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Differentiated approach to physical education of adolescents with different speed of biological development

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Abstract
Aim: to justify and experimentally verify themethodology of differentiated approach to developing motor skills of seventh-graders depending on paces of their biological development. Material: 304 schoolchildren (148 boys and 156 girls), seventh-graders from the general education school No 20 in Lutsk, participated in the formative pedagogical experiment. The control group consisted of 99 boys and 105 girls and the experimental group – 49 boys and 51 girls, who were classified into the main medical group for health reasons and were not involved in sports sections. Results: It was found that schoolchildren with different levels of biological development within one age-sex group differ significantly in terms of the cardiorespiratory system capacity, physical performance and physical fitness. Therefore, the authors designed the methodology for allocating educational time to develop motor skills of seventh-graders during physical education lessons depending on paces of their biological development under the conditions of three physical education lessons per week. Conclusions: this methodology of differentiated approach to allocating educational time to develop motor skills of seventh-graders is an effective means for differentiated physical education of adolescents, which is reflected in the increase in the level of physical fitness and performance in seventh-graders during the pedagogical experiment.
Keywords: motor skills, quantitative estimation of biological age, differentiated physical training, differentiated assessment of physical fitness..

Introduction

According to the existing data, the body functioning during adolescence is determined by biological development rather than the calendar age. Individual acceleration and retardation of biological development is followed by significant variabilityof morphofunctional maturity, physical performance and fitnessof adolescents. Different paces of adolescents' physical development during this period create a peculiar set of individual quantitative and qualitative features of development (Farber, 1988; Halaidiuk,& Maksymchuk, 2018). Individual features of adolescents' biological development are determined by different learning abilities (Ermakov, 1996; Hlazyrin, 1999; Nikityuk, Musagalieva, & Savchenko, 1990; Serhienko, 1993; Volkov, 2002).In relation to pubertal processes in the body of the adolescent, individual advances or deficiencies inbiological, functional and motor development can reach on averageup to 5 years (Bakhraev, & Dorokhov, 1991; Chyzhyk, 1999; Maksimov, 1994; Shakhanova, 1997; Volkov, 1988).

Programmes for physical education in general educationschools are aimed at average schoolchildren and do not take into account the characteristics of adolescencedevelopment (Andrieieva, 2002; Kuts, 1997;Mytchyk, 2002).

It is therefore of practical interest to design the methodology of differentiated physical education and assessment of adolescents' physical fitness based on the estimation of the biological age and individual paces of morphofunctional and motor development associated with it (Korobeinikov, Korobeinikova, Nenasheva, & Tsaipiuk, 2002; Krustevych, 2000a; 2000b; Pryimak, 2003; Serhienko, 1993; Volkov, 2002).

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The issue of differentiated physical education taking into account individual morphofunctional development and physical fitness was studied by many scholars (Hasiuk, 2003; Krustevych, 2000a; Leonova, & Kuts, 1996; Sidorova, 1998; Tsos, 1994).However, these studies did not take into account hormonally dependent development paces, in particular the paces of adolescents' biological development which are important in this period. The study on the differentiation of physical activity and assessment of adolescents' physical fitness taking into account paces of their biological development are normally aimed at individual age-sex groups of schoolchildren, in particular boys aged between 15 and 17 (Filchenkov, 1994; Hlazyrin, 2003), girls aged between 12 and 13 (Andrieieva, 2002; Krustevych, 2000b), adolescents aged between 13 and 14 (Maksimov, 1994). Some studies are dedicated to the differentiation of physical activity in sports (Shakhanova, 1997; Volkov, 2002).

Taking into account individual peculiarities of development and the body of everyadolescent will make it possible touse adequate methods of physical education to enhance his/her motor skills. Inadequate ones can negatively affect adolescents' health, which will eventually slow down paces of their physical development and decrease their interest in physical education lessons (Apanasenko, & Popova, 1998; Blahii, & Cherniavskyi, 2005;Sukharev, 1991; Volkov, 2002).

L. Volkov (2002) distinguishes the following activity levels of motor skills development: high activity – the annual increase amounts to more than 3%; average activity – the annual increase ranges from 0 to 3%; low activity – one can observe some decreasing trends.

Therefore, it is necessary to develop organizational and methodological approaches to differentiated physical education of adolescents in modern schools.

*Hypothesis.*In adolescence, the level of physical development and the indicators of same-age adolescents' physical fitness largely differ and depend on paces of their biological development. Therefore, it is essential to justify the methodology of differentiated physical training taking into account biological development of seventh-graders, which will make it possible to specify the intensity of motor activityduring physical education lessons.

Thus, *the current research attempts* to justify and experimentally verify the methodology of differentiated approach to developing motor skills of seventh-graders depending on paces of their biological development.

Materials andmethods

Participants. The formative pedagogical experiment involved 304 schoolchildren (148 boys and 156 girls) aged between 12 and 13 from general education schools. The control group consisted of 99 boys and 105 girls and the experimental group – 49 boys and 51 girls, who were classified into the main medical group for health reasons and were not involved in sports sections.

Organization. The research was conducted in the laboratory of functional diagnostics at the Institute for Physical Culture and Health of Lesia Ukrainka Volyn State University and on the experimental site. The degree of puberty development in the schoolchildren was assessed by an andrologist and a gynecologist.

The degree of biological development was assessed by the level of puberty development. The scheme for a complex assessment of the biological age is composed based on creative processing of certain schemes (Krustevych, 2006; Chizhyk, Romanyuk, Sitovsky, & Chizhyk, 2002) using the regression analysis method.

The experiment involved four stages. Each of them solved a part of interrelated tasks determined in accordance with the general logic of the research design.

Physical education lessons in the control group (CG) and the experimental group (CG) were conducted three times a week (on Monday, Wednesday and Friday). The CG followed the general state programme. In the EG, educational time was distributed according to the changes in the development of the schoolchildren's motor skills during the school year and paces of their biological development. The training method mainly used in the EG was the group one. Group 1 includedlow-performingschoolchildren, who lag behind the biological age by one or more years compared to their peers. Group 2includedaverageschoolchildrenwith the average biological age for this sample (± 1 year). Group 3included high-performing schoolchildren, who outpace their peers by one or more years in the biological age.

