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Increase in morphofunctional indicators for girls aged 7–17 living in the northern and southern regions of Kazakhstan

The article is devoted to the study of growth of morphofunctional indices of modern schoolgirls of 7–17 years old in Pavlodar and Kyzylorda. The results of the study of such anthropometric parameters as body length, body weight (BL, BW) and chest circumference (CC), wrist strength (WS), amount of reserve fat and active body weight of schoolgirls and their increase in the age range from 7 to 17 years are presented. In the article the growth of blood circulation system indicators such as heart rate (HR), systolic blood volume (SBV), minute blood volume (MBV) in girls of 7–17 years old in Pavlodar and Kyzylorda after a standard load of 12 kg/min relative to the resting state (in %). It was found out that in ontogenesis from 7 to 17 years of age anthropometric and functional indicators of physical development of all examined schoolgirls significantly increased. It was noted that there are significant differences in many ages between peers living in Pavlodar and Kyzylorda. Thus, the values of BW, CC, wrist strength, active body weight are lower in schoolgirls from Kyzylorda than from Pavlodar, while BL is higher in girls from Kyzylorda aged 14–17 years. The data obtained testify to the regional peculiarities of schoolgirls' development and determine the need to continue monitoring studies and observations of changes in the condition of schoolgirls in these regions.

Keywords: morphofunctional indicators, modern schoolchildren, absolute indicators, relative indicators, physical development, research monitoring, body length, body weight, chest circumference, heart rate.

Introduction

Clarification of child development regularities, specificity of physiological systems functioning at different stages of ontogenesis and mechanisms, which determine this specificity, is a necessary condition for ensuring normal physical development of the younger generation [1].

Systematic observations of growth and development are an important link in the system of control over the state of health of the younger generation. One of the most relevant directions for the study is the establishment of shifts in the indicators of physical development of children and adolescents over time, characterizing morphological changes in the development of the population from generation to generation [2, 3]. Thus, knowledge of the individual capabilities of a child and prediction of his or her ontogenesis is a prerequisite for the successful education and upbringing of children without compromising health [4, 5].

The aim of the following research is to study the growth of morphofunctional indices of modern schoolgirls of 7–17 years old in Pavlodar and Kyzylorda.

Materials and research techniques

In order to achieve this goal, 441 female schoolgirls aged 7–17 studying at general education school No. 22 in Pavlodar ($n = 221$) and at lyceum No. 7 in Kyzylorda ($n = 220$) were examined.

Generally accepted methods were used to determine the main anthropometric parameters of physical development: body length (BL), body weight (BW), chest circumference (CC) [6], arm flexor muscle strength using a hand dynamometer «DH-50». Based on the data of body length, body weight, and chest circumference, Kettle (KI) indices ($KI = BW, \text{ kg/BL, m}^2$) and stenum (S) $S = BL, \text{ cm}/(2 \times BW, \text{ kg} + CC, \text{ cm})$ were calculated [7].

The reserve fat content was determined by indirect method of caliperometry [8]. Then, the developed tables were used to determine the percentage of reserve fat in the organism of the subjects for different age groups [9]. This, in turn, made it possible to calculate the body fat and active weight (FBW and ABW) [10].

The state of the cardiovascular system was evaluated by heart rate (HR) under relative rest and standard exercise. Heart rate was determined with the help of electrocardiograph «Aksion EC 1T-07». Blood pressure (BP) was measured using Korotkov's auscultative method, taking into account the width of the cuff for children. Blood volume systolic (Blood volume) was determined by the formula «Stagg Y» [11] in the modification of N.S. Pugina and Ya.F. Bomash (1963) [12], the Minute volume of blood circulation was determined by the formula ($MVB = SBV \times CC$).

All obtained material was processed using statistical analysis methods. Reliability of the differences was estimated by the Student's t-criterion, the differences were considered reliable at $p < 0.05$ [13].

