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Original Article

Control of physical preparedness of schoolchildren using index method

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Abstract: *Purpose:* The aim of our work is to substantiate and develop an informative and accessible system for assessing the physical preparedness of children, teens and young people, focused on proper standards. *Material:* The research was conducted on the basis of secondary schools in different regions of Ukraine. 2016 pupils took part in. *Results:* The article provides a system for assessing the physical preparedness of schoolchildren and students, which is based on indices (speed, strength, speed-strength and endurance). ***Conclusions:*** The homeostatic relationship between the results of these motor tests and the parameters of the body of children, teens and young men makes it possible to determine the proper standards for their development. A reasonable approach to the rapid assessment of physical fitness of children aged 7-17 years, using the index method, which can be used in the system of physical education.
Key words: physical education, teenagers, indexes, physical preparedness.

Introduction.

In recent decades, in different countries of the world, physical education has become regarded as a powerful means of improving the health of the population, ensuring high efficiency and quality of life. Today, recreational orientation prevails in advanced systems of physical education and is the basis of a healthy lifestyle (Bar-Or & Rowland, 2009; Trachuk, 2009; Krutsevich, 2017).

The main task of physical education at school is health, therefore the due standard of physical fitness of schoolchildren will be the one that ensures a high level of health (Krucevich & Trachuk, 2017; Vaskov & Pashkov,2006).

In recent years, there have been discussions in the speeches of scientists and practitioners of Ukraine about the feasibility of using motor tests in controlling physical fitness of schoolchildren in the process of physical education, their informativeness in terms of interrelation with physical health indicators and motor test standards (Vaskov & Pashkov, 2006; Krucevich & Trachuk, 2017).

To substantiate the standards of physical fitness, objective data are needed, according to which it would be possible to establish that schoolchildren who have fulfilled these standards have a higher level of health, that is, high resistance to disease factors and fatigue than those who have not met the standards (Cooper Institute for Aerobics Research,1992; Isaac, 2005). Training standards are established most often empirically, on the basis of recommendations, specialists, or on average test standards for a specific age and gender group. Such a standard is not objectively justified, since the average value is not always the one that corresponds to a high level of health and efficiency. Middle-aged standards for children and adolescents can be used as a guideline, assessing the physical fitness of a certain age group of schoolchildren.

Material and method.

The aim of our work is to substantiate and develop an informative and accessible system for assessing the physical fitness of children, teens and young people, focused on proper standards.

The study was conducted on the basis of secondary schools in different regions of Ukraine, where 2016 pupils of 7-17 years old took part in. In these studies, we studied the indicators characterizing the morphofunctional status, physical preparedness of pupils of 1-11 forms. Used methods of motor tests, methods of mathematical statistics, factor, 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 homeostatic indicators of the ratio of body parts, functional systems in the body, since they are the basis for determining the standards of physical development and the physiological norms of the human body (Sapin, M. & Sivoglazov, 2002; Isaac, 2005; Romanenko, *2005; Apanasenko, 2011;* Krutsevich, Vorobyov, Bezverkhnya, 2011).

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To identify homeostatic connections, the analysis of correlations between certain results in the process of ontogenesis is addressed (Rebrova,2006).

After analyzing the correlation coefficients between the results in the 60 m race and the body length in different age periods and in different regions of Ukraine, we determined their sufficient significance at the level of $p < 0,05$ (from $r = 0,434$ до $r = 0,685$) (Krutsevich, 2007; Krutsevich, Pangelova & Trachuk, 2018).

At the same time, the ratio of the speed of running with the length of the body remains a fairly stable indicator and ranges from 3.6 to 3.8 sr. units It can be interpreted as an indicator of the effectiveness of the use of the levers of the body, in this case the lower limbs, when running for speed.

However, having such a standard value, we believe that individuals with shorter body length and developing greater speed at a distance will have greater efficiency in implementing their anthropometric parameters.

This may indicate their high functional abilities and be one of the indicators of the bioenergy potential of the organism. The general formula for calculating is:

$$\text{Speed index} = \frac{V\ (m \cdot s^{-1})}{LB\ (m)}, \text{ where} \quad (1)$$

distance - 30 м for children 7-10 years, 60 м for teens 11-15 years, 100 м for youth 16-17 years

t – time of distance duration in seconds (s), V ($m \cdot s^{-1}$)

LB – length of body (growth) in metres.

Qualitative levels (high above average, medium, below average, low) were taken according to the standards derived in the State tests of Ukraine for determining physical fitness of different groups of people (Table 1, 2).