The current research suggests the following distribution of educational time allocated for developingmotor skills in the schoolchildren aged between 12 and 13 in the structure of the annual plan and physical education lessons: 15% of the total time should be allocated to the development of those motor skills, which assume high activity level during the school year; 35% of the total time should be allocated to the development of those motor skills, which assume average activity level during the school year; 50% of the total time should be allocated to the development of those motor skills, which assume low activity level during the school year (see Table 1). More time should be allocated to the development of those motor skills, which tend to deteriorate during the school year and are characterized bya low pace of development.

It should be noted that there is practically no data on the dynamics of the cardiorespiratory system

capacity, physical capacity and physical fitness during the school year, especially in terms of paces of adolescents' biological development. Therefore, the effectiveness of thesuggested methodologyfor differentiated approach to allocating educational time to develop motor skills of schoolchildren aged between 12 and 13 yearsin accordance with pacesof their biological development was analyzed based on the relative increase in the indicators under study during the school year and was compared with that in the CG.

The cardiorespiratory system functional capacity was studied to monitor the adaptation to physical activity. The obtained indicators were compared between the schoolchildren in the CG and the EG, as well as with the data obtained by other researchers.

Table 1

Planning educational time for training certain motor skills in the schoolchildren aged between 12 and 13

Girls

Group	Motor skills									Symbols
	Speed	Strength	Coordi-nation	Endu-rance	Speed strength	*Dynamic strength endurance	**Dynamic strength endurance	Static strength endurance	Flexi-bility	
Relative educational time for training certain motor skills during the school year according to the suggested scheme of educational time distribution, tr, %										∑ t r
Low-performing schoolchildren	15	15	15	50	50	15	50	15	50	275
Average schoolchildren	35	15	35	50	50	15	50	50	50	350
High-performing schoolchildren	35	15	15	35	15	15	50	50	50	280
Adjusted relative educational time for training certain motor skills during the school year, t adj., %									∑ t adj.	
Low-performing schoolchildren	5	5	5	18	18	5	18	5	18	100
Average schoolchildren	10	4	10	14	14	4	14	14	14	100
High-performing schoolchildren	13	5	5	13	5	5	18	18	18	100

Boys

Relative educational time for training certain motor skills during the school year according to the suggested scheme of educational time distribution, tr, %										$\sum t_r$
Low-performing schoolchildren	50	15	35	50	50	15	50	50	15	330
Average schoolchildren	35	15	15	50	15	15	50	15	35	245
High-performing schoolchildren	15	15	15	15	15	15	15	15	15	135
Adjusted relative educational time for training certain motor skills during the school year, t adj., %										$\sum t_{adj.}$
Low-performing schoolchildren	15	5	11	15	15	5	15	15	5	100
Average schoolchildren	14	6	6	20	6	6	20	6	14	100
High-performing schoolchildren	11	11	11	11	11	11	11	11	11	100

Notes: – dynamic strength endurance according to the test "Sit-ups";*
*** – dynamic strength endurance according to the test "Chin-ups".*

Statistical analysis. The absolute time of physical activity is determined provided that the obtained relative values are adjusted depending on the number of motor skills, which are expected to be developedduring the school year (or within the structure of one lesson),based on formulas 1 and 2:

$$t_{adj.} = \frac{t_r}{\sum t_r} \times 100. \quad (1)$$

where$t_{adj.}$ – adjusted time, t_r – relative educational time allocated for training certain motor skills determined by the suggested scheme for the distribution of physical activity duration; $\sum t_r$– the amount of relative educational time allocated for each motor skill as defined by the annual plan (or by the objectives of one lesson).

In accordance with relative educational time allocated for training each motor skill, its absolute value can be determined in hours or minutes based on formula 2:

$$t_{abstr.} = \frac{t_{adj.} \times t_{ttl.}}{100}. \quad (2)$$

where$t_{abstr.}$ – time (hours) allocated for intentional impact on the development of certain motor skills during the school year; $t_{adj.}$ – adjusted time; $t_{ttl.}$ – the total time of intentional impact on the development of motor skills in the annual plan (or within one lesson).

In the same way, one can calculat.e educational time allocated for training certain motor skills in the structure of one lesson.

Thus, the lesson assumes intentional impact on the development of speed, strength, coordination skills and endurance. Accordingly, it is expedient to allocate 35% of the total time to the development of speed skills in girls with the average pace of biological development, another 35% of the total time – with the accelerated pace of biological development; 15% of the total time – with the slow pace of biological development. In relation to the development of strength skills, 15% of the total time should be allocated to their development in all three groups. As for coordination skills, it is important to allocate 35% of the total time to their development in children with the average pace of biological development, 15% of the total time – with the accelerated pace of biological development and another 15% – with the slow pace of biological development. Accordingly, 50% of the total time should be allocated to the development of endurance skills in children with the average pace of biological development, 50% of the total time – with the accelerated pace of biological development and another 50 % – with the slow pace of biological development (see Table 2).

Table 2

Planning educational time for training certain motor skills in girls aged between 12 and 13 in the structure of one lesson

Group	Motor skills				Symbols
	Speed	Strength	Coordination	Total endurance	
Relative educational time for training certain motor skills in the structure of one lesson, t_r %					$\sum t_r$
Low-performing schoolchildren	15	15	15	50	95
Average schoolchildren	35	15	35	50	135
High-performing schoolchildren	35	15	15	35	100
Adjusted educational time for training certain motor skills in the structure of one lesson, tadj. %					$\sum t_{adj.}$
Low-performing schoolchildren	16	16	16	53	100
Average schoolchildren	26	11	26	37	100
High-performing schoolchildren	35	15	15	35	100
Educational time allocated for intentional impact on the development of certain motor skills in the structure of one lesson, $t_{ttl.}$, min					$\sum t_{ttl.}$ *(min)*
Low-performing schoolchildren	6	6	6	18	35
Average schoolchildren	9	4	9	13	35
High-performing schoolchildren	12	5	5	12	35

The total time needed to develop the four motor skills is allocated as follows: 95% –low-performing schoolchildren, 135% – average schoolchildren, 100 % – high-performing schoolchildren. These values are adjusted based on the formulas 1 and 2. Consequently, it is possible to obtain the duration of intentional impact on the development of motor skills in the structure of one lesson in minutes.

