ORIGINAL ARTICLE

APPROPRIATE LEVELS OF PHYSICAL CAPACITIES DEVELOPMENT IN ADOLESCENTS WITH DIFFERENT STATE OF HEALTH

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ABSTRACT

The aim: To justify the appropriate levels of physical capabilities development in 12-13-years-old girls with different levels of physical health.

Materials and methods: The research involved 101 12-13-years-old female high-school students. The choice of the female high-school students of this age is due to the greatest variability of their morphofunctional state. The physical health of the girls was assessed according to the method of H. L. Apanasenko. Physical fitness was assessed with the help of 13 motor tests that determine different aspects of girls' physical capabilities.

Results: Appropriate normative standards of physical fitness for 12-13-years-old girls with different levels of health and rational parameters of physical activity were determined. It was established that a rational option for planning physical training for 12-13-years-old girls is: 26 % of time should be spent on strength development; speed and strength qualities and agility – by 22 %; endurance – 18 % and speed qualities – 12 %.

Conclusions: It was found that the main principle of the implementation of developmental and health-oriented training sessions for physical education of adolescents is the differentiated use of loads and assessment of their physical fitness. Calculated with the help of correlation coefficients and regression equations, the appropriate values of physical development in 12-13-years-old girls with different levels of physical health make it possible, using appropriate exercises, to eliminate deviations in their health indicators.

KEY WORDS: physical capabilities, health, developmental and health-oriented training sessions, adolescents

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INTRODUCTION

The theory and methodology of physical education involves determining the rational set and scope of special tools and methods, the sequence of their application at different stages of the health process in accordance with the goals and objectives of exercise implementation for people of different ages, levels of health and fitness [1, 2].

Programs of physical education training sessions for those involved are drawn up for people of the same age, gender, level of physical well-being, etc. The following forms of organization are used: school lesson, sectional training sessions and classes in health groups. Programs are also drawn up for a specific person who is engaged, taking into account individual characteristics as part of fixed forms both in terms of individual tasks and unfixed, organized and independent ones [3, 4]. The problem of programming in physical education has been studied by many scientists [5-7]. According to the results of their development, it has been established that: programming is one of the options for normative predictive modelling, as the norm is the goal of physical education i. e. achievement of the optimal level of physical health; normative levels of physical well-being can be presented in the form of models, the characteristics of which constitute indicators of physical working capacity, physical development, physical fitness, etc.

The generalization of scientific and methodological sources on the programming of developmental and health-oriented training sessions shows that the effective solution of this problem depends on the research of the peculiarities of adaptive responses to the proposed load in homogeneous groups of involved people in terms of their physical health level (PHL). Such research is important for adolescent high-school students, because the heterochronic nature of biological development affects the variability of the manifestation of their physical capabilities [8-10].

THE AIM

The aim of this article is to justify the appropriate levels of physical capabilities development in 12-13-years-old girls with different levels of physical health.

Table I. Regression between the indicators of physical fitness (x) and physical health (y) of 12-13-years-old girls

Indicators	r	R	y	x
Below-average level of physical health				
Push-ups (x), times Strength index (y), %	0.719	x = (y-31.62/1.17) ± 1.97	43	10 ± 2
Standing long jump, (x), cm Robinson Index (y), c. u.	0.521	x = (y-90.21/0.007) ± 9.6	91	157 ± 10
Lifting the torso to the sitting position, (x), times Rufier index (y), c. u.	-0.581	x = (y-17.77/-0.23) ± 1.67	12	25 ± 2
60 m run (x), s Vital index (y), ml/kg	-0.362	x = (y-41.86/3.06) ± 0.40	44	9.6 ± 0.4
1500 m run (x), min, s Robinson Index (y), c. u.	0.637	x = (y-97.86/-0.01) ± 10	92	9 min 45 s ± 10 s
4 x 9 m shuttle run (x), s Vital index (y), ml/kg	-0.687	x = (y-14.2/2.51) ± 0.2	44	11 9 ± 0.2
Torso flexion (x), cm Kettle Index (y), g/cm	0.355	x = (y-1.03/0.02) ± 1.2	-0.9	7 ± 0.1
Average level of physical health				
Push-ups (x), times Strength index (y), %	-0.696	x = (y-8.59/0.03) ± 1.3	9	14 ± 1
Standing long jump, (x), cm Robinson Index (y), c. u.	0.699	x = (y-52.84/0.001) ± 5.4	53	160 ± 5
Lifting the torso to the sitting position, (x), times Rufier index (y), c. u.	0.688	x = (y-31.54/0.61) ± 2.1	50	30 ± 2
60 m run (x), s Vital index (y), ml/kg	-0.397	x = (y-86.33/-3.43) ± 0.2	53	9.7 ± 0.2
1500 m run (x), min, s Robinson Index (y), c. u.	0.773	x = (y-53.52/-0.001) ± 5.3	53	8 min 05 s ± 5 s
4 x 9 m shuttle run (x), s Vital index (y), ml/kg	-0.707	x = (y-84.28/-2.74) ± 0.2	53	11.4 ± 0.2
Torso flexion (x), cm Kettle Index (y), g/cm	0.398	x = (y-0.02/-0.007) ± 1.1	-0.05	10 ± 1