Table1. Middle-aged standards for body length of schoolchildren of 7-10 years old, standards of 30 meters running speed (State tests) and speed index (I.S.)

Age, years	Body length, m	*Qualitative levels* High		Above average		Middle		Below average		Low	
		t,s	I.S, con.un.	t,s	I.S., con.un.	t,s	I.S., con.un.	t, s	I.S., con.un.	t,s	I.S., con.un.
						Boys					
7	1,30	5,7	4,0	6,3	3,66	7,0	3,29	7,6	3,0	8,1	2,8
8	1,32	5,4	4,2	5,9	3,85	6,5	3,49	7,1	3,2	7,5	3,03
9	1,38	5,1	4,26	5,6	3,88	6,2	3,5	6,7	3,24	7,2	3,02
10	1,42	4,8	4,4	5,3	3,98	5,9	3,58	6,4	3,3	7,0	3,01
						Girls					
7	1,27	6,1	3,87	6,8	3,47	7,5	3,15	8,2	2,88	8,9	2,65
8	1,29	5,8	3,98	6,4	3,6	7,0	3,3	7,6	3,03	8,2	2,81
9	1,34	5,5	4,07	6,1	3,67	6,7	3,34	7,2	3,1	7,8	2,87
10	1,43	5,2	4,03	5,7	3,68	6,2	3,38	6,8	3,08	7,6	2,76

Table 2. Middle-aged standards of body length for boys 11–15 years old, standards for speed of running at 60 m (State tests) and speed index (I.S.)

Age, years	Length of body, m	*Qualitative levels* Low		Below average		Middle		Above average		High	
		t,s.	I.S. con.un.	t, s.	I.S. con.un.	t, s.	I.S. con.un.	t, s.	I.S. con.un.	t, s.	I.S. con.un.
11	1,45	13,0	3,17	12,1	3,41	11,1	3,71	10,1	4,09	9,2	4,49
12	1,49	12,3	3,27	11,5	3,49	10,6	3,78	9,7	4,13	8,9	4,51
13	1,56	11,9	3,2	11,1	3,45	10,2	3,76	9,4	4,08	8,6	4,46
14	1,64	11,2	3,25	10,5	3,46	9,8	3,71	9,1	3,99	8,4	4,33
15	1,70	10,9	3,23	10,2	3,45	9,6	3,67	8,9	3,96	8,2	4,29

The index of the speed index below the norm may indicate a low level of functional abilities. Since the ratio of running speed and body length does not change with age, we can recommend age standards for children, adolescents and young people aged 7-17 (Table 3).

Table 3. Evaluation of the speed index for children, adolescents and young men, the conv. units

Sex	Functional level High	Above average	Middle	Below average	Low
Boy	4,3	4,2-3,9	3,8-3,5	3,4-3,1	3
Girl	4,0	3,9-3,7	3,6-3,4	3,3-3,1	3

The body length of schoolchildren is in a high correlation dependence with the result of a long jump from the spot (the correlation coefficient ranges from r = 0,480 до 0,785)

To determine the effectiveness of the use of anthropometric indicators and identify speed-strength abilities, we developed an estimate of the speed-strength index (Table 7), which determines the ratio of the result of the long jump from the place (in sm) to the body length (B.L.):

$$\text{Speed-power index} = \frac{\text{Long jump (sm)}}{\text{B.L. (sm)}} \quad (2)$$

The ratio of these indicators in different age periods is standard and averages 1-1.2 c.u. (Table 5, 6).

Table 5. Middle-aged standards for body length of schoolchildren of 7-10 years old, standards for long jump from place (State tests) and speed-strength index (S.P.I.)

Age, years	Body length, sm.	*Qualitative levels*									
		High		Above average		Middle		Below average		Low	
		Jump*, sm.	S.P.I, con.un.	Jump*, sm.	S.P.I., con.un.	Jump*, sm.	S.P.I., con.un.	Jump*, sm	S.P.I., con.un.	Jump*, sm.	S.P.I., con.un.
		Boys									
7	130,4	145	1,11	133	1,02	119	0,91	106	0,81	94	0,71
8	131,6	156	1,18	142	1,08	129	0,98	116	0,88	103	0,78
9	137,7	167	1,21	152	1,10	138	1,0	125	0,91	111	0,81
10	141,9	177	1,24	161	1,13	147	1,03	134	0,94	120	0,81
		Girls									
7	126,9	128	1,01	117	0,92	106	0,83	96	0,76	86	0,68
8	129,6	135	1,04	124	0,96	113	0,87	103	0,79	93	0,71
9	134,2	143	1,06	131	0,98	120	0,89	109	0,79	98	0,73
10	143,2	150	1,05	138	0,96	127	0,89	117	0,82	105	0,73

****- Jump in length from place***

The length of the limbs affects the result in this test, since an individual who has a shorter body length and who shows a result within the average age limit derived in the State tests will have greater functionality.

