

Features of Physical Development of Schoolchildren in the Conditions of Specialized Training

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Abstract: The article presents a comparative analysis of physical development of 13-year-olds and cadet basic profile of teaching in urban schools in the parameters of somatometry and visiometry characterizing physical development, functional state, adaptation of the heart and body to current training loads. Coming of puberty is marked by intense growth of the body with heterochronous changes in the proportions and dimensions of its muscular skeletal system and the structure of internal organs. During this period, the role of mechanisms for self-regulation of heart activity and, in general, autonomous regulation of the functions of the cardiovascular system increases. At the initial stage in adolescents the manifestation of tachycardia and cardiac type of self-regulation of blood circulation increases. It is accompanied with deterioration in inotropic function of the myocardium against the background of a pronounced effect of sympatonia and vagotonia on the systolic function of the myocardium.

Keywords: Learning profile, adolescence, physical development, hemodynamic parameters.

INTRODUCTION

An urgent problem of our time is the preservation of the health of adolescent schoolchildren. There is a negative tendency to increase the percentage of children with chronic diseases and even disabilities (Apanasenko, 2004; Sukhareva, 2014). At the present stage of school education, issues of preserving and strengthening the health of adolescents have scientific and practical significance (Alifanova, 2007; WMA Declaration of Helsinki, 2013). Intensive and heterochronous processes of physical and sexual development weaken the functional capabilities of the growing organism (Kosovanova, Melnikova & Aizman, 2003; Kuchma, Sukhareva, 2005).

The modern educational system, along with the traditional school, creates various educational environments – lyceums, gymnasiums, colleges, seminaries, and other educational institutions that provide specialized training (Babenko, Kaminsky, 2001; Solodkov, 2013). Each profile is aimed at a more thorough study of disciplines. At the same time, the volume of mental and informational load on students increases significantly (Alifanova, 2007; Baranov, Shcheplyagina, 2009). This process, first of all, negatively affects the systolic activity of the myocardium and the circulatory system (Babenko, Kaminsky, 2001; Zarytovskaya, Kalmykova, 2012). A growing organism, in contrast to an adult, is more sensitive to any negative effects of environmental factors. In this regard, a study of the functional state

and adaptation of adolescents to the educational environment was conducted. The heterogeneity of growth and development processes in this age period causes tension of functional systems and mechanisms regulating their intensity (Apanasenko, 2004; Bezrukikh, Sonkina, 2002). Against this background, relatively weak stimuli that do not change the activity of the adult organism can change the functional state of the growing organ, and with prolonged exposure disrupt its functions, changing the intensity of growth and development processes (Alifanova, 2007; Anisimova, Savina, Makoveeva, 2013). In this regard, the features of the rate of physical development according to morphofunctional indicators in students of the sixth and seventh grades were studied.

THE PURPOSE OF WORK

Study the features of physical development and functional state of the cardiovascular system in adolescents of different specialized classes.

METHODS

100 13-year-old students from different specialized classes of secondary school No. 3 in Stroitel took part in the experiment voluntarily. Some of them were trained according to the standard program of secondary education (general profile), while others were representatives of cadet classes, in which the study of subjects such as mathematics, physics, foreign languages together with the study of military training and compliance of an organized daily routine had an advantage. On the base of the study of outpatient development maps of a school student,

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taking into account the gender (girls and boys) and the training profile (basic and cadet), four groups were formed, each of 25 students.

The research was conducted in the first half of the day in the school's medical office in the 2018-2019 academic year. All children were informed about the purpose of the study and gave written consent to participate in it before it started with the consent of their parents (WMA Declaration of Helsinki, 2013).

During the survey of adolescents, unified somatometric methods were used to assess the physical development of schoolchildren in terms of body length (BL, cm), body weight (BW, kg), chest circumference (CC, cm) (Apanasenko, 2004; Kosovanova *et al.* 2003). Psychometric indicators were determined in the state of relative rest in the "sitting" position of the body. Direct indicators— heart rate (HR, min⁻¹), blood pressure (BP, mmHg) and its components—systolic (BPs), diastolic (BPd) and pulse pressure (PP) were recorded (Sukhareva, 2014; Kosovanova *et al.* 2003; Kuchma, Sukhareva, 2005). Based on the initial individual indicators of central and peripheral hemodynamics, informative indices that characterize the rates of physical growth and development of the examined adolescents were calculated: BWI (kg / m²) (Sukhareva, 2014; Babenko, Kaminsky, 2001); indices of functional activity and adaptation of the heart and blood vessels, and the features of autonomous regulation of the cardiovascular system functions: systolic volume (SV, ml), minute blood volume (MBV l / min), heart rate (W, kg / m), double production (Robinson index, conv.un.), coefficient of circulatory efficiency (CEC, conv.un), coefficient of endurance (EC conv.un), the type of self-regulation of blood circulation (TSR, conv.un.) (Kosovanova, Melnikova, Aizman, 2003). Statistical processing of the obtained data was carried out using a package of computer programs Microsoft Excel 2010 and Statistica 10.0. Microsoft Excel 2002 and StatSoft Statistica-6.0. Individual and group indicators of the functional state of the heart and blood vessels using

centile scales developed taking into account age and gender was evaluated. The average values of indicators (M) and their standard errors (=m) were calculated.