Research results and their discussion

The analysis of morphological data of girls of 7–17 years old in Pavlodar and Kyzylorda (Tables 1 and 2) has allowed to establish that in ontogenesis all studied indicators of physical development of children and teenagers — length and weight of a body, a circle of a chest, active weight of a body naturally increased. In some cases, the differences between age groups are reliable ($p < 0.05$). The increase in body length in schoolgirls of Pavlodar for the period from 7 to 17 years was 33.9 % (from 122.4 ± 0.8 to 164.0 ± 0.7), body weight — 162.6 % (25.5 ± 0.6 to 59.1 ± 1.1), chest circumference — 44.5 % (from 58.2 ± 0.7 to 84.1 ± 1.2). Increase in body length in schoolchildren of the town of Grozny of Kyzylorda for this period is 33.4 % (from 127.4 ± 0.6 to 169.9 ± 0.5), body weight — 184.1 % (20.7 ± 0.5 to 58.8 ± 0.6), chest circumference — 43.6 % (from 55.7 ± 0.7 to 80.0 ± 0.5). The highest increase in body length in girls was observed in Pavlodar at the age of 11 years, and in girls from Kyzylorda at the age of 10 years, the average body length increased by 6.8 % and 7.5 %, respectively. The largest increase in body weight was observed in all surveyed schoolgirls at 8 and 13 years of age. Thus, the weight increased by 19.5 and 17.9 % for Pavlodar girls, and by 18.4 and 18.1 % for girls in Kyzylorda, and there are significant differences between the surveyed schoolgirls living in the northern and southern regions of Kazakhstan ($p < 0.05$).

Table 1

Indicators of physical development of schoolgirls aged 7–12 living in Pavlodar and Kyzylorda

Indexes	City	Age, years					
		7	8	9	10	11	12
N (quantity)	P	$n = 20$	$n = 20$	$n = 20$	$n = 21$	$n = 20$	$n = 20$
	K	$n = 20$	$n = 20$	$n = 20$	$n = 20$	$n = 20$	$n = 20$
BL, sm	P	122.4 ± 0.8	$128.5 \pm 1.1^*$	$132.9 \pm 1.1^*$	$139.0 \pm 1.3^*$	$148.5 \pm 1.2^*$	150.8 ± 1.1
	K	$127.4 \pm 0.6^{\#}$	$131.2 \pm 1.0^*$	134.1 ± 1.2	$144.2 \pm 0.8^{\#*}$	$150.3 \pm 0.9^*$	151.0 ± 0.9
BW, kg	P	22.5 ± 0.6	$26.9 \pm 0.7^*$	$29.2 \pm 0.5^*$	$34.2 \pm 0.9^*$	$39.3 \pm 0.7^*$	$43.3 \pm 0.8^*$
	K	$20.7 \pm 0.5^{\#}$	$24.5 \pm 0.9^{\#*}$	$26.5 \pm 0.7^{\#}$	$33.4 \pm 0.6^*$	$37.0 \pm 0.6^{\#*}$	$40.4 \pm 0.8^{\#}$
CC, sm	P	58.2 ± 0.7	59.0 ± 0.5	60.2 ± 0.9	$64.8 \pm 1.0^*$	$69.2 \pm 1.2^*$	70.3 ± 0.8
	K	$55.7 \pm 0.9^{\#}$	$57.4 \pm 0.5^{\#}$	59.2 ± 0.8	$63.2 \pm 0.6^*$	$63.4 \pm 0.6^{\#}$	$67.0 \pm 0.8^{\#}$
Kettle index, s.u.	P	15.0 ± 0.4	$16.3 \pm 0.4^*$	16.6 ± 0.3	$17.7 \pm 0.3^*$	17.8 ± 0.3	$19.0 \pm 0.3^*$
	K	$12.8 \pm 0.3^{\#}$	$14.2 \pm 0.4^{\#*}$	$14.7 \pm 0.3^{\#}$	$16.1 \pm 0.3^{\#*}$	$16.4 \pm 0.3^{\#}$	$17.7 \pm 0.4^{\#}$
Sthenie index, s.u	P	1.19 ± 0.02	1.14 ± 0.01	1.12 ± 0.01	$1.05 \pm 0.01^*$	$1.01 \pm 0.01^*$	$0.96 \pm 0.01^*$
	K	$1.32 \pm 0.02^{\#}$	$1.24 \pm 0.02^{\#*}$	$1.20 \pm 0.01^{\#}$	$1.11 \pm 0.02^{\#*}$	$1.10 \pm 0.01^{\#}$	$1.03 \pm 0.02^{\#*}$
Reserve fat, %	P	22.3 ± 0.6	21.8 ± 0.5	22.6 ± 0.7	$24.7 \pm 0.6^*$	23.6 ± 0.6	23.7 ± 0.6
	K	21.4 ± 0.9	22.8 ± 0.8	$20.3 \pm 0.8^*$	$22.8 \pm 0.6^{\#*}$	23.0 ± 0.5	24.3 ± 0.5
Reserve fat, kg	p	5.0 ± 0.2	$5.9 \pm 0.2^*$	$6.7 \pm 0.3^*$	$8.5 \pm 0.4^*$	9.3 ± 0.4	10.3 ± 0.4
	к	4.5 ± 0.3	$5.7 \pm 0.4^*$	$5.4 \pm 0.3^{\#}$	$7.6 \pm 0.3^*$	$8.5 \pm 0.2^*$	$9.9 \pm 0.4^*$
ABW, kg	P	17.5 ± 0.5	$21.0 \pm 0.6^*$	$22.5 \pm 0.3^*$	$25.7 \pm 0.6^*$	$30.0 \pm 0.5^*$	$33.0 \pm 0.6^*$
	K	$16.2 \pm 0.3^{\#}$	$18.8 \pm 0.6^{\#*}$	$21.1 \pm 0.6^{\#*}$	$25.8 \pm 0.6^*$	$28.5 \pm 0.5^{\#*}$	$30.5 \pm 0.5^{\#}$
Wrist strength, kg	P	12.5 ± 0.8	$17.4 \pm 0.7^*$	$19.7 \pm 0.7^*$	$24.0 \pm 0.8^*$	$28.6 \pm 0.6^*$	$32.0 \pm 0.5^*$
	K	$10.5 \pm 0.4^{\#}$	$14.9 \pm 0.5^{\#*}$	$16.2 \pm 0.4^{\#}$	$22.9 \pm 0.5^*$	$25.3 \pm 0.5^{\#*}$	$28.7 \pm 0.7^{\#}$
KI, kg/kg	P	0.55 ± 0.03	$0.65 \pm 0.03^*$	0.68 ± 0.02	0.71 ± 0.03	0.70 ± 0.02	0.74 ± 0.02
	K	0.51 ± 0.02	$0.61 \pm 0.02^*$	$0.62 \pm 0.02^{\#}$	0.67 ± 0.02	0.66 ± 0.02	0.71 ± 0.01