Table 6. Middle-aged standards for the body length of boys aged 11–16 years, standards in the long jump from the spot (Gos. Tests) and speed-power index (S.P.I.)

Age, years	Body length, sm.	*Qualitative levels*									
		High		Above average		Middle		Below average		Low	
		Jump, sm.	S.P.I, con.un.	Jump, con.un.	S.P.I., con.un.	Jump, sm.	S.P.I., con.un.	Jump, sm.	S.P.I., con.un.	Jump, sm.	S.P.I., con.un.
11	145,2	128	0,88	143	0,98	156	1,07	172	1,18	187	1,29
12	149,4	137	0,92	151	1,01	166	1,1	181	1,21	198	1,32
13	156,6	146	0,93	160	1,03	175	1,12	190	1,22	208	1,33
14	164,8	154	0,93	170	1,03	185	1,12	201	1,22	219	1,33
15	170,2	163	0,96	179	1,05	195	1,14	211	1,24	229	1,34
16	173,1	171	0,99	188	1,08	205	1,18	222	1,28	240	1,39

Both the speed and speed-power index take into account the corresponding values of the ratio of morphological and functional indicators of children, so the deviations of these values in the individual downward may indicate a low level of functionality as an indicator of physical condition (Table 7).

Table 7. Assessment of speed-power index units

Age, years	Functional level				
	High	Above average	Middle	Below average	Low
			Boys		
7-10	1,11	1,1-1,01	1,0-0,91	0,9-0,81	0,8
11-15	1,26	1,25-1,16	1,15-1,07	1,06-0,96	0,95
16-17	1,31	1,3-1,21	1,2-1,11	1,1-1,01	1,0
			Girls		
7-10	1,04	1,03-0,92	0,91-0,84	0,83-0,73	0,72
11-15	1,1	1,09-1,01	1,0-0,91	0,9-0,81	0,80
16-17	1,16	1,15-1,06	1,05-0,96	0,95-0,85	0,84

Given the correlation ratios of physical development indicators and results of running at a distance of 1000 m, 1500 m, 2000 m, an index of endurance was developed. (Table 8).

$$\text{Endurance index} = \frac{V\ (m \cdot s^{-1})}{BL\ (m)}\text{, where} \quad (3)$$

BL - body length, m; 1000 m distance for schoolchildren 7-10 years old 1500 m for girls and boys 11-15 years old, 2000 m for girls 16-20 years old, 3000 m for boys 16-21 years old; t is the time to overcome the distance in seconds (s), V ($m \cdot s^{-1}$).

Table 8. Middle-aged standards of body length for schoolchildren of 7-10 years old standards of running 1000 m (State tests) and endurance index (E.I.)

Age, years	Body length, sm.	*Qualitative levels*									
		High		Above average		Middle		Below average		Low	
		Jump, sm.	E.I., con.un.	Jump, sm.	E.I., con.un	Jump, sm.	E.I., con.un	Jump, sm.	E.I., con.un	Jump, sm.	E.I., con.un
					Boys						
7	130,4	5,05	2,52	5,30	2,33	6,0	2,14	6,35	1,95	7,10	1,79
8	131,6	4,45	2,66	5,10	2,44	5,40	2,23	6,15	2,02	6,55	1,8
9	137,7	4,40	2,58	5,05	2,37	5,30	2,20	6,0	2,01	6,35	1,8
10	141,9	4,25	2,65	4,50	2,43	5,15	2,23	5,45	2,04	6,15	1,9
					Girls						
7	126,9	5,45	2,28	6,15	2,1	6,45	1,99	7,25	1,77	8,05	1,62
8	129,6	5,25	2,37	5,55	2,17	6,25	2,0	7,05	1,81	7,45	1,65
9	134,2	5,10	2,38	5,35	2,23	6,0	2,07	6,40	1,86	7,20	1,7
10	143,2	4,55	2,37	5,20	2,18	5,45	2,03	6,15	1,86	6,50	1,7

Evaluation of endurance index by functional levels is presented in table 9.

