COMPARATIVE EVALUATION OF PHYSICAL DEVELOPMENT AND FUNCTIONAL RESERVES OF SCHOOLCHILDREN AT THE HIGH AND LOW-ALTITUDE OF THE SOUTH OF KYRGYZSTAN

Belov G.V., Abdyganiev N.A., Syed Ali Abbas Rahat

Osh State University, Osh, e-mail: bagdan1954@mail.ru

The work was aimed at studying the functional development and functional reserves of school children of primary, secondary and graduate classes living in the lowlands and highlands of southern Kyrgyzstan – a total of 2,000 surveyed. Anthropometric methods, sports and medical functional tests of Martine-Kushelevsky, the test of Stange and Genchi were applied. Comparative analysis revealed differences in body weight at different age periods in both boys and girls, and different growth rates in the highlands and lowlands. Boys in the highlands at the age of 10–13 years old have a smaller height and lower body weight than there fellows from the lowlands, girls have a smaller mass at the age of 8–13 years, then both boys and girls of the highlands catch up on the mass of their fellows in the lowlands. Greater chest coverage in high school students was accompanied by a greater lung capacity. The features of anerobic reserve, endurance and performance tests, sports results interconnected with anthropometric parameters are revealed.

Keywords: highlands, schoolchildren, physical development, anthropometry, functional tests

The rapid growth of population leads to the development of new territories, be it the polar zone, the desert or the highlands. Of course, at the same time, each climatic-geographical habitat imposes its own characteristics on the anatomical and physiological characteristics of the development of children and adolescents. Physical development of a person in a mountain climate has its own distinctive features [1, 2]. One of the primary values is the height of the population, but also genetic and medico-social aspects are important. The Kyrgyz – herders for decades have adapted themselves to live in high mountains, unlike their neighbors – farmers, which allowed them to preserve their originality and not to assimilate into other ethnic groups, for example, the Chinese, whose number is many dozen times higher than that of the Kyrgyz. Adaptation of the Kyrgyz to the conditions of the highlands ensures the country's defense and economic development.

Multi-center data of many years shows that children in the highlands of Tibet and the Andes are lagging behind their fellows in the lowland areas, but they are more likely to have good height when sitting, due to the size of the chest, which is more developed to compensate for the increased load on the lungs in high-altitude hypoxia [1, 6 ten]. At the same time, there was no lag in the intellectual development and behavior of adolescents [5]. Also, the effect of gender on the direction and severity of shifts in anthropometric characteristics among high-mountain residents was not observed [3]. However, in functional terms, in modern socio-economic conditions, high school students are not examined enough to suggest any corrective interventions. True, scientifically substantiated increased nutritional standards for military personnel and workers in the mining industry in high-altitude conditions, but extensive research is required for children and adolescents.

Aim of study

The work was aimed at studying the physical development of primary, secondary and graduate schoolchildren living in the high-altitude villages of Alai and Chon-Alai districts of the Osh region.

Materials and research methods

2000 healthy children aged 7-17 years old living at an altitude of more than 3000 m above sea level in the villages of Sary-Tash, Kyzyl-Suu, Kashka-Suu, Kara-Kabak were surveyed. The survey was conducted in the autumn period of 2017-2018. Anthropometric methods (50 height, weight and length parameters,circumference parameters and their annual analysis), sports tests for speed, strength and endurance (pulling up, pushing up, running at 80m and 1 km, hand strength, deadlift), medical functional tests (Vital capacity of lungs, BP, pulse at rest and after 20 squats in 30 seconds – Martine-Kushelevsky's test, breath holding while inhaling – Shtanga test and exhaling – Genchi's test). As a control parameter, a database of schoolchildren of the city of Osh (elevation 900 m above sea level), accumulated in the anthropology laboratory of the Department of Normal Anatomy of the Medical Faculty of Osh State University, was taken. The exclusion criterion from the study was patients with chronic diseases of any organs and systems.

Research results and discussion

The results of the study testify to the special characteristics of the dynamics of the physical development of schoolchildren living in the high mountains compared with their fellows living in the plain and low mountains. Anatomical and physiological indicators of schoolchildren of the city of Osh were close to those in the city of Bishkek, other low-mountain and mid-mountain regions of Kyrgyzstan [2, 7–9].