Note. Reliability of differences in mean values for non-parametric independent samples: * — in relation to the previous age group ($p < 0.05$); # — when comparing schoolgirls living in the northern and southern regions of Kazakhstan ($p < 0.05$); P — Pavlodar, K — Kyzylorda.

The increase in CC was observed at 10 and 14 years for schoolgirls of Pavlodar city (by 7.6 and 7.4 % respectively) and 10 and 13 years for Kyzylorda city (6.7 and 8.2 % respectively compared to the previous age), this indicator is significantly lower for women of Kyzylorda city.

Children living in Pavlodar have a significantly higher Kettle index, while the structure index is much lower in comparison with schoolgirls living in Kyzylorda. At the same time, (Tables 1 and 2), the value of the

Ketle index in ontogenesis increased, and the values of the stension index decreased, which indicates an increase in the density of the body and a decrease in the severity of dolichomorphism in all children surveyed.

There was no particular pattern of fat percentage in girls in both cities. At the same time, the absolute content of reserve fat in the age period from 7 to 17 years for schoolgirls living in Pavlodar and Kyzylorda increased by 9.4 and 7.4 kg, respectively, compared to the original data.

According to the data obtained (Tables 1 and 2), the values of absolute and relative values of the wrist dynamometer significantly increased with age in all surveyed schoolgirls in both cities. Thus, the absolute values of wrist strength for the period from 7 to 17 years increased by 38.3 and 37.4 kg, respectively, with significant differences between schoolgirls of Pavlodar and Kyzylorda ($p < 0.05$).