Table 9. Evaluation of endurance index units

Age, years	Functional level				
	High	Above average	Middle	Below average	Low
			Boys		
7-10	2,5	2,49-2,3	2,29-2,10	2,09-1,9	1,89
11-15	2,5	2,49-2,3	2,29-2,1	2,09-1,9	1,89
16-17	2,3	2,29-2,10	2,09-1,9	1,89-1,7	1,69
			Girls		
7-10	2,3	2,29-2,1	2,09-1,9	1,89-1,7	1,69
11-15	2,0	1,99-1,8	1,79-1,7	1,69-1,6	1,59
16-17	2,0	1,99-1,8	1,79-1,7	1,69-1,6	1,59

For a comprehensive assessment of the physical fitness of schoolchildren, we recommend that you take into account the Rufier test - 30 squats for 45 s. Ruffie index is calculated by the formula:

$$\text{Rufier Index} = \frac{4\ (P_1+P_2+P_3)-200}{10}\text{, where} \quad (4)$$

P1 - pulse at rest for 15 seconds, P2 – pulse for 15 seconds immediately after doing the squat, P3 - pulse for 15 seconds at the end. The first minute of recovery. Index rating: less than 3 - high performance, 4-6 - above average, 7-9 - medium, 10-14 - below average, 15 and above - low (*Apanasenko, 2011;* Krutsevich, Vorobyov, Bezverkhnya, 2011).

A hand dynamometer is used to assess the strength of the carpal muscles. The strength of a strong brush of the right or left hand is measured (*Apanasenko, 2011*).

Power Index Calculation:

$$\text{Power index} = \frac{\text{Brush Dynamometry, kg}}{\text{Body weigh, kg}} \times 100. \quad (5)$$

Evaluation of the power index for young men: low - less than 45%, below average - 46-50%, average – 51–60%, above average 61–65%, high –66% and above; low for girls - less than 40%, lower than average - 41-45%, medium - 46-50%, higher than average 51-55%, high –56% and higher.

A general assessment of physical fitness based on individual indicators of physical development can be

obtained by summing using a point system (Table 10).

Table 10. Rapid assessment of the level of physical fitness for children, adolescents and young people 7-20 years

Indicators	Level				
	High	Above Average	Medium	Below Average	Low
Rufys index	0	1	2	3	4
Power index	0	1	2	3	4
Speed index	0	1	2	3	4
Speedy- power index	0	1	2	3	4
Endurance index	0-2	3-6	7-11	12-16	17-20

To determine the general level of physical preparedness, scores of three, four, or five tests summarize and determine the average score.

The calculation of the indices of physical preparedness in lower grades can be carried out by parents, for whom a sheet has been developed to monitor the physical preparedness of their children. The teacher records the test results in the control sheet, which is embedded in the student's diary, taking into account the assessment system. In middle and high school, students independently record and calculate indices of physical fitness as homework, and then the teacher transfers the marks to the journal.

The system of evaluation of individual indixes of speed, speed-strength, endurance, taking into account the pace of physical development in terms of body length, makes it possible to hold competitions of different age groups of schoolchildren among themselves, as non-absolute results will be compared in the 30m, 60m, 100m race , long jump from place, endurance run, and relative, that is, indixes (speed, speed-strength, endurance). This means that a junior high school student can beat a high school student, which will be a motivational incentive for systematic physical exercise.

Discussion.

Turning to the experience of the United States (Fitnessgram, 1982; tests of the Presidential Council on physical fitness, 1986; AANRERD), England (battery of motor skills tests of schoolchildren, 1981), a number of European Union countries (Eurofit, 1988; Unifit, 1995), international physical fitness tests children and youth (1993), physical fitness test systems do not have a uniform methodological basis, but are an important and effective tool that determines the conditions for comprehensive harmonious human development.

In spite of this, Tomkinson GR, et al (2017) note that the development of national norms and the definition of a national policy on children is carried out thanks to a battery of test Eurofit. Even in the use of the sigma deviation method, the calculation is done differently. Some authors take the basis of the calculation of the tables 0.5 sigma (±) from the general average value, others - 0.67 (±), others - one sigma.

For instance, several authors (Eurofit,1993; Kemper, Van Mechelen,1996; Sergiienko, 2001; Malina, Bouchard & Bar-Or, 2004; Tomkinson et al, 2017) have suggested using a normative quintile-based framework to classify the fitness levels of children and adolescents, where those below the 20th centile are classified as ‘very low/poor’; 20–40th centiles as ‘low/poor’; 40–60th centiles as ‘moderate’; 60–80th centiles as ‘high/good’ and those above the 80th centile as ‘very high/good’. Single test measures can be qualitatively interpreted using these quintile-based thresholds and longitudinal changes tracked against centile bands to identify expected, better than expected or worse than expected developmental changes.