Provided that the main part of the lesson is 35 minutes, 6 minutes is allocated to the development of speed, strength and coordination skills and 18 minutes – to endurance skills in the group with low-performing schoolchildren; 9 minutes is allocated to the development ofspeed and coordination skills, 4 minutes – to strength skills and 13 minutes – to endurance skills in the group with average schoolchildren; 12 minutes is allocated to the development of speed and endurance skills and 5 minutes – to strength and coordination skills in the group with high-performing schoolchildren.

Thus, the duration of intentional impact on the development of motor skills in the structure of the annual plan and physical education lessonslargely depends on paces of schoolchildren's biological development.

It should be noted that low-performing schoolchildren have more time to develop motor skills than high-performing ones. Still, this approach is entirely justified, since the obtained results show that it is the low-performing boys and girls, whose functional capacity of the body at the beginning of the school year is most optimal. Indeed, they show markedly lower indicators of adaptive potential of blood flow, Robinson index, heart rate and higher indicators of birth-death ratio and physical activity than high-performing schoolchildren.

Therefore, the suggested scheme of educational time distribution makes it possible to develop motor skills in the schoolchildren aged between 12 and 13 taking into account the individual characteristics of motorskills development, especially paces of their biological development.

Nowadays, the methods and approaches to differentiating quantitative and qualitative parameters of assessment are insufficiently justified and do not meet modern requirements (Mudryk, Oliinyk, Prykhodko, & Ashanin, 2002). Somescholarsindicate that regulatory requirements are calculated based on the average indicators and do not take into account the individual characteristics of schoolchildren, although the representatives of one age group are not homogeneous in terms of morphofunctional development, physical capacity and physical fitness (Blahii, & Cherniavskyi, 2005; Pryimak, 2003; Sitovskyi, 2005a; 2005b; 2005c; 2005d).

Therefore, it is necessary to take into account the individual characteristics of schoolchildren, whichdeterminefinal results. It is suggested to assess physical fitness of children aged between 12 and 13 taking into account paces of their biological development (Sitovskyi, 2005a; 2005b; 2005c; 2005d). In order to assess the dynamics of motor skills development during the school year, tests should be conducted at the beginning and at the end of the school year. Physical fitness was assessed based onthe 12-point system. Physical fitness standards based on the 12-point system were distributedin accordance with the results of percentile analysis by S. Glants.

Results

It is proved that the suggested methodology of differentiated approach to allocating educational time to develop motor skills of children aged between 12 and 13 is an effective means of differentiated physical education of adolescents, which is reflected in the increase in the level of physical fitness and physical performance in the schoolchildren aged between 12 and 13 during the pedagogical experiment (see Tables 3 and 4).

Table 3

Changes in physical fitness of boys aged between 12 and 13 during the pedagogical experiment depending on paces of their biological development, %

Motor skills, type of assessment	CG			EG		
	Low-performing schoolchildren	Average schoolchildren	High-performing schoolchildren	Low-performing schoolchildren	Average school-children	High-performing school-children
Strength skills, hand strength	+61,1***	+60,2***	+16,6**	+84,9***	+66,1***	+36,7***
Flexibility skills, seated forward bend	+6,3	+0,7	+29,4**	+12,1	+16,1	+35,9**
Speed strength skills, broad jump	-0,2	+5,0*	+8,4***	+11,7**	+7,8**	+9,7**
Dynamic strength endurance, sit-ups	+6,2	+21,2***	+44,4***	+11,3	+24,0***	+38,5***
Speed skills, 30-meter sprint	+4,8**	0	-7,2*	-4,9*	-5,7***	-8,9*
Total endurance, 6-minute sprint	-8,9**	-1,2	+21,3***	+13,7***	+8,1**	+22,1***
Coordination skills, shuttle run 4×9	-0,7	-4,6***	-9,4***	-6,8***	-5,3***	-9,7***
Physical performance	-14,3*	-6,7	+1,1	+7,6	+17,8**	+17,2**

*Notes: * – p<0,05; ** – p<0,01; *** – p<0,001.*

It is found that strength skills have increased by 84.9% (p<0.001) inlow-performing boys, by 66.1% (p<0.001)in average boys, by 36.7% (p <0.001) inhigh-performing boys and respectively by 31.0% (p <0.01), 37.0% (p<0.001) and 30.5% (p<0.01) in girls;flexibility skills – by 12.1%, 16.1% and 35.9% (p<0.01) in boys

and by 4.9%, 7.9% and 9.9% in girls; speed strength skills – by 11.7% ($p<0.01$), 7.8% ($p<0.01$) and 9.7% ($p<0.01$) in boys and by 4.4%, 4.6% and 6.9% in girls; coordination skills – by 6.8% ($p<0.001$), 5.3% ($p<0.001$) and 9.7% ($p<0.001$) in boys and by 11.2% ($p<0.001$), 4.8% ($p<0.001$) and 8.0% ($p<0.001$) in girls; speed skills – by 4.9%, 5.7% ($p<0.01$) and 8.9% ($p<0.001$) in boys and by 6.7% ($p<0.05$), 7.1% ($p<0.001$) and 7.9% ($p<0.01$) in girls; endurance skills – by 13.7% ($p<0.001$), 8.1% ($p<0.01$) and 22.1% ($p<0.001$) in boys and by 15.5% ($p<0.05$), 19.4% ($p<0.001$) and 15.5% ($p<0.01$) in girls. The results obtained from the pedagogical experiment show that physical fitness ofschoolchildren aged between 12 and 13 corresponds to high and average levels.

