts' interactions. As mathemmatical apparatus differential equations, mthematical statistic, linear graphs and other approaches are used. If the processes are described with differential equations (ordinary or partial) then such equations are non-linear and require significant additional researches for solution of appropriate tasks from mathematical physics. Recent time numerical methods of mathematical physics tasks solution, which have own advantages and disadvantages, have been being used. Their advantage is that numerical methods permit to solve wide range of initially bordering tasks and build on this base authomatized algorithms.

When building mathematical models, initial information,objects, methods of research shall satisfy the given conditions (see fig. 1).

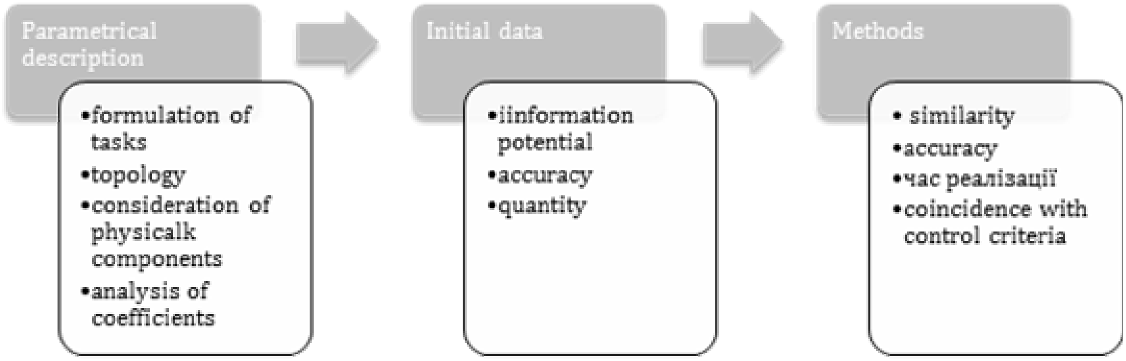

Fig.1. Structural diagram of mnatural processes' mathematical modeling

When building mathematical modl it is necessary to observe certain reqyuirements to the modl itself and to initial information, on the ase of which the description of phenomnon shall be created. Below are given the requirements, received on the base of some phenomena analysis in the process of gas transportantion in gas transportation systems.

In rquirements to components of the process's mathematical model attenion shall be paid to the following:

- Adaptibility in the given space-time limits, hich determines space-time interval of model's acting;
- Consideration of main physical dependences – determines the sphere of model's usage;
- Adequatea consideration of topolog – determines the object of modeling;
- Analysis of parametric correlations coefficients – determines need in usage research methods or building iterative structures.

Information potential of initial data shall ensure in space and time information, which would permit the following: identification of model; specifying of coefficients' values; possibility to compare the measured and calculated data as well as accuracy, which shall be agreed with: adaptibility of model; accuracy of initial data and accuracy of solution mehods. The required quantity of the data shall ensure: model's adaptation; building of initial-bordering conditions; analysis of numerical results.

In respect to requirements to methods, it should be noted the following: similarity – need in study application limits - numerical; links do not permit to receive solutions in special zones; accuracy – remembering that numerical methods have limited error from below – analytical methods require regulation of summing up operation. Realization time substantially depends on the set tasks: in planning for long periods of time it takes secondary place; in solution of operative control tasks – realization time shall be such as to provide opportunities for taking appropriate decisions after calculations; if the latter requirements can not be fulfilled it is necessary to use other methods (or opportunities) of calculations.

Accuracy of the calculated values shall permit to solve the tasks of optimal control over natural processes. It shall be: within the given range of space time fragment; proportionate to accuracy of initial data. Mathematical models and algorithms, programs and program complexes, support systems for solution of tasks are the elements of modeling. Their role and place can be correctly assessed in all chain of modeling, which is called processing chain. Processing chain of modeling shall be interpreted by us as combination of its elements, which are realized in definite sequence and make a completed cycle. The process of modeling can be presented as the following sequence: the studied phenomena – mathematical models; formulation of mathematical physicas tasks – numerical algorithms – programming and realization – calculations – results and their analysis. The latter generalizes the known trine of mathematic modeling: model- algorithm – program.

Alongside with physical and live experiment mathematical modeling is the main method of research and receiving new klnowledge in different fields of natural sciences. In the future its importance will grow but won't replace live and physical experiments because experience is always the base of any study. Extremely wide application of mathematical modeling in different spheres of natural sciences is conditioned by a number of factors, including: complication of the studied tasks; demand in solution ecological, social and other problems; impossibility to realize live or physical modeling in some fields of esearch and other.