Legend: x – appropriate normative standard of physical fitness, y – indicator of physical health, r – correlation coefficient, R – regression equation

MATERIALS AND METHODS

The research involved 101 12-13-years-old female students. The choice of these high-school students is due to the greatest variability of their morphofunctional state among all female high-school students.

The determination of the level of physical health is based on the assessment of the strength and efficiency of aerobic energy supply. In physiology, this indicator integrally characterizes the state of respiratory, circulatory and metabolic functions, and in biology – the degree of stability of a living organism.

The method of quantitative rapid assessment of physical health, proposed by Professor H. L. Apanasenko, includes registration of the indicators of anthropometry (length and body weight), physiometry (vital capacity of the lungs and dynamometry), as well as analysis of the cardiovascular system. The criterion for reserving and economizing the functions of the cardiovascular system are the indicators of the Rufier index and the Robinson index. The Rufier index was defined as the sum of three heart rate values (at rest for 15 seconds, for the first 15 and last 15 seconds of the first minute of recovery after 30 squats for 45 seconds) multiplied by 4, minus 200 and divided by 4. The Robinson index was determined by the ratio of the product of heart rate and systolic arterial blood pressure to 100. The criterion for the reserve of external respiration is the indicator of the vital index, which was determined by the ratio of vital capacity of the lungs to body weight. The criterion of the effectiveness of the muscular system is the strength index, which was determined by the ratio of the dynamometry of the stronger hand to body weight. The correspondence of body weight to body length (the Kettle index) was also evaluated. All indicators were ranked. The total amount of points was determined after calculating each index, which was used to assess the level of physical health [11].

To determine the level of manifestation of the basic physical capabilities of girls, motor tests were selected, which determine different aspects of the physical capabilities of 12-13-years-old girls, and were tested for validity, reproducibility and objectivity. A total of 13 motor tests were used. The most significant of them, as well as the specific weight of individual capabilities in the overall structure

Table II. Factor structure of physical capabilities of 12-13-years-old girls

No.	Motor tests on physical fitness	Factors				
		1	2	3	4	5
1.	Physical working capacity (PWC150)	029	341	012	751	146
2.	Maximum oxygen consumption	-122	034	036	734	140
3.	The strength of the hand flexors	747	047	-102	067	109
4.	The strength of the shoulder flexors	759	200	-029	138	005
5.	The strength of the torso extensors	654	030	261	015	168
6.	Long standing jump	044	683	263	106	111
7.	High standing jump	078	800	-122	068	014
8.	Throw a stuffed ball weighing 1 kg	639	045	210	012	113
9.	Running for 5 seconds (maximum rate)	002	157	-156	-219	860
10.	Running 70% of the maximum rate	067	-318	284	634	479
11.	Spinal mobility	586	-074	-073	041	-073
12.	Time difference in 3 x 10 m and 30 m run	-057	-145	808	094	-242
13.	30 m run	-189	-336	-730	052	-418
	Specific weight of factors (%)	26.0	19.0	18.0	16.3	10.3

Note: lines 1-13 show only decimal places of correlation coefficients

of physical capabilities of girls were identified by factor analysis (principal components method).

The research methods included the analysis and generalization of data from special literature (30 sources on the topic of the article from the scientometric databases PubMed, Scopus, Web of Science Core Collection and others were used), anthropometry, physiometry, methods of mathematical statistics (correlation and factor analyses).

The procedure for organizing the research was previously agreed with the Committee on compliance with Academic Integrity and Ethics of the National Pedagogical Drahomanov University. Prior consent to participate in the research was obtained from all the participants.

RESULTS

The first task of this research was to determine the appropriate values of physical fitness indicators in the group of girls of interest. To do this, based on the correlation between motor test indicators and physical health indicators, regression equations were calculated separately for girls with below-average and average PHL (Table I).