During the pedagogical experiment, relative physical performance ofEG boys has improved in three groups (by 7.6%, 17.8% and 17.2% respectively). In relation to average and and high-performing boys, however, the indicators are statistically significant. Relative physical performance of EG girls has improved by 15.0%, 7.1% and 8.3% respectively. Physical performance of CG boys has decreased during the school year, both in absolute ($p>0.05$) and relative ($p<0.05$) values. In relation to CG girls, one can observe a significant decrease in physical performance ($p<0.001$).

Table 4

Changes in physical fitness of girls aged between 12 and 13 during the pedagogical experiment depending on paces of their biological development, %

Motor skills, type of assessment	CG			EG		
	Low-performing schoolchildren	Average schoolchildren	High-performing schoolchildren	Low-performing schoolchildren	Average school-children	High-performing schoolchildren
1	2	3	4	5	6	7
Strength skills, hand strength	+22,2	+26,2***	+13,0*	+31,0**	+37,0***	+30,5**
Flexibility skills, seated forward bend	-15,0	-10,7*	-2,1	+4,9	+7,9	+9,9
Speed strength skills, broad jump	-2,4	-2,5	+4,2	+4,4	+4,6	+6,9
Dynamic strength endurance, sit-ups	+15,7**	+7,5	+27,7***	+13,4	+10,8	+29,3**
Speed skills, 30-meter sprint	-4,3	-2,7*	-0,5	-6,7*	-7,1***	-7,9**
Total endurance, 6-minute sprint	-5,4	-7,2***	+2,1	+15,5*	+19,4***	+15,5**
Coordination skills, shuttle run 4×9	-9,2***	-2,6**	-4,4***	-11,2***	-4,8***	-8,0***
Physical performance	-16,0*	-15,3***	-18,2**	+15,0***	+7,1***	+8,3***

*Notes: * – p<0,05; ** – p<0,01; *** – p<0,001.*

In the context of speed and speed strength indicators, physical performance of EG schoolchildren is at appropriate level, whereas it is at rather low and average levels in the CG. The progress in physical fitness of EG boys is assessed as excellent in three groups. In relation toEG girls, it is assessed as good in low-performing and average girls and as excellent in high-performing girls. It should be noted that during the school yearlow- and high-performing EG boys have shifted from average to high level of physical fitness,average boys – from appropriate to high level of physical fitness. EG girls have shifted from average to appropriate level in all three groups. In the CG, the progress in physical fitness in girls from all three groups and low-performing and average boys is assessed as unsatisfactory.

It is proved that almost all indicators of somatic development in schoolchildren aged between 11 and 16 have significantly closer ($p<0,05$-$0,001$) correlations with the biological age than with the chronological one. This dependence is also observed between individual parameters of the cardiorespiratory system capacity and the biological age. Almost all indicators of physical fitness in boys and girls reliably correlate with the biological age. However, this dependence is more pronounced in boys than in girls.

It is found that schoolchildren with different levels of biological development within one age group differ in terms of the cardiorespiratory system capacity, physical fitness and performance both at the beginning and at the end of the school year. Reliable ($p<0,05$-$0,001$) differences were found between high- and low-performing boys in terms of heart rate, blood pressure, Robinson index, adaptive capacity of blood flow, systolic blood pressure and shock index, lung capacity, forced respiration, chest excursion, hand strength, deadlift strength, broad jumps, chin-ups.

Statistically significant difference (p<0,05-0,001) was found between girls with extreme paces of biological development in terms of adaptive capacity of blood flow, systolic blood pressure and shock index, physical capacity, lung capacity, birth-deathrate, forced respiration, chest excursion, hand strength, deadlift strength,seated forward bend, 30-meter sprint, shuttle run.

During the school year, one could observe significant heterochrony of the cardiorespiratory system capacity, physical fitness and performancein both boys and girls as a result of the paces of their biological development. The effectiveness of differentiated physical training for children aged between 12 and 13 is confirmed by the dynamics of physical performance during the pedagogical experiment. Physical performance increases by 7.6%, 17.8% (p<0.01) and 17.2% (p<0.01) in low-performing, average, high-performing boys in the EG and is lower by 20.4% (p<0.001), 19.4% (p<0.001) and 13.9% (p<0.001) than thatin the CG. In relation to girls, physical performance increases by 15.0%, 7.1% and 8.3% in the EG and is lower by 27.5% (p<0.001), 20.5% (p<0.001) and 28.5% (p<0.001) respectively in the CG. During the school year, however, physical activity has decreased in CG boys (p<0,05) and girls (p<0,001).

Discussion

The results obtained from the pedagogical experiment show that physical fitness of schoolchildren aged between 12 and 13 corresponds to high and average levels in comparison with the data provided by some scholars (Hlazyrin, 2003; Krustevych, 2000a;Kuts, & Vynohradskyi, 2003). In particular, absolute and relative hand strength corresponded to high and average levels (Apanasenko, & Popova, 1998;Romanenko, 1999; 2005). According to T. Krutsevych (2006), strength index in EG boys and girls corresponds to average and appropriate levels of physical fitness. Flexibility skills of high-performing boys and girls corresponded to average (Kuts, & Vynohradskyi, 2003)and high levels (Romanenko, 1999; 2005).

Speed strength skills corresponded to average level in low-performing and average boys,to high level in high-performing boys(Romanenko, 1999; 2005), tohigheraverage level in three groups (Hlazyrin, 2003); to average level in low-performing and average girls (Hlazyrin, 2003); to average level in girls in three groups (Kuts, & Vynohradskyi, 2003; Romanenko, 1999). According to T. Krutsevych (2006), speed strength indexcorresponds to average level in low-performing and average boys andto higher average level in high-performing boys in the EG andto average level in EG girls in three groups.

Coordination skills of boys corresponded to higher average level in three groups (Kuts, & Vynohradskyi, 2003) and to high level in three groups (Romanenko, 1999; 2005).Coordination skills of girls corresponded to high level in three groups (Krutsevych, 2006; Kuts, & Vynohradskyi, 2003; Romanenko, 2005).