Thus, as on to day, mathematical modeling is the main method of research and receiving new knowledge. Mathematical modeling is the most spread in solution of tasks of social medium's mechanic, often owing to impossibility of obtaining solutions on the base of other approaches.

Mathematical modeling in physical education: alongside with modeling biological and natural objects and processes as well as motor actions in sports it is possible to simulate educational process and motor ailities' training. Simulation of motor skills' formation process relates to building models in conditions of significant ambiguity. Physical education objects< which can be studied with the help of mathematical modeling, are:

- Age dynamic of cardio-vascular system's functional state and adolescents' and children's motor fitness;
- Regimes of p[hysical exercises' fulfillment and their influence on efficiency of activity;

- Children's and adolescents' motor training;

Mathematical models of the emntioned processes are based on processing of data, receievd directly in the procss of exercises' fulfillment and in the course of complete factorial experiments of 2^k type. In this cases mathematical statistic, theory of probability and factorial experiments serve as mathematical tools (Khudolii, 2005; Khudolii & Ivashchenko, 2014; Ivashchenko, 2016). For obtaining models the following can be used: complete factorial experiment of 2^k type (models of training impacts), logistic function (for determination of training motor abilities terms) and discriminant function (pedagogic control over fitness level). The method of complete factorial experiment permits to receive mathematical description of the process in some local field of factorial space around point with coordinates *n* of the measured space. It also permits to verify regression model.

The conducted researches permitted to find effectiveness and reliability of factorial 2^2 type experiment's plans in determination results of different training regimes' impact on functional state change and on motor training of junior gymnasts (Khudolii, 2011; Khudolii et al., 2014).

Analysis of results and pulse changes in every training session shoed that both processes can be described with the help of dependence (model)

$$Y = A/(1 + 10^{(a_m + bx)}) + C,$$

where Y (heart beats rate/ level of mastering) – result of function, depending onquantity of attempts; x, A, C, a_m, b – coefficients of the so-called logistic function.

Coefficients of logictic function's regression equation significantly change depending on regimes of exercises' fulfillment and rest period in points of plan. This dependence can be described by equations of the following type:

$$Y = b_0 + b_1x_1 + b_2x_2 + b_3x_1x_2,$$

where x_1 – volume of movements in a training session, x_2 – rest interval.

It was found that dependence between training results and pulse frequency changes in the process of training can bt described by non-linear dependence:

$$Y = a + b\acute{\eta} + b\acute{\eta}^2,$$

where Y – training result, ή– pulse frequency.

In point $\acute{\eta} = -b_1/2b_2$ we registered maximal level and pulse frequency acquires value of border between work, oriented on training and endurance development.

Thus, simulation method is an effective method of new knowledge receiving, about laws of physical exercises' training.

Analysis of scientific-methodic literature shows that strength development is a process of adaptation, which combines urgent and long stages of realization (Verkhoshanskij, 1985; Khudolii, 2011; Ivashchenko & Yermakova, 2015). With it, great attention shall be paid to creation of proper training conditions (Kudryavtsev et al., 2016; Pryimakov, Iermakov, Kolenkov, Samokish, & Juchno, 2016) and consideration sportsmen's individual characteristics (Korobeynikov, Korobeynikova, Iermakov, & Nosko, 2016; Kozina et al., 2016). It permits to correct the level of power loads e (Bliznevsky, Kudryavtsev, Iermakov, & Jagiello, 2016; Iermakov et al., 2016; Iermakov, Podrigalo, & Jagiello, 2016; Nosko, Razumeyko, Iermakov, & Yermakova, 2016). The studies, fulfilled by the program of complete factorial experiment (CFE) of 2^2 type in the groups of specialized training permitted to find models of urgent and postoped training effect of power loads. Basing on regression equations we calculated two kinds of power loads a) concentrated load (M-s) (regime "A"), b) power load, facilitating manifestation of maximal efforst (M+s) (regime "D").

In junior gymnasts of 12-13 years' age change of strength under influence of regime "A" loads is described by logistic equation:

$$Y_a = [5{,}5 / (1 + 10^{-0{,}88+0{,}46\,X})] + 9{,}5.$$

The moment of transition of function's change quickness from increasing to reducing is |x|= 1.9 trainings. Optimal reduction of strength after the offered load is 10.344 kg. The quantity of training sssions, required for reaching optimum is caklculated by formula:

$$\mathrm{Lg}\ (A / Y_{opt.l} - C) = a + bx,$$

where, $A = 5{,}5$; $Y_{\mathrm{opt.l}} = 10{,}344$; $C = 9{,}5$; $a = –0{,}88$; $b = 0{,}46$.

$$x = (0{,}742 + 0{,}88) / 0{,}46 = 3{,}52.$$

So, optimum of junior 12-13 years' age gymnasts under "A" regime of loads is reahced after 3-4 training sessions.