In the equations, the variable "y" is replaced by the quantitative value of the corresponding physical health indicator (below-average or average) from the table of PHL assessment. These values in the equations are given in parentheses. The variable "x" indicates the indicators of physical fitness, the appropriate values of which are given with the standard error of the equation in the last column. The equations were calculated for adolescent girls with below-average and average PHL. This is due to the fact that no girls with higher PHL were identified within the research. The main difference between the developed normative standards and those existing in the "State Tests and Standards of Physical Fitness of the Population of Ukraine" is that they are designed for 12-13-years-old girls with low and below-average PHL.

Comparing the initial values of motor tests (for example, in girls with low PHL) with the appropriate values (for girls with below-average PHL) will help the teacher (instructor, parents) to identify weaknesses in children's physical health and to eliminate deficiencies by means of exercise.

In addition to assessing the level of physical fitness, we studied the factor structure of girls' physical capabilities in order to justify the rational planning of physical training of the studied contingent (Table II).

The elaboration of rational parameters of developmental and health-oriented training sessions for 12-13-years-old girls was carried out with the help of:

- reasonable ratio of physical activity of various orientations for a given contingent of high-school students;
- pulse regimes of physical activity, which determine the training effect for 12-13-years-old girls with different levels of their physical health.

The problems of reasonable ratio of physical activity of various orientations in the course of developmental and health-oriented training sessions of 12-13-years-old adolescent girls were solved with the help of factor analysis. The expediency of the latter for such problems has been proven repeatedly.

As a result of factoring the matrix of intercorrelations of 13 indicators of physical capabilities, 5 statistically independent factors were identified: muscle strength, speed and strength qualities, agility, endurance and speed. The total contribution of these factors to the generalized variance of the sample made 89.6 %.

The first factor i. e. muscle strength (26.0 % of the total variance of the sample) combined control tests for the dynamometry of the shoulder flexors, which is most closely related to this factor; for the dynamometry of the hand

flexors and extensors of the torso; throwing a stuffed ball weighing 1 kg over the head from a sitting position with legs apart.

The second factor i. e. speed and strength qualities (the contribution to the generalized variance of the sample is 19.0 %) is characterised by high factor weights represented by a high standing jump (the most informative indicator) and a long standing jump.

The *third factor* i. e. agility (specific weight of 18.0 %) is represented by the time difference in 3 × 10 m and 30 m run.

The *fourth factor* i. e. endurance (contribution to the generalized variance of the sample of 16.3 %) has high correlations with relative working capacity (PWC_{150} test), maximal oxygen consumption and running results at a rate of 70 % of maximal. Physical working capacity according to the PWC_{150} test is the most informative indicator in the fourth factor.

The *fifth factor* i. e. speed accounts for 10.3 % of the generalized variance of the sample. It combined the rate of movements (run in place for 5 seconds) and the result in running 30 m. The first indicator has the largest factor weight here.

Thus, among the studied physical capabilities of 12-13-years-old girls, the most statistically informative are: to assess muscle strength – dynamometry of the shoulder flexors; speed and strength qualities – standing high jump; agility – time difference in 3 × 10 m and 30 m run; endurance – physical working capacity (according to the PWC_{150} test), speed – run in place for 5 seconds at maximum speed. These tests can be used as objective criteria for qualitative changes in the physical fitness of 12-13-years-old girls in the process of experimental research.

Hypothetically, a rational option for planning the physical training of 12-13-years-old girls is when 29 % of the total time planned for physical training is devoted to the development of muscular strength, for example, for a month or six months; to the development of speed and strength qualities and agility – by 22 %, to endurance – 18 %, to speed – 11 %.

For developmental and health-oriented training sessions, in addition to knowledge of the reasonable ratio of motor activity of various orientations, it is important to choose pulse modes in the process of these loads, which determine the training (health) and effective impact. In the special literature, such modes are developed according to special equations for persons from 20 years of age. Therefore, the calculation of effective working heart rate for primary school students was carried out according to the equations adequate for this age, according to which:

$\text{Heart rate}_{max} = 208 - (0.7 \times \text{age})$,

$\text{Heart rate}_{training}$ (bottom level) $= 0.65 \times \text{heart rate}_{max}$,

$\text{Heart rate}_{training}$ (top level) $= 0.75 \times \text{heart rate}_{max}$,

The choice of these equations for teenage girls is explained by the fact that physical education of schoolchildren, especially during puberty, prohibites the use of extreme and almost extreme loads. Therefore, the pulse range, which determines the health effects on the body, is 130-150 beats / min^{-1}.