Table 2

Indicators of physical development of schoolgirls aged 13–17 living in Pavlodar and Kyzylorda

Indexes	City	Age, years				
		13	14	15	16	17
N (quantity)	P	$n = 20$	$n = 20$	$n = 20$	$n = 20$	$n = 20$
	K	$n = 20$	$n = 20$	$n = 20$	$n = 20$	$n = 20$
BL, sm	P	$157.7 \pm 1.1^*$	$161.0 \pm 1.0^*$	162.1 ± 1.2	163.2 ± 0.8	164.0 ± 0.7
	K	$160.5 \pm 1.1^*$	$164.0 \pm 0.8^{*#}$	$166.7 \pm 0.8^{*#}$	$169.6 \pm 0.6^{*#}$	$169.9 \pm 0.5^{\#}$
BW, kg	P	$50.7 \pm 0.8^*$	$54.1 \pm 0.9^*$	$56.4 \pm 0.7^*$	57.7 ± 1.0	59.1 ± 1.1
	K	$47.7 \pm 0.8^{*#}$	$51.7 \pm 0.6^{*#}$	$54.5 \pm 0.4^{*#}$	$57.5 \pm 0.6^*$	58.8 ± 0.6
CC, sm	P	$74.5 \pm 0.7^*$	$80.0 \pm 0.8^*$	81.1 ± 0.9	82.7 ± 1.1	84.1 ± 1.2
	K	$72.5 \pm 0.7^{*#}$	$76.9 \pm 0.6^{*#}$	$78.0 \pm 0.8^{\#}$	$78.3 \pm 0.7^{\#}$	$80.0 \pm 0.5^{*#}$
Ketle index, s.u.	P	$20.4 \pm 0.2^*$	20.9 ± 0.3	21.5 ± 0.2	21.7 ± 0.4	22.0 ± 0.3
	K	$18.5 \pm 0.3^{\#}$	$19.2 \pm 0.3^{\#}$	$19.6 \pm 0.2^{\#}$	$20.0 \pm 0.3^{\#}$	$20.4 \pm 0.2^{\#}$
Sthenia index, s.u.	P	$0.90 \pm 0.01^*$	$0.86 \pm 0.01^*$	0.84 ± 0.01	0.83 ± 0.01	0.81 ± 0.01
	K	$0.96 \pm 0.01^{*#}$	$0.91 \pm 0.01^{*#}$	$0.89 \pm 0.01^{\#}$	$0.88 \pm 0.01^{\#}$	$0.86 \pm 0.01^{\#}$
Reserve fat, %	P	21.7 ± 1.0	24.1 ± 1.0	22.9 ± 0.9	24.7 ± 0.8	24.2 ± 0.8
	K	$19.1 \pm 0.7^{*#}$	$20.6 \pm 0.8^{\#}$	$18.4 \pm 1.0^{\#}$	$19.3 \pm 0.8^{\#}$	$20.1 \pm 0.8^{\#}$
Reserve fat, kg	P	11.1 ± 0.6	$13.1 \pm 0.7^*$	13.0 ± 0.6	14.3 ± 0.7	14.4 ± 0.7
	K	$9.2 \pm 0.4^{\#}$	$10.7 \pm 0.5^{*#}$	$10.1 \pm 0.6^{\#}$	$11.2 \pm 0.5^{\#}$	$11.9 \pm 0.5^{\#}$
ABW, kg	P	$39.6 \pm 0.5^*$	40.9 ± 0.5	$43.4 \pm 0.5^*$	43.4 ± 0.5	44.7 ± 0.6
	K	$38.5 \pm 0.6^*$	$41.0 \pm 0.5^*$	$44.4 \pm 0.5^*$	$46.3 \pm 0.4^{*#}$	$46.9 \pm 0.5^{\#}$
Wrist strength, kg	P	$39.3 \pm 0.78^*$	$43.7 \pm 1.4^*$	45.2 ± 0.7	$49.0 \pm 1.2^*$	50.8 ± 0.8
	K	$34.1 \pm 0.4^{*#}$	$37.5 \pm 0.8^{*#}$	$40.9 \pm 0.8^{*#}$	$46.4 \pm 1.2^*$	$47.9 \pm 0.5^{\#}$
KI, kg/kg	P	0.78 ± 0.02	0.81 ± 0.02	0.82 ± 0.03	0.85 ± 0.02	0.86 ± 0.02
	K	$0.72 \pm 0.02^{\#}$	$0.73 \pm 0.02^{\#}$	$0.75 \pm 0.01^{\#}$	$0.81 \pm 0.02^*$	0.82 ± 0.01

Note. Reliability of differences in mean values for non-parametric independent samples: * — in relation to the previous age group ($p < 0.05$); # — when comparing schoolgirls living in the northern and southern regions of Kazakhstan ($p < 0.05$); P — Pavlodar, K — Kyzylorda.