RESULTS AND DISCUSSION

Analysis of somatometric indicators of physical development has shown that boys and girls of both training profiles are characterized by an average level of physical development (Table 1). The average parameters of body length in girls of the general training profile group were more significant compared to their peers of the cadet profile.

The analysis of the intensity of physical development processes showed its proportionality in 44% of boys and 56% of girls of cadet profile, in 40% of boys and 32% of girls of general profile. Inharmonious physical development was established in other adolescents. In the group of general profile boys, 8% of teenagers were not included in growth processes, and 52% of them had slower body growth and corresponded to a lower than average level of physical development. Disharmony of physical development was established in 8% of girls in each training profile. These data are consistent with the general laws of the heterochronous growth process of vertical and longitudinal body sizes in schoolchildren with the beginning of their individual entry into puberty.

The normal heart rate at the age of 12-14 years is 80 min⁻¹. The analysis of the average values of the main central indicator of hemodynamics—heart rate—showed that they corresponded to the age norm in boys and girls of general profile groups, amounting to 77.5±2.70 min⁻¹ (with fluctuations from 59 to 91 min⁻¹) and 80.2±2.51 min⁻¹ (with fluctuations from 68 to 100 min⁻¹). In cadet groups, the average heart rate was slightly higher than normal for boys and girls, amounting to 81.1±3.34 min⁻¹ (with fluctuations from 67 to 102 min⁻¹) and 81.5±3.23 min⁻¹ (with fluctuations from 62 to 120 min⁻¹), respectively.

Table 1: Somatometric Characteristics Of Physical Development Of School Children (M±M)

Indicators, measure unit	General profile		Cadet profile	
	Girls	Boys	Girls	Boys
Body Length, cm	159.3±1.33	157.9±1.65	156.8±1.36	159.1±1.65
Body Weight, kg	52.4±2.28	49.6±1.86	51.0±2.06	50.3±1.86
Chest Circumference, cm	75.5±1.24	79.0±2.12	75.1±1.15	79.0±2.21
Body Weight Index, kg/m ²	20.0 ±1.82	18.4±2.62	20.8±1.80	19.9±2.10

The distribution of adolescents according to individual heart rate values is presented in Figure 1. Analysis of individual heart rate parameters showed the presence of a high percentage of adolescents with tachycardia and bradycardia in each training profile.

The manifestation of a marked deviation of the heart rate from the physiological norm in adolescents in physiological conditions is an unfavorable diagnostic indicator that requires clinical observation.

Table 2 shows the indicators of BP components. In all groups of schoolchildren, the average parameters of BPs and BPd corresponded to age norms (Apanasenko, 2004; Sukhareva, 2014).

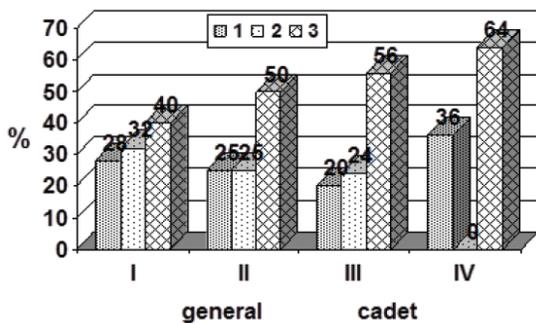


Figure 1: Distribution of schoolchildren by individual heart rate parameters: 1-bradycardia, 2-norm, 3-tachycardia. Profile: basic – I (girls) and II (boys); cadet-III (girls), IV (boys).

The analysis of the individual parameters of the BPs showed that its value corresponded to the age norm only 60% of boys and 68% girls of general profile, 68% of boys and 44% girls group of cadets (Table 2). BPs exceeded the upper limit of age norm, 44% of girls and 40% boys of general profile, 32% of boys and 52% girls of cadet group. In the age norm, the BPs was reduced only in 8% of girls in the cadet group.

Individual blood pressure values in the majority of adolescents corresponded to the age norm – in 68% of boys and girls of general profile, 76% of boys and 56% of girls of cadet profile. The tendency to increase blood pressure was found in the remaining boys of both profiles, girls of the general profile group (32%) and cadets (44%).