Speed skills of boys and girls corresponded to average level (Hlazyrin, 2003; Romanenko, 1999; 2005). According to T. Krutsevych (2006), speed index corresponds to average level in high-performing and average boys and to higher average level in low-performing boys in the EG. In relation to EG girls, it corresponds to average level in three groups.

Endurance skills corresponded to average level in low-performing and average boys and to higher average level in high-performing boys (Hlazyrin, 2003), to average level in average boys and to high level in low- and high-performing boys (Romanenko, 1999; 2005). In relation to girls, they corresponded to higher average level in three groups (Hlazyrin, 2003), to higher level in average girls and to higher average level in high- and low-performing girls (Romanenko, 1999; 2005).

The obtained results can be divided into three groups: those confirmed by other studies; those complementing the already existing ones; novel results.

Therefore, the obtained results prove the views (Blahii, & Cherniavskyi, 2005; Krustevych, 2006; Pryimak, 2004) that functional development, physical performance and development of adolescents' motor skills are more dependent on the degree of biological development than on the calendar age. Schoolchildren with different levels of biological development within one age group are significantly different in terms of physical fitness, the cardiorespiratory system capacity and physical capacity. It is also confirmed that physical fitnessstandards are calculated based on average indicators and do not take into account the individual characteristics of schoolchildren (Mudryk, Oliinyk, Prykhodko, & Ashanin, 2002). In addition, the requirements for assessing these standards are overestimated.

Based on the view that the changes in the indicators of the cardiorespiratory system capacity, physical capacity and physical fitness are characterized by their significant heterochronity in both boys and girls, it is found that theheterochronity is caused by the paces of their biological development. In particular, one can observe some heterochronityduring sensitive periods of the studied indicators of physical fitnessinschoolchildren aged between 12 and13 in the middle of age-sex groups with different levels of biological development. It is also proved that one can assess physical fitness of schoolchildren aged between 12 and 13 in accordance with their levels of biological development(Korobeinikov, Korobeinikova, Nenasheva, & Tsaipiuk, 2002); one can assess the biological age by the method of its quantitative determination (Andrieieva, 2002); the periods of increase and decrease in the indicators of physical fitness, the cardiorespiratory system capacity and physical performance

during the school year can be determined by the paces of adolescents' biological development (Volkov, 2002; Sukharev, 1991). Novel results include development of differentiated approach to allocating educational time to develop motor skills of children aged between 12 and 13 depending on paces of their biological development and experimental verification of its efficiency.

Conclusions

Significant differences in paces of biological development of girls and boys and its individual characteristics lead to the situation, when classes can include children with different functional characteristics and adaptation skills. Therefore, it is necessary to employ differentiated approach, since one of the criteria for distributing schoolchildren to groups should be paces of their biological development.

Taking into account the dynamics of physical performance and physical fitness of schoolchildren aged between 12 and 13 during the school year, it is vital to plan developmental training of all the main motor skills with an emphasis on those that might deteriorate during the school year and have low growth rate. Indeed, 15% of the lesson time should be aimed at developing the motor skills, which improve by more than 3% during the school year; 35% of the lesson time should be aimed at developing the motor skills, which improve by 3% during the school year; 50% of the lesson time should be aimed at developing the motor skills, which deteriorate during the school year.

Physical fitness of children aged between 12 and 13 should be assessed in a differentiated waytaking into account paces of their biological development and the initial level of physical fitness. In this case, the dynamics of motor skills should be assessedat the beginning and at the end of the school year.

The proposed distribution of educational time to develop motor skills of children aged between 12 and 13 taking into account paces of their biological development is an effective means of differentiated physical education for adolescents, which proves the increase in the level of physical fitness in the EG during the pedagogical experiment.

Further research may consist in introducing differentiated approach to distributing educational time to develop motor skills in physical education lessons depending on the pace of biological development in the practice of physical education of other age groups and conducting more studies on its effectiveness.

References:

Aghyppo, A., Kamaev, O., Mulyk, V., Mulyk, K., Grynova, T., & Kotliar, S. (2017). Influence of the level of development of motive qualities on the technique of ski styles and shooting of 14-16-year-old biathletes. *Journal of Physical Education and Sport*, 17 (4), 2643–2648.

Andrieieva, O. V. (2002). *Programming physical education and recreation classes for girls aged between 12 and 13*. (Doctoral thesis). National University of Physical Education and Sports of Ukraine, Kyiv.

Andrieieva, O., Hakman, A., Balatska, L., Moseychuk, Yu., Vaskan, I., & Kljus, O. (2017). Peculiarities of physical activity regimen of 11-14-year-old children during curricular and extracurricular hours. *Journal of Physical Education and Sport*, 17 (4), 2422–2427.

Apanasenko, H. L., & Popova, L. A. (1998). *Medical valeology*. Kyiv: Zdorovia.

Azhippo, A. Yu., Shesterova, L. Ye., & Maslyak, I. P. (2017). Influence of functional condition of visual sensory system on motive preparedness of school-age children. *Journal of Physical Education and Sport*, 17 (4), 2519–2525.

Bahinska, O. V. (2015). Dynamics and features of strength skills manifestation in schoolchildren from different age groups as a significant factor in the development of their motor function. *Physical Education, Sports and Health Culture in Modern Society: a Collection of Scientific Works of t Lesia Ukrainka Eastern European National University*, 3 (31), 109–112.

Bahinska, O. V. (2016). Modeling biodynamic and coordination structure of movement in the integrated assessment of motor skills development in pupils aged between 6 and 15. *Bulletin of Taras Shevchenko Chernihiv National Pedagogical University. Series: Pedagogy*, 139 (1), 14–18.

Bahinska, O. V. (2017). The ratio between factor loadings of individual indicators of motion coordination structure, which characterize the level of motor function development in schoolchildren from different age groups. *Pedagogics, Psychology, Medical-Biological Problems of Physical Training and Sports*, 3, 100-104.