DISCUSSION

Today, the amount of scientific information that characterizes the relationship between the health of schoolchildren, students and their physical activity has increased significantly [12-14]. However, only a small part of it is reflected in the theory and methods of physical education for the purpose of its practical application. Most authors consider this problem without regard to gender, physical development and puberty. There are also gaps in the study of the peculiarities of adaptation of schoolchildren and students to physical activity. There is an ongoing discussion about the existence of phases in the period of formation of the high-school student, during which his / her certain capabilities are most (or least) influenced by external stimuli [15, 16].

Motor activity can be considered from the standpoint of biomechanics and physiology. Motor activity in biomechanics is characterized by such indicators as strength, speed, acceleration, inertia, mechanical force or mechanical work. Physiology analyses motor activity using metabolic indicators such as oxygen consumption, metabolic energy (e. g., in kilocalories or kilojoules), etc. [17, 18].

In 2004, the World Health Assembly adopted the WHO Global Strategy on Nutrition, Physical Activity and Health, which emphasized that motor activity is a key tool for improving a person's physical and mental health. Each individual is recommended to ensure an adequate level of motor activity [19].

The mechanisms of the relationship between motor activity and functional capabilities have been and are the subject of research for many scientists [20-22]. The physiological nature of the positive effects of motor activity on the human body is due to the complex interdependent relationships between the muscular system and internal organs. These relationships are explained by the presence of two types of reflex effects: from the internal organs to the muscles i. e. viscero-motor reflexes and from the muscles to the internal organs i. e. motor-visceral reflexes. According to the needs of the organism in the activity of vegetative systems (respiration, blood circulation, etc.) motor-visceral reflexes are directed (by changing the metabolism) to change the functional state of these systems. Thus, along with the contraction of muscles that occur when the motor zone of the cerebral cortex is excited, nerves are stimulated, which increase blood circulation in working muscles [23]. In the case of insufficient human motor activity (hypodynamia), as well as excessive nervous and emotional stress, according to the experts [24], the functional state of the CNS as a mediator between muscles and internal organs is broken down. This causes a violation of the functional state of certain organs and systems of the body and the emergence of diseases. According to modern research [11], the deficit of muscular activity results in the following consequences: only 1.3 % of school-age children, according to an express assessment of the level of somatic health by Professor H. L. Apanasenko, can be considered healthy; 22.6 % are in the "risk group"; "sick" – 76.0 % of children. More than half of children have low levels of cardiovas-

cular and respiratory systems [25, 26]. The consequences of hypodynamics of high-schools students are disorders of the cardiovascular and respiratory systems, obesity, posture disorders, endocrine and mental diseases. Current research shows that only 15 % of high school graduates are healthy, the remaining 85 % have some deviation from the normative standard [15, 23].

How do the levels of physical fitness assessed by physical tests interact with the levels of physical health? To what extent are the former a reflection of health and can be an indicator of it? And if we assume that there is a statistical relationship between them, then the question arises – what quantity amount for each component of physical fitness will be the normative standard that corresponds to the average (and above) level of physical health? The latter is important for physical education, and therefore for everyone who is engaged in organized or independent physical exercises for health purposes. The results of the research of these issues on the example of 12-13-years-old girls are presented in this article. The precondition for asking these questions was the following judgment: the levels of development of certain motor qualities achieved by a particular individual are a consequence of the state of the individual body systems and, ultimately, other things being equal, determine the level of his / her physical health.

It should be noted that no research to assess the interaction of motor normative standards to determine physical fitness with the level of physical health of high-school students has been conducted, and therefore the answers to these questions are of both theoretical and practical interest. The obtained results expand and deepen the results of research by other authors [27-30].

CONCLUSIONS

1. It was found that the main principle of the implementation of developmental and health-oriented training sessions for physical education of adolescents is the differentiated use of loads and assessment of their physical fitness.
2. Calculated with the help of correlation coefficients and regression equations, the appropriate values of physical development in 12-13-years-old girls with different levels of physical health make it possible, using appropriate exercises, to eliminate deviations in their health indicators.
3. A rational option for planning developmental and health-oriented training sessions for 12-13-years-old girls is one in which 26 % of time should be spent on strength development; speed and strength qualities and agility – by 22 %; endurance – 18 % and speed qualities – 12 %. The developmental and health pulse regime for girls with low and below average levels of physical health is 163-176 beats / min, and for girls with average level of health – 167-190 beats / min. There were no girls with higher levels of health in this research.

Prospects for further research are to substantiate the appropriate levels of development of physical capabilities of adolescent boys with different levels of health.

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