The normal PP in 13-15-year-olds is 40-52 mm MC. Its average values exceeded the age norm in adolescents of all groups – 20% of girls in both profile groups, 28% of boys in general and 24% of cadets. This result indicated a pronounced diastolic stress of the myocardium in these adolescents, which does not allow the myocardium to relax as much as possible during diastole, which reduces the volume of blood in the ventricles, worsens the pumping function of the heart and the functional state of the body (Baranov, Shcheplyagina, 2000).

According to this diagram, the average level of systolic activity of the myocardium and heart fitness is typical for most of the General profile girls and boys of both groups. Data for adolescents are characterized by a high level of opportunities the systolic pumping function of the heart and myocardial adaptation to stress (see Figure 2). The highest percentage of adolescents with low pumping function of the myocardium and adaptation to the loads identified in the group of girls cadet profile.

The values of indicators of quantitative characteristics of the pumping function of the heart and vascular tone are presented in Table 3.

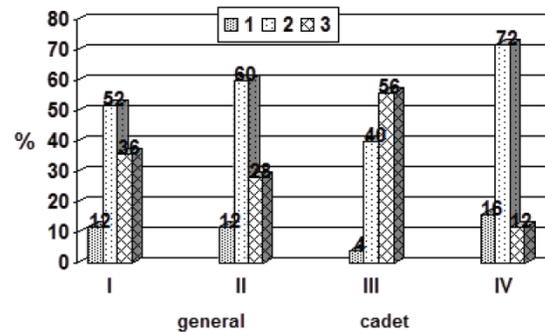


Figure 2: Distribution of schoolchildren by individual heart rate parameters: 1-bradycardia, 2-norm, 3-tachycardia. Profile: general – i (girls) and ii (boys); cadet-iii (girls), iv (boys).

The value of blood SV characterizes the contractile force of the myocardium and the elasticity of the tone of the arteries. At the age of 10-15 years, this parameter is normally 37-40 ml (Kosovanova et al. 2003). The

Table 2: Physiometric Characteristics Of Physical Development School Children (M+M)

Indicators, mm, mercury column	General profile		Cadet profile	
	girls	boys	girls	boys
BPs,	114.4±3.27	112.5±3.32	113.9±2.25	113.5±2.50
BPd	67.5±1.67	63.7±2.55	67.1±1.45	64.2±1.52
PP	46.9±1.71	48.1±2.36	48.5±2.45	47.2±2.33

Table 4: Somatometric Characteristics of Physical Development in Schoolchildren (m+m)

Indicators, mm, MC	General profile		Cadet profile	
	girls	boys	girls	boys
CEC, conv. un.	3804.5±248.24	3791.5±285.60	3832.3±230.22	3840±261.52
EC, conv.un.	17.7±1.06	17.8±1.22	18.41±1.25	18.8±1.66

average SV values found in the examined adolescents only slightly exceeded the upper limit of the norm in boys of the general profile, while in other groups of adolescents they corresponded to the age norm. At this age stage, the average SV values were similar in boys and girls. This result is due to the fact that girls enter puberty earlier (Sukhareva, 2014).

The MBV value in girls of the main profile corresponded to the age norm equal to 2500-3100 ml. However, in other adolescent groups, the MBV values exceeded the upper limit of the age norm (see Table 3). The adaptation of the myocardium to the tested loads in boys of both profiles was carried out by increasing their tachycardia (see Figure 1), which increases the MBV (Apanasenko, 2004; Anisimova et al. 2013). A similar trend was detected in the indicators of heart work-in boys of cadets, it was higher compared with girls of this training profile (see Table 2).

The values of CEC exceeded the physiological norm equal to 2600-3000 units in all groups of boys and girls, indicating functional fatigue of their circulatory system and body (Table 4).

The EC indicators presented in Table 3 in all groups of adolescents exceeded the norm equal to 16 conv.units, indicating a weakening of functional capabilities and lack of training of cardiovascular system in them. More pronounced negative changes were found in adolescents of the cadet profile.

The assessment of the leading TSR in adolescents showed that the least pronounced cardiac TSR prevailed in most of the adolescents of general and cadet profile (Figure 3), which was typical for the majority of boys and girls of the cadet profile.

Cardiovascular TSR was detected only in 24% of girls and 28% of boys of the general profile, in 28% of girls and 12% of boys of the cadet profile. The most effective vascular TSR for the functioning of the body was established in 12% of girls of the profile and 8% of the cadet profile, and only in one cadet boy. These data indicate an intensive restructuring of the

cardiovascular system and its regulatory mechanisms in the body of adolescents.