Bakhmat, N., Maksymchuk, B., Voloshyna, O., Kuzmenko, V., Matviichuk, T., Kovalchuk, A. … Maksymchuk, I. (2019). Designing a cloud-oriented university environment in teacher training of future physical education teachers.*Journal of Physical Education and Sport*, 19 (4), 1323–1332.

Bakhraev, A. I., & Dorokhov, R. N. (1991). Investigation and assessment of children and adolescents' biological age. In S. S. Tikhvin & S. V. Khrushchev (Eds.), *Children's sports medicine: a guide for doctors* (pp. 165–171). Moscow: Meditsina.

Behas, L., Maksymchuk, B., Babii, I., Tsymbal-Slatvinska, S., Golub, N., Golub, V. … Maksymchuk, I. (2019).

The influence of tempo rhythmic organization of speech during gaming and theatrical activities on correction of stammering in children.*Journal of Physical Education and Sport*, 19 (4), 1333–1340.

Blahii, O. L., & Cherniavskyi, M. V. (2005). *Innovative approaches to organizing physical education of schoolchildren*. Proceedings of the IX International Scientific Congress on Olympic Sport and Sport for All. Kyiv: Olimpiiska literatura.

Bolotin, A, & Bakayev, V. (2017). The differences in response of the respiratory system of long and middle-distance runners and their influence on recovery rate. *Journal of Physical Education and Sport*, 17 (4), 2443–2446.

Chyzhyk, V. V. (1999). *Assessing physical performance of schoolchildren and athletes: methodical recommendations*. Lutsk: Vezha.

Ermakov, V. A. (1996). *Theory and technology of differentiated physical education for children and students*. (Abstract of postdoctoral research). Tula State University, Tula.

Faizrakhmanov, I. M, Allanina, L. M,. & Talantuly, N. E. (2017). Study of special endurance of young volleyball players of different age groups and its impact on the effectiveness of the performance of certain game actions. *Journal of Physical Education and Sport*, 17 (4), 2526–2530.

Farber, D. A. (Ed.). (1988). *The physiology of adolescence*. Moscow: Pedagogika.

Filchenkov, D. A. (1994). *Methodology of implementing an individual approach to physical education of senior pupils*. (Abstract of PhD thesis). Yanka Kupala State University of Grodno, Grodno.

Galamandjuk, L., Prozar, M., Stasjuk, I., Bakhmat, N., Iedynak, G., Kljus, O., Guska, M., & Dokuchina, T. (2017). Physiological characteristics and physical fitness of girls at the beginning of classes at the volleyball sports school. *Journal of Physical Education and Sport*, 17 (4), 2467–71.

Hagiwara, G. (2017). Relationship between sport participation behavior and the two types of sport commitment of Japanese student athletes. *Journal of Physical Education and Sport*, 17 (4), 2412–2416.

Hakman, A., Nakonechniy, I., Moseychuk, Yu., Liasota, T., Palichuk, Yu., & Vaskan, I. (2017). Training methodology and didactic bases of technical movements of 9-11-year-old volleyball players. *Journal of Physical Education and Sport*, 17 (4), 2638–2642.

Halaidiuk, M., Maksymchuk, B., Khurtenko, O., Zuma, I., Korytko, Z., Andrieieva, R. … Maksymchuk, I. (2018). Teaching approaches in extracurricular physical activities for 12-14-year-old pupils under environmentally unfavourable conditions. Journal of Physical Education and Sport, 18 (4), 2284–2291.

Hasiuk, I. L. (2003). *Programming the health-improving direction of physical education lessons for girls aged between 11 and 14 with different somatotypes*. (PhD thesis). Lviv State Institute of Physical Culture, Lviv.

Hlazyrin, I. D. (1999). Differentiated physical training of boys in the system of curricular and extracurricular activities. *Physical Education in School*, 2, 28–32.

Hlazyrin, I. D. (2003). *Principles of differentiated physical education*. Cherkasy: Vidlunnia-Plus.

Holienka, M., Babic, M., Doležajová, L., Šelinger, P., & Musilová, E. (2017). Motor performance of young soccer players based on their biological age. *Journal of Physical Education and Sport*, 17 (4), 2508–2512.

Iedynak, G., Galamandjuk, G., Kyselytsia, O., Nakonechnyi, I., Hakman, A., & Chopik, O. (2017b). Special aspects of changes in physical readiness indicators of young men with different somatotypes between 15 and 17 years of age. *Journal of Physical Education and Sport*, 17 (4), 2690–2696.

Iedynak, G., Galamandjuk, L, Kyselytsia, O., Balatska, L., Nakonechnyi, I., & Mazur, V. (2017a). Physiological characteristics of pubertal schoolchildren with chronic diseases. *Journal of Physical Education and Sport*, 17 (4), 2462–2466.

Kolokoltsev, M., Iermakov, S., & Potop, V. (2017). Creativity project method in academic physical education process. *Journal of Physical Education and Sport*, 17 (4), 2659–2664.

Korobeinikov, H. V., Korobeinikova, L. H, Nenasheva, L. V., & Tsaipiuk, L. V. (2002). Physiological features of shaping physical development of primary school pupils. *Bulletin of Cherkasy University. Series: Biology*, 39, 64–69.

Krustevych, T. U. (2000a). *Managing physical capacity of adolescents in the system of physical education*. (Postdoctoral thesis). National University of Physical Education and Sports of Ukraine, Kyiv.

Krustevych, T. U. (2000b). Rational training modes for adolescents with different typological features of higher nervous activity. *Pedagogy, Psychology and Medical and Biological Problems of Physical Education and Sport*, 20, 19–26.

Krustevych, T. U. (2006). *Methodical recommendations for determining physical fitness of schoolchildren by the index method (for physical education teachers)*. Kyiv: Naukovyi svit.

Kuts, O. S. (1997). *Concept of continuing physical education and health-improving work with pupils of secondary school age*. Kyiv: Ukrainska akademiia nauk natsionalnoho prohresu.