Change of strength under influence of regime "D" loads is described by logistic equation:

$$Y_b = [11,5 / (1 + 10^{2,26-0,332 X})] + 9,5.$$

Analysis of the equation shows that in point |x|= 6.8 change on's quickness from increasing to reducing happens. In ponit $Y_{opt.h.}$ = 19.235 kg function reeaches optimum.For reaching the point of optimum x = 9.04 of training sessions are required. So, point of optimim is reached by junior gymnsts at ninth training. For receivng the required effect "D" regime is used at four training sessions. Verification of the presented models of strength change under influence of training loads showed that these equations describe experimental data rather accurately (p<0.01).

Thus, on the base of modeling the process of junior gymnasts' training can be divided into two naturally connected stages. The first stage is formation of urgent stage of nervous-muscular system's adaptation to power loads. For this purpose power loads with recreation period of more than 24 hours are used consequently during 3-4 training sssions. Duration ofapplication of differently directed power loads is found on the bse of logistic function's analysis. Consequent application of differently directed power loads permits to increase the strength of muscular group by 30-60% during 10-12 training sessions.

For determination of system's transition from one state to other discriminant function can be used.Pedagogic control of functional and motor fitness is targeted at finding of minimal changing, characterizing this process (Ivashchenko, Yermakova, Cieślicka, & Śukowska, 2015; Ivashchenko et al., 2015, 2016; Khudolii, Iermakov, & Prusik, 2015; Ivashchenko, Yermakova, Cieslicka, & Muszkieta, 2015; Khudolii, Iermakov, & Ananchenko, 2015; Sgro', Quinto, Pignato, & Lipoma, 2016). On the base of discriminant function's canonic coefficients it is possible to classify children and adolescents by their motor fitness according to their age that is of practical importance in working out effective programs of their motor training. The functions' verification shows at their high discriminat potential and significance in interpretation of general population (see tables 1, 2).

Table 1. Canonic discriminant function. Own values

Function	Own values	% of explained dispersion	Cumulative %	Canonic correlation
1	16.161	95.2	95.2	0.970
2	0.579	3.4	98.6	0.605
3	0.136	0.8	99.4	0.346
4	0.096	0.6	100.0	0.296

Table 2. Canonic discriminant function. Wilky's lambda

Function's verification	Wilky's lambda	χ-square	Degrees of freedom	p
From 1 to 4	0.030	805.684	60	0.000
From 2 to 4	0.509	154.721	42	0.000
From 3 to 4	0.803	50.142	26	0.003
4	0.913	20.958	12	0.051

Discussion

In this work we adapted general-systemic terminology to requirements of mathematical modeling, which is based on methodological foundationby Blauberg (1973), Kacenelinbojgen (1970), Ludwig Von Bertalanffy (1972). It makes the bases and foundation for correct usage of approaches to motor actions' modeling in physical education and sports.

We also supplemented the data about methodological approaches to modeling in physical education and sports (Lopatiev et al., 2004, 2007, 2009; Khudolii, 2005, 2010, 2011; Lopatiev, Tkachek, & Vlasov, 2014; Morozov, 2016). Alongside with it, there is a demand in correction of methodological approaches and their adaptation to training tasks. Further pedagogic control of sportsmen's children's adolescents' motor functioning is rather important. It is proved by the conducted studies and results of other experiments (Vlasov et al., 2010; Khudolii et al., 2014).

It was found that in the frames of the delivered conception, for determinationof system's transition from one state to other plans of complete factorial experiments of 2^k type can ve used (Khudolii, 2011; Khudolii et al., 2014), models of growth (Khudolii, 2005; Khudolii et al., 2014, 2016) and discriminant function (Khudolii et al., 2015; Ivashchenko et al., 2016; Sgro` et al., 2016). Their application permits to find influence of some indicators (criteria) on motor actions' system in the whole.

The prospects of further researches imply working out and substantiation effectiveness of expert systems' application as well as systems of decisions' support in training of adolescents' and children's motor abilities.

Conclusions:

At modern stage of science development modeling is one of the most efficient and promising tools for study complex phenomena and processes. All methods of scientific researches are based on idea of modeling: theoretical, with application of different abstract models, and experimental, with subjective models.

Method of modeling is an effective tool for study the laws of motor fitness and working out training programs for adolescentas and children.

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Conflict of interests

The authors declare that there is no conflict of interests.

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