Comparative analysis revealed differences in body mass at different age periods in both boys and girls, and different growth rates in the high mountains and low mountains (Table 1).

Boys living at high altitudes at the age of 10-13 years old have a lower body weight than their fellows from the low altitudes, girls have a smaller mass at the age of 8-13 years, then both boys and girls of the high altitudes catch up on the mass of their fellow in the low altitudes. At 16-17 years old boys and girls living at high altitudes have a weight corresponding to the age norm for Kyrgyzstan as a whole.

The growth of the body also differs in according to the place of residence (Table 2).

Boys at the high altitudes at the age of 10–15 years old have a significantly smaller growth compared to their fellows from the low altitudes, at 16–17 years old they have a sharp increase in body length, and during this period the difference in height is not significant. Similar growth rates were noted by other authors who studied the anthropometric indicators of students in southern Kyrgyzstan [9, 10].

Table 1

Age dynamics of body weight of school children at high and low altitudes (kg)

Age	BOYS		GIRLS	
	High altitude	Low altitude	High altitude	Low altitude
7 years	22,3 ± 0,4	22,5 ± 0,4	21,4 ± 0,3	21,8 ± 0,2
8 years	24,5 ± 0,3	25,5 ± 0,3	22,6 ± 0,3 *	24,1 ± 0,3
9 years	26,3 ± 0,3	27,1 ± 0,3	25,9 ± 0,8 *	27,9 ± 0,7
10 years	28,1 ± 0,4 *	34,1 ± 0,9	28,5 ± 0,6 *	29,6 ± 0,6
11 years	30,6 ± 0,3 *	37,2 ± 0,9	29,1 ± 0,9 *	31,3 ± 0,8
12 years	34,6 ± 0,7 *	43,7 ± 0,8	34,3 ± 0,8 *	36,5 ± 0,8
13 years	38,1 ± 0,5 *	42,5 ± 1,2	40,7 ± 1,1 *	43,7 ± 1,06
14 years	46,2 ± 1,0	48,2 ± 1,0	46,1 ± 1,0	46,4 ± 1,0
15 years	51,9 ± 0,9	52,8 ± 0,9	49,2 ± 1,22	49,8 ± 1,22
16 years	57,6 ± 0,6	57,9 ± 0,6	50,8 ± 1,0	53,8 ± 1,0
17 years	61,6 ± 0,9	61,9 ± 0,9	55,6 ± 0,8	55,8 ± 0,8

N o t e : * – the difference with the comparison group $p < 0.05$.

Table 2

Age dynamics of body length at high altitude and low altitude schoolchildren (cm).

Age	BOYS		GIRLS	
	High altitude	Low altitude	High altitude	High altitude
7 years	115,7 ± 1,3	114,3 ± 1,3	113,6 ± 2,3	113,6 ± 2,3
8 years	118,8 ± 1,4	119,7 ± 1,4	117,7 ± 1,6	118,8 ± 2,1
9 years	123,2 ± 1,4	125,2 ± 1,4	124,2 ± 1,8	124,6 ± 2,3
10 years	124,3 ± 2,1 *	129,3 ± 2,0	125,8 ± 1,8 *	131,2 ± 2,3
11 years	130,6 ± 2,1 *	136,6 ± 2,0	130,0 ± 1,5 *	136,7 ± 1,9
12 years	138,4 ± 1,6 *	148,4 ± 1,9	134,5 ± 2,2 *	139,3 ± 1,5
13 years	145,1 ± 1,8 *	151,1 ± 1,8	140,3 ± 2,0 *	146,1 ± 1,9
14 years	149,3 ± 1,8 *	158,3 ± 1,8	146,2 ± 2,1	149,2 ± 2,1
15 years	156,5 ± 1,8 *	165,5 ± 1,8	150,1 ± 2,1	154,5 ± 2,1
16 years	164,7 ± 2,1	171,3 ± 1,6	152,8 ± 2,1	157,3 ± 2,8
17 years	171,4 ± 1,5	172,2 ± 1,5	155,4 ± 2,2	157,7 ± 2,5

N o t e : * – the difference with the comparison group $p < 0.05$.

The coverage parameters of body parts at different levels were almost the same in both groups, with the exception of greater breast coverage in high school students (Table 3).