Kuts, O. S., & Vynohradskyi, V. A. (2003). *Advanced medical and pedagogical technologies for strengthening and preserving students' health*. Lviv: Ukrainski tekhnolohii.

Lagestad, P., & Sørensen, A. (2018). Longitudinal changes in sports enjoyment among adolescents. *Journal of Physical Education and Sport*, 18 (1), 89–97.

Leonova, V. A., & Kuts, A. S. (1996). *Differentiated approach to choosing methods for improving motor skills of schoolchildren*. Proceedings of the II International Scientific and Practical Conference on Physical Culture, Sport and Health of the Nation. Vinnytsia: Ukrainska akademiia.

Lima, R. F., Silva, Da V. F., & Oliveira, De G. L. (2017). Practicing karate may improves executive functions of 8-11-year-old schoolchildren. *Journal of Physical Education and Sport*, 17 (4), 2513–2518.

Maksimov, A. V. (1994). *Differentiated approach to male pupils aged between 13 and 14 in the process of developing motor skills in physical education lessons, taking into account the stages of puberty*. (PhD thesis). Russian Academy of Education. Institute of Age-Related Physiology, Moscow.

Maksymchuk, B. (2016a). Defining Quality of the Future Coaches-Instructors' Professional Competence in the Process of Training. *Slobozhanskyi Herald of Science and Sport*, 6, 51–55.

Maksymchuk, B. (2016c). Forming Future Specialists' Valeological Competency: Theoretical Analysis of Domestic and Foreign Scholars' Views.*Comparative Professional Pedagogy*, 6 (4), 47–54.

Maksymchuk, B. A. (2014). The Essence, Content and Structure of Professional Pedagogical Competency.*Zbiór raportów naukowych."Współczesna nauka.Nowe perspektywy"*, 3/2, 73–83.

Maksymchuk, B. A. (2015a). Features of Student's Valeological Self-Development during Physical Training.*Relevant Problems of Humanities and Natural Sciences*, 3 (74), Part 2, 112–114.

Maksymchuk, B. A. (2015b). Forming Students' Motivation towards Valeological and Pedagogical Activities.*Young Scientist*, 6, 651–653.

Maksymchuk, B. A. (2016b). Experimental Verification of the Conceptual Model Content, Diagnostic Technologies and Development of Valeological Competency in Future Teachers during Physical Training.*Physical Culture, Sport and Health of the Nation*, 1, 109–116.

Maksymchuk, B. A. (2016d). *Forming Future Teachers' Valeological Competency in the Process of Physical Education.* Vinnytsia: Planer.

Maksymchuk, B. A. (2016e). *Forming Valeological Competency in Future Teachers during Physical Education.*Proceedings of the Scientific and Practical Conference onPsychology of Personality Development: Theory and Practice. Vinnytsia.

Maksymchuk, B. A. (2016f). Input Results of Formation of Valeological Competency in Future Teachers during

Maksymchuk, B. A. (2016g). *Methodological and Technological Principles of Forming Valeological Competency in Future Teachers during Physical Education*. Vinnytsia: Planer.

Maksymchuk, B. A. (2016h). *Pedagogical Design of the Process of Forming Future Teachers' Valeological Competency in the Process of Physical Education.* Vinnytsia: Planer.

Maksymchuk, B. A. (2016i). *Pedagogical Projects onForming Valeological Competency in Future Teachers during Physical Education*. Vinnytsia: Planer.

Maksymchuk, B. A. (2016j). *The Basics ofForming Valeological Competency in Future Teachers during Physical Education*. Vinnytsia: Planer.

Maksymchuk, B. A. (2017a). *Developing Future Physical Training Teachers' Professional Skills in the Process of Professional Training.*(Abstract of doctoral thesis). Khmelnytskyi: Khmelnytskyi National University.

Maksymchuk, B. A. (2017b). Pedagogical Valeology in the System of Sciences.*Zbiór raportów naukowych."Badania naukowe naszych czasów"*, 2, 87–98.

Maksymchuk, B. A. (2017c). *Theoretical and Methodological Foundations for Forming Valeological Competency of Future Teachers during Physical Education*.Doctoral thesis.Mykhailo Kotsiubynskyi Vinnytsia State Pedagogical University, Vinnytsia.

Maksymchuk, B. A. (2017d). *Theoretical and Methodological Framework for Forming Future Teachers' Valeological Competency in the Process of Physical Education.*(Doctoral thesis). Vinnytsia: Mykhailo Kotsiubynskyi Vinnytsia State Pedagogical University.

Maksymchuk, B. A., & Shestopaliuk, O. V. (2009).*Professional Training of Future Teacher: Physical Education, Sport, Health*. Vinnytsia: Planer.

Maksymchuk, I., Maksymchuk, B., Frytsiuk, V., Matviichuk, T., Demchenko, I., Babii, I. … Savchuk, I. (2018). Developing pedagogical mastery of future physical education teachers in higher education institutions. *Journal of Physical Education and Sport*, 18 (2), 810–815.

Melnyk, N., Bidyuk, N., Kalenskyi, A., Maksymchuk. B., Bakhmat, N., Matviienko, O. … Maksymchuk, I. (2019). Models and organizational characteristics of preschool teachers' professional training in some EU countries and Ukraine. *Зборник Института за педагошка истраживања*, 51 (1), 46–93.

Mudryk, V. I., Oliinyk, M. O., Prykhodko, I. I., & Ashanin, V. S. (2002). Analyzing some problems in the implementation of state examinations and standards for assessing physical fitness of the population of Ukraine. *Theory and Methodology of Physical Education and Sport*, 2-3, 16–18.

Mytchyk, O. P. (2002). *Individualizing physical education of adolescents in general education school*. (Abstract of PhD thesis). Lviv State Institute of Physical Culture, Lviv.

Nazarenko, L. D, & Kolesnik, I. S. (2017). Conditions for improving basic sports training of 13-14-year-old boxers. *Journal of Physical Education and Sport*, 17 (4), 2484–2494.