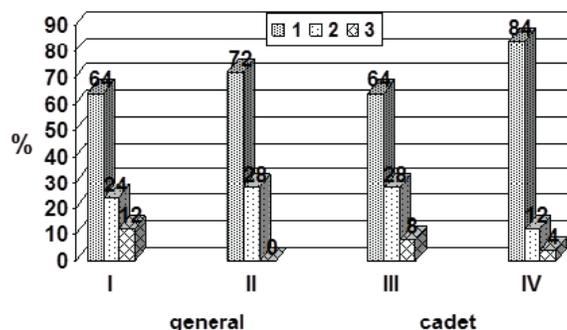


Figure 3: Distribution of adolescents based on individual TSR: 1-cardiac, 2-cardiovascular, 3-vascular. Profile: general-i (girls) and ii (boys); cadet – iii (girls), iv (boys).

SUMMARY AND CONCLUSION

Thus, the data obtained as a result of the study shows:

1. According to somatic indicators, 13-year-olds have an average level of physical development, including a harmonious one-56% of girls and 44% of boys of the cadet profile, 32% of girls and 40% of boys of the general profile. Inharmonious process of physical development, characteristic of other teenagers of each profile, testified to the activation of their processes of intensive growth.
2. Heart rate in adolescents of the general profile corresponded to the upper limits of the age norm, in cadets-boys and girls, it exceeded the age norm, indicating the tension of the chronotropic function of the heart and the body as a whole. Tachycardia (40% of girls and 50% of boys in the general profile, 56% of girls and 64% of boys in cadets) and bradycardia (on average in 25% of adolescents in each profile) were detected against the background of activation of growth processes. They pointed to the disadaptation of adolescents to physiological conditions.
3. The average values of blood pressure components in adolescents corresponded to the

age norm. However, the individual values of the BP components differed from the age norm: BPs and BPd were increased, respectively, PP only in 20% of girls in both profile groups, 28% of boys in the general profile, and 24% of cadets corresponded to the norm. In other adolescents of both profiles, diastolic myocardial tension was expressed, depressing the pumping function of the myocardium. The average blood SV values corresponded to the physiological norm. Increased MBV values against the norm in boys of both profiles are due to the manifestation of tachycardia in them.

4. The values of CEC and EC exceeding the norm in adolescents of both sexes indicated functional fatigue, the lack of training of the cardiovascular system against the background of the action of the heart-type of self-regulation of blood circulation. This TSR was active in the predominant part of boys and girls of cadet profile, indicating the lowest functional capabilities of their myocardium and circulatory system.

REFERENCES

- Alifanova, L. A., (2007). Implementation of a systematic approach to health care and harmonious development of schoolchildren. *Pediatrics*, 86, 2: 106-110. (In Russian)
- Anisimova, N. V., Savina, L. N., Makoveeva, O. S., (2013). Criteria of schoolboy's health: Indicators of physical, mental and social well-being. Proceedings of higher educational institutions. Volga region. 1 (1): 1102-108. (In Russian)
- Apanasenko, G. L., (2004). Diagnostics of individual health, Hygiene and sanitation, 2: 55-58. (In Russian)
- Babenko, T. I., Kaminsky, I. I., (2001). Express assessment of physical health of schoolchildren, conditions of their training and education. Method. Recommendations. Publishing house of the Rostov Regional University. (In Russian)
- Baranov A., Shcheplyagina L. A. 2000. Physiology of growth and development of children and adolescents (theoretical and clinical issues). 426. (In Russian)
- Bezrukikh M. M., Sonkina V. D. 2002. Health-saving technologies in secondary schools: methodology of analysis, forms, methods, experience of application, 181 (In Russian)
- Kosovanova, L. V., Melnikova, M. M., Aizman, R. I., (2003). Screening diagnostics of health of schoolchildren and students. Organization of health-improving work in educational institutions: Educational-method. guide. Novosibirsk: Sib. Univ. ed.: 240 p. (In Russian)
- Kuchma, V. R., Sukhareva, L. M., (2005). Priority criteria for assessing the state of health and disease prevention in children and adolescents. *Health and sanitation*, 6: 42-45. (In Russian)
- Solodkov, A. S., (2013). Physical and functional development state of health of schoolchildren and students of Russia. *Scientific notes of the Lesgaft University*, 3: 163-171. (In Russian)
<https://doi.org/10.5930/issn.1994-4683.2013.03.97.p163-171>
- Sukhareva, S. M., (2014). Research of features of physical development of girls at the age of 13-15 years. *Scientific and theoretical journal "Scientific notes"*, 4 (110): 164-168. (In Russian)
<https://doi.org/10.5930/issn.1994-4683.2014.04.110.p164-168>
- WMA Declaration of Helsinki - Ethical Principles for Medical Research Involving Human Subjects (as amended in (2013): 1-5 (ethical principles of human researches): 9. (In Russian)
- Zarytovskaya, N. V., Kalmykova, A. S., (2012). Individual health of young teenagers studying in secondary school. *Hygiene and sanitation*, 2: 84-85. (In Russian)

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