In boys of highlands, in 6 of the periods under consideration, breast coverage was significantly greater than that of fellows from low altitude($p < 0.05$), in other periods the difference was not significant. In girls, the high altitude also had more breast coverage than their fellows from the low altitude, the difference was also significant for 6 age periods.

Greater chest coverage in high school students was accompanied by a higher lung capacity (Table 4).

Analysis of digital data suggests that among high school students the vital capacity of the lungs significantly exceeds the values of the control group in 9 age groups. In girls, the difference is not so significant – only reliably in 3 age periods. Higher numbers of VCs are explained by increased load on the respiratory organs in conditions of high-altitude hypoxia. Such an adaptation of the respiratory organs in children of the highaltitudes in Tibet and in the Andes has been described by foreign authors [1, 6]. The results of sports tests of high school students for speed (80 m run) and endurance (1 km run) at high altitudes were lower than in the low mountains, which will be described in detail in the next report.

Table 3

The age dynamics of the circumference of the chest in schoolchildren of high altitude and low altitude (cm)

Age	BOYS		GIRLS	
	High altitude	Low altitude	High altitude	Low altitude
7 years	58,2 ± 0,5 *	56,4 ± 0,5	57,6 ± 0,2 *	56,3 ± 0,4
8 years	61,0±0,6	60,2±0,6	59,2 ± 0,2	59,0 ± 0,2
9 years	61,5 ± 0,3	60,9 ± 0,4	60,6 ± 0,2	60,1 ± 0,3
10 years	63,4 ± 0,4	62,4 ± 0,4	61,7 ± 0,3	61,3 ± 0,3
11 years	65,9 ± 0,4 *	63,9 ± 0,4	64,9 ± 0,3 *	64,0 ± 0,3
12 years	68,2 ± 0,4 *	66,6 ± 0,4	69,8 ± 0,4	66,1 ± 0,3
13 years	71,5 ± 0,4 *	69,5 ± 0,5	73,6 ± 0,48	70,4 ± 0,3
14 years	76,3 ± 0,9 *	72,4 ± 0,8	79,2 ± 0,8 *	74,3 ± 0,4
15 years	80,2 ± 1,3	78,2 ± 1,1	82,3 ± 0,9 *	77,5 ± 0,5
16 years	84,3 ± 1,0 *	81,1 ± 1,1	85,4 ± 0,9 *	82,3 ± 0,8
17 years	87,1 ± 0,7	86,1 ± 0,9	87,2 ± 0,8 *	84,1 ± 0,8

Note: * – the difference with the comparison group $p < 0.05$.

Table 4

Age dynamics of the vital capacity of the lungs in school children of high and low altitudes (ml)

Age	BOYS		GIRLS	
	High altitude	Low altitude	High altitude	Low altitude
7 years	1752 ± 37 *	1618 ± 45	1630 ± 28 *	1555 ± 36
8 years	1820 ± 36*	1715 ± 32	1728 ± 34 *	1632 ± 34
9 years	1940 ± 32 *	1820 ± 44	1820 ± 28	1740 ± 36
10 years	2106 ± 32*	1960 ± 52	1881 ± 45	1821 ± 45
11 years	2175 ± 35 *	2048 ± 45	1936 ± 28 *	1852 ± 51
12 years	2242 ± 39*	2171 ± 33	1978 ± 34	1920 ± 37
13 years	2293 ± 32	2220 ± 48	2035 ± 28	2011 ± 36
14 years	2306 ± 38*	2296 ± 47	2069 ± 45	2054 ± 45
15 years	2387 ± 37	2337 ± 38	2154 ± 37	2137 ± 38
16 years	2489 ± 32 *	2380 ± 32	2226 ± 32	2180 ± 33
17 years	2596 ± 38*	2413 ± 38	2246 ± 38	2213 ± 30

Note: * – the difference with the comparison group $p < 0.05$.

The strength exercises in most tests did not reveal significant differences in the results of the main groups of boys and girls with the comparison groups.

Samples with delayed breathing showed features in the anaerobic reserve in high school and low mountain schoolchildren (Table 5).