Nikityuk, B. A., Musagalieva, G. M., & Savchenko, K. A. (1990). *Accelerated development of children and its effects*. Alma-Ata: Kazakhstan.

Physical Education.*Slobozhansky Scientific and Sport Bulletin*, 6 (56), 58–63.

Pryimak, S. H. (2003). *Modeling parameters of adolescents' physical fitness in the process of physical education*. (Abstract of PhD thesis). Lviv State Institute of Physical Culture, Lviv.

Romanenko, V. A. (1999). *Person's motor skills*. Donetsk: UKTsentr.

Romanenko, V. A. (2005). *Assessing motor skills*. Donetsk: DonNu.

Serhienko, L. P. (1993). *Genetic factors in the development and physical education of the individual*. (Abstact of postdoctoral thesis). Kyiv State Institute of Physical Culture, Kyiv.

Serhienko, L. P. (2001). *Assessing motor skills of schoolchildren*. Kyiv: Olimpiiska literatura.

Shakhanova, A. V. (1997). *The influence of the extended motor activity on development and physical fitness of children and adolescents*. (Abstract of postdoctoral thesis). Adyghe State University, Maykop.

Sidorova, O. A. (1998). *Characteristics of morphofunctional development in child's body in the pre- and pubertal period of ontogenesis with different levels of motor activity*. (Abstract of PHD thesis]. Tyumen State Agricultural Academy, Tyumen.

Sitovskyi, A. M. (2001). Physiological criteria for differentiating the education process in physical education of schoolchildren aged between 10 and 17. *Scientific Journal of Volyn State University: Health, Physical Culture and Sports*, 136–141.

Sitovskyi, A. M. (2002a). Physiological criteria for differentiated physical training of schoolchildren. *Young Sports Science of Ukraine: a Collection of Scientific Works in the Field of Physical Culture and Sports*, 6 (2), 378–380.

Sitovskyi, A. M. (2002b). The functional state of the cardiovascular system as a criterion for differentiation of physical activity for schoolchildren. *Physical Education, Sports and Health Culture in Modern Society*, 2, 34–6.

Sitovskyi, A. M. (2004). Physiological criteria of differentiated approach to developing motor skills in girls aged between 12 and 13. *Pedagogy, Psychology and Medical and Biological Problems of Physical Education and Sports*, 15, 118–123.

Sitovskyi, A. M. (2005a). Annual dynamics of physical performance in girls aged between 12 and 13 in the conditions of three physical education lessons depending on paces of their biological development. *Physical Education, Sports and Health Culture in Modern Society*, 108-112.

Sitovskyi, A. M. (2005b). Characteristics of developing some interest in physical education lessons in schoolchildren aged between 12 and 13. *Dnieper Sports Journal*, 2, 124–127.

Sitovskyi, A. M. (2005c). Characteristics of the annual dynamics of physical performance in boys aged between 12 and 13 depending on paces of their biological development. *Young Sports Science of Ukraine: a Collection of Scientific Works in the Field of Physical Culture and Sports*, 9 (4), 58–62.

Sitovskyi, A. M. (2005d). Planning of physical activity volumes of selective orientation for girls aged 12-13 depending on the pace of their biological development. *Slobozhanshyna Scientific and Sports Journal*, 8, 197–199.

Sitovskyi, A. M. (2006). Differentiated physical education of children aged between 12 and 13 taking into account paces of their biological development. *Young Sports Science of Ukraine: a Collection of Scientific Works in the Field of Physical Culture and Sports*, 10 (1), 113–117.

Sitovskyi, A. M. (2009). Physical capacity of adolescents under conditions of differentiated physical education taking into account paces of their biological development. *Physical Education, Sports and Health Culture in Modern Society*, 1 (5), 61–65.

Sitovskyi, A. M. (2010). The capacity of respiratory system of adolescents with different paces of biological development.*Young Sports Science of Ukraine: a Collection of Scientific Works in the field of Physical Culture and Sports*, 14 (2), 224–231.

Sitovskyi, A. M., & Chyzhyk, V. V. (2004). Physiological criteria of differentiated approach to developing motor skills of girls aged between 12 and 13. *Young Sports Science of Ukraine: a Collection of Scientific Works in the Field of Physical Culture and Sports*, 8 (2), 332–336.

Sitovskyi, A. M., & Chyzhyk, V. V. (2008). Planning differentiated physical training for adolescents taking into account paces of their biological development. *Scientific Journal for the Youth: a Collection of Scientific Works of Lesia Ukrainka Volyn National University: Physical Education and Sports*, 18–23.

Sitovskyi, A. M., & Chyzhyk, V. V. (2009a). Developing motor skills under the conditions of differentiated physical education for adolescents taking into account paces of their biological development. *Slobozhanshyna Scientific and Sports Journal*, 2, 16–21.

Sitovskyi, A. M., & Chyzhyk, V. V. (2009b). The dynamics of physical fitness of adolescents with different paces of biological development during the school year. *Pedagogy, Psychology and Medical and Biological Problems of Physical Education and Sports*, 6, 135–140.

Sitovskyi, A. M., & Chyzhyk, V. V. (2010). The way of determining the biological age of boys based on the development of secondary sexual characteristics. *Physiological Journal*, 56 (2), 268–269.

Sukharev, A. G. (1991). *Health and physical education of children and adolescents*.Moscow: Meditsina

Tsos, A. V. (1994). Differentiated approach to professional training of physical education teachers. (Abstract of PhD thesis). M. P. Drahomanov Ukrainian State Pedagogical University, Kyiv.

Volkov, L. V. (1988). *Physical education of pupils*. Kyiv: Sovetskaya shkola.

Volkov, L. V. (2002). *Theory and methodology of children's and youth sports*. Kyiv: Olimpiiska literatura.

Yarmak, O, Kyselytsia, O, Moseychuk, Yu, Dotsyuk, L, Palichuk, Yu, & Galan, Ya. (2018). Comparative analysis of parameters of the physical condition of 17-19-years-old male youths with different motion activity level. *Journal of Physical Education and Sport*, 18 (1), 276–281.