The degree of cardiovascular system response to physical activity in different age periods is of great importance in the assessment of functional reserves and adaptability of the body to adequate blood supply to the body [14].

The values of SBV and MBV are integral indicators characterizing the adaptive reaction of blood circulation to physical activity [15]. Compared to rest after physical activity, Pavlodar girls aged 7–17 years increased by an average of 33.8 to 25.4 %, MBV by 135.9 to 150.0 %, and heart rate by 77.7 to 100.7 % (Fig. 1).

SBV for girls aged 7–17 from Kyzylorda grew by an average of 30.8 to 25.6 %, MBV by 116.7 to 144.4 %, and HR by 65 to 97.7 % (Fig. 2).

At the same time, a significant increase in heart rate and MVB indicators reached the maximum values in the puberty period for schoolgirls of both cities compared to younger age. All female schoolgirls surveyed had a slight decline in SBV with age.

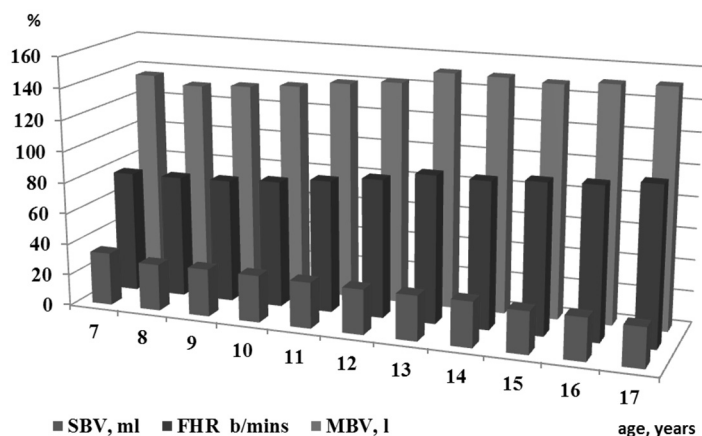


Figure 1. Changes in the blood circulation system of girls aged 7–17 in Pavlodar after a standard strain of 12 kg/min (increase in relation to the resting state, in %)

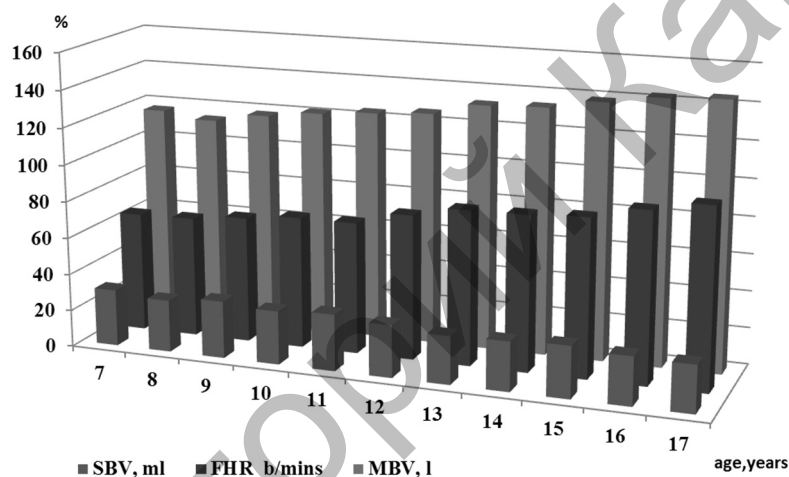


Figure 2: Changes in the blood circulation system in girls aged 7–17 in Kyzylorda after a standard load of 12 kg/min (increase in relation to the resting state, in %)

Thus, the increase in heart rate and MBV growth in the surveyed schoolgirls of both cities during puberty indicates a decrease in the economic activity of the circulatory system during this period of ontogenesis.

Conclusion

Thus, in ontogenesis from 7 to 17 years of age, anthropometric and functional indicators of physical development of all examined schoolgirls significantly increased. It has been established that morphofunctional development of the examined girls is subject to general biological laws and is characterized by heterochronicity and discontinuity. There are significant differences between peers living in Pavlodar and Kyzylorda in many ages in terms of physical development (length, body weight, chest circumference, hand strength), especially in terms of relative indicators (Kettle index, stenion index). The data obtained testify to the regional peculiarities of schoolgirls' development and determine the need to continue monitoring studies and observations of changes in the condition of schoolgirls in these regions.