Endurance to hypoxic samples increases with age in all groups. By the age of 17, the duration of breath holding during the Stange test in young men of low mountains reaches 50 seconds, which is considered to be an excellent result of functional reserves. In the low mountain males, the Stange sample did not achieve an excellent result, but the difference with the comparison group is not reliable ($p > 0.05$). In high-altitude girls, the delay time of the Stange test was significantly less than in the comparison group ($p < 0.05$). The Genchy test in the high altitude boys only at one age period was slightly higher than that in the low altitude fellows, and in girls of 9 years the same peculiarity was noted.

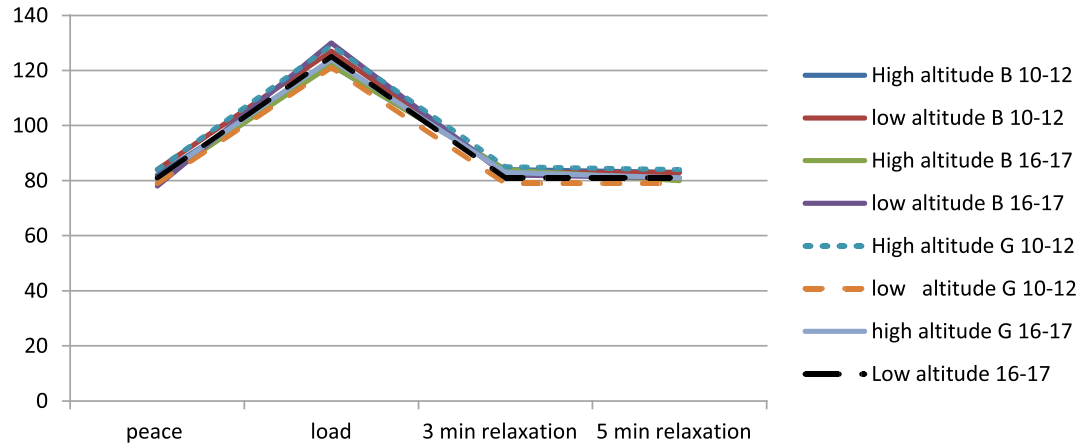
Thus, it can be seen that the anaerobic reserve of high altitude students is sufficient, although at the same time they experience additional effects of natural hypoxia.

Table 5

Age dynamics of the Stange-Genchi test in children of high and low altitudes(s)

AGE	STANGE TEST				GENCHI TEST			
	BOYS		GIRLS		BOYS		GIRLS	
	High altitude	Low altitude	High altitude	Low altitude	High altitude	Low altitude	High altitude	Low altitude
7 years	28,5 ± 2,3	27,2 ± 3,5	25,9 ± 2,1	25,1 ± 2,5	14,4 ± 2,0	11,4 ± 2,0	14,2 ± 1,8	11,4 ± 1,7
8 years	28,9 ± 2,4	30,2 ± 2,9	31,8 ± 2,5	28,5 ± 2,4	15,9 ± 2,3	12,8 ± 2,7	17,1 ± 1,5	11,6 ± 1,8
9 years	31,2 ± 2,0	31,0 ± 2,0	34,8 ± 1,6	38,9 ± 1,8	18,4 ± 1,9	14,6 ± 1,8	17,8 ± 1,9*	13,2 ± 1,5
10 years	36,2 ± 2,8	33,3 ± 1,9	31,3 ± 2,0*	39,2 ± 1,4	21,6 ± 1,5*	16,2 ± 1,5	19,8 ± 2,1	15,5 ± 2,0
11 years	37,3 ± 2,0	38,2 ± 1,9	34,3 ± 2,0	38,2 ± 1,9	23,3 ± 1,5	18,2 ± 1,5	20,5 ± 2,1	17,8 ± 2,0
12 years	38,1 ± 2,2	38,9 ± 2,0	36,1 ± 2,2	38,9 ± 2,0	24,6 ± 1,6	21,2 ± 1,5	21,8 ± 2,0	20,0 ± 2,1
13 years	38,8 ± 2,0	39,8 ± 1,8	37,8 ± 2,0	39,9 ± 1,6	24,6 ± 1,5	24,2 ± 1,5	23,8 ± 1,8	23,0 ± 2,0
14 years	39,2 ± 2,1	41,3 ± 1,8	38,2 ± 2,1	41,3 ± 1,8	25,7 ± 1,5	25,2 ± 1,5	24,2 ± 2,1	24,7 ± 1,7
15 years	40,1 ± 2,8	43,4 ± 1,9	39,6 ± 2,0	42,3 ± 1,9	29,6 ± 1,7	28,2 ± 1,5	26,8 ± 2,0	30,0 ± 2,0
16 years	43,2 ± 2,1	47,3 ± 1,9	41,2 ± 2,1	46,6 ± 1,9	34,6 ± 1,6	32,2 ± 1,5	31,8 ± 2,1	29,7 ± 1,8
17 years	46,1 ± 1,8	50,3 ± 1,8	44,1 ± 1,9*	50,0 ± 1,7	38,6 ± 1,7	38,2 ± 1,5	34,8 ± 2,1	34,5 ± 1,0