The criteria for the standard of motor skills of schoolchildren should not be a comparative norm based on average standards, but should be, which corresponds to a high level of health, professional and household performance (Priymak, 2003; Peleshenko, 2010; Liakh, 2000; Krutsevich, 2017).

The natural age development of schoolchildren changes and one of the criteria is body length (Isaac, Panasyuk, Tambovtseva, 2005; Makarova, Loktev, 2006). Considering this indicator when calculating physical fitness indixes, we focus pupils on maintaining a balance between the indices of their physical development and motor skills, that is, an increase in motor test results not only due to a natural increase in leg length, total body weight, but also through consciously increased motor activity, aimed at self-improvement.

During the determination of physical fitness, we propose to take into account the actual level of physical fitness, which can be expressed in qualitative categories: “high”, “above average”, “average”, “below average”, “low”.

The definition of physical fitness of schoolchildren of 7–17 years in the cities of Kiev, Lutsk, Chernihiv, Dnepropetrovsk using the rapid assessment system developed by us (2016 people in total) made it possible to find out that 14% of students have a “high” level, 16% above “Average” –33%, “below average” –20%, “low” –17% (Fig.1).

The estimate of the normal distribution of the percentage of students' physical fitness levels is confirmed by the Gaus curve (Rebrova, 2006)

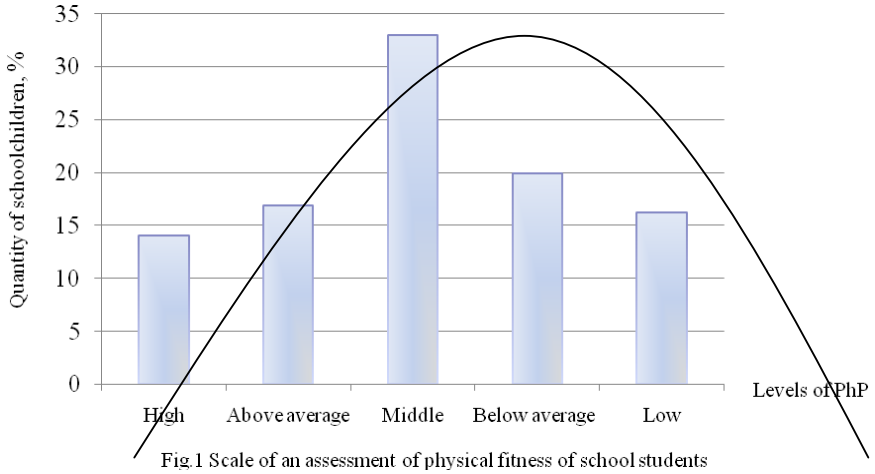

Fig.1 Scale of an assessment of physical fitness of school students

Assessment of physical preparedness mainly carried out either in absolute terms, or as a percentage of requirements, standards, or in the form of differentiated marks for the implementation of training standards or points (Vaskov & Pashkov, 2006; Loshitska, 2007; Bodnar Andres, 2016).

The system of assessing the physical fitness of children, adolescents and young people, tested in experimental studies, based on speed, speed-strength and endurance indices, is informative and accessible in the practice of physical education. Testing of the developed indixes when working with children of school age makes it possible to introduce it into the general system for assessing the physical preparedness of schoolchildren of all age groups with the definition of proper standards for the development of speed-strength, speed and endurance (Ischenko, 2016). Under the relevant standards of physical preparedness understand those that meet the above average and high levels. The average level can be regarded as the minimum critical rate.

We supplemented the data of Peleshenko (2010) and Bodnar, Kozhukh (2015) on the need to take into account in monitoring the level of schoolchildren's health a number of indicators of their functional state. According to Bodnar, Kozhukh (2015), the value of the correlation coefficient between the index of physical preparedness and schoolchildren's health and the level of the schoolchildren's functional health is r = 0.54.

The results obtained are an addition to our previous studies (Krutsevich, Panhelova, Trachuk, 2019) in the context of substantiating tests and standards of the system for monitoring physical fitness and health of students.

Conclusion.

Express assessment of the level of physical preparedness of pupils allows to improve the methodology of a differentiated approach, to develop individual programs for physical training and health classes, as well as to adjust the whole pedagogical process in terms of the size and direction of changes in physical preparedness. And this, in the context of physical development and physical preparedness, will allow to orient the program basis of physical education towards the achievement of proper standards, namely high and above-average levels of physical preparedness of schoolchildren, which will contribute to increasing the level of physical health and safe life activities of the young generation.

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

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