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Қазақстанның солтүстік және оңтүстік облыстарында тұратын 7–17 жастағы қыздардың морфофункционалды көрсеткіштерінің өсуі

Мақала Павлодар және Қызылорда қалаларының 7–17 жас аралығындағы қазіргі заманғы оқушылардың морфофункционалды көрсеткіштерінің өсуін зерттеуге арналған. Дене ұзындығы, дене салмағы (ДҰ, ДС) және кеуде қуысының шеңбері (КҚШ), қолдың күші (ҚК), қыз оқушылардың резервтік май мөлшері және белсенді дене салмағы және олардың 7-ден 17 жасқа дейінгі жас аралығындағы өсімі сияқты антропометриялық көрсеткіштері зерттеу нәтижелерінде келтірілген. Мақалада қан айналымы жүйесі көрсеткіштерінің өсуі: жүрек жиырылу жиілігі (ЖЖЖ), қанның систолалық көлемі (ҚСК), қыздарда қалыпты жағдайына қатысты қуаты 12 кг/мин стандартты жүктемені орындағаннан кейін қанның минуттық көлемі (ҚМК) (%-бен) көрсетілген. Онтогенезде 7 жастан 17 жасқа дейін барлық тексерілген оқушылардың физикалық дамуының антропометриялық және функционалдык көрсеткіштері айтарлықтай ұлғайған. Павлодар және Қызылорда қалаларында тұратын құрдастарының арасында көптеген жастарда айтарлықтай айырмашылықтар бар екені атап өтілді. Мәселен, Қызылорда қаласы оқушыларының ДС, КҚШ, қол күші, белсенді дене салмағы көрсеткіштерінің мәні, Павлодар қ. құрдастарына қарағанда, төмен, ал ДҰ Қызылорда қ. тұратын қыздарда 14–17 жас аралығында айтарлықтай жоғары. Алынған мәліметтер мектеп оқушыларының дамуының аймақтық ерекшеліктері туралы куәландырады және мониторингтік зерттеулер мен осы өңірлердің мектеп оқушылары ағзасының жай-күйінің өзгерістеріне бақылау жасауды жалғастыру қажеттілігін анықтайды.

Кілт сөздер: морфофункционалды көрсеткіштер, қазіргі мектеп оқушылары, абсолюттік көрсеткіштер, салыстырмалы көрсеткіштер, физикалық даму, зерттеу мониторингі, дене ұзындығы, дене салмағы, кеуде қуысының шеңбері, жүрек жиырылу жиілігі.

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Прирост морфофункциональных показателей девочек 7–17 лет, проживающих в северных и южных областях Казахстана

Статья посвящена изучению прироста морфофункциональных показателей современных школьниц 7–17 лет городов Павлодара и Кызылорды. Приведены результаты исследования таких антропометрических показателей, как длина, масса тела (ДТ, МТ), окружность грудной клетки (ОГК), силы кисти (КС), количество резервного жира и активная масса тела школьниц и их прирост в возрастном диапазоне от 7 до 17 лет. В статье показан прирост показателей системы кровообращения, таких как частота сердечных сокращений (ЧСС), систолический объем крови (СОК), минутный объем крови (МОК) у девочек

после выполнения стандартной нагрузки мощностью 12 кгм/мин кг по отношению к состоянию покоя (в %). Установлено, что в онтогенезе от 7 до 17 лет существенно увеличивались антропометрические и функциональные показатели физического развития всех обследованных школьников. Отмечено, что между сверстниками, проживающими в г. Павлодаре и Кызылорде, имеются существенные различия. Так, значения показателей МТ, ОГК, кистевой силы, активной массы тела у школьников г. Кызылорды ниже, чем у их сверстников из г. Павлодара, тогда как ДТ выше, чем у девочек, проживающих в г. Кызылорде. Полученные данные свидетельствуют о региональных особенностях развития школьников и определяют необходимость продолжения мониторинговых исследований и наблюдений за изменениями состояния организма школьников данных регионов.

Ключевые слова: морфофункциональные показатели, современные школьники, абсолютные показатели, относительные показатели, физическое развитие, мониторинг исследования, длина тела, масса тела, окружность грудной клетки, частота сердечных сокращений.

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