Note: * – the difference with the comparison group $p < 0.05$.



Heart rate during the Martin-Kushelevsky test in high and low altitude schoolchildren

We carried out the Martine-Kushelevsky sample only in two age groups of 10–12 years old and 16–17 years old. The indicators of heart rate at rest in all the studied groups were slightly higher than the previously described data, although they did not go beyond the age norm. Perhaps, mass surveys of schoolchildren have become less frequent, and those examined experience more stress in front of doctors and classmates than before.

All the students reacted to the Martine-Kushelevsky test with a significant increase in heart rate and blood pressure, that is, a normal physiological response (Figure). Recall that there are other reactions to intense physical activity (hypertonic, hypotonic, dystonic), but the vast majority of schoolchildren reacted physiologically.

Restoration of the pulse of schoolchildren from both the high altitude of the south of Kyrgyzstan and the low altitude took place mainly in three minutes, that is, modern high school students have sufficient backup reserve capabilities.

Conclusion

The anatomical and physiological features of high school students differ from those of their fellows in the low mountains and valleys, but do not go beyond the age norm and physiological response to additional physical and hypoxic stress, which must be considered when moving young men to low mountains for military service or study.

References

1. Argnani L., Cogo A., Gualdi-Russo E. Growth and nutritional status of Tibetan children at high altitude // Coll Antropol. 2008 Sep;32(3):807-12.

2. Bolsheva E.Sh. Indicators of physical development of girls of the Kyrgyz ethnic population in conditions of middle mountains // Medicine of Kyrgyzstan. 2008. № 5. P. 28–31.

3. Boos C.J., Vincent E., Mellor A., et al. The Effect of Sex on Heart Rate Variability at High Altitude // Med Sci Sports Exerc. 2017 Dec;49(12):2562-2569. DOI: 10.1249/MSS.0000000000001384.

4. Borisov E.Yu., Grekhova Yu., Manuilenko Yu.I. The main indicators of the physical development of schoolchildren of Bishkek over 50 years in dynamics // Medicine of Kyrgyzstan. 2009. № 4. WITH. 34-37.

5. Hogan A.M., Virues-Ortega J., Botti A.B., et al. Development of aptitude at altitude // Dev Sci. 2010 May;13(3):533-544. DOI: 10.1111/j.1467-7687.2009.00909.x.

6. Pawson I.G., Huicho L. Persistence of growth stunting in a Peruvian high altitude community, 1964-1999 // Am. J. Hum. Biol. 2010 May-Jun; 22(3):367-74. DOI: 10.1002/ajhb.21001.

7. Sattarov A.E., Karelina N.R. Peculiarities of growth processes in boys and young men of various proportions and physique living in the southern part of Kyrgyzstan // Pediatrician. 2018. Vol. 9. No. 5. P. 47–52.

8. Stepanova A.V., Godina E.Z. Growth and development of children in the highlands: intergroup analysis. Part I. Morphological and physiological characteristics of girls // Moscow University Bulletin. Series 23: Anthropology. 2015. No. 4. P. 14–33.

9. Tulekeev T.M., Imanaliev T.T., Sattarov A.E. Physical development of adolescents and young men of different climatic and geographical zones / Bulletin of physical culture and sports. 2016. № 2 (14). P. 157–164.

10. Xi H., Chen Z., Li W., et al. Chest circumference and sitting height among children and adolescents from Lhasa, tibet compared to other high altitude populations // Am. J. Hum. Biol. 2016 Mar-Apr;28(2):197–202. DOI: 10.1002/ajhb.22772. Epub 2015 Aug 7.