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cardiovascular parameters in
7–11-year-old boys residing in
northern and southern Kazakhstan //
Vergleichendes Charakteristikum der
Indikatoren des kardiovaskulären
Systems von Jungen im Alter von
7–11 Jahren**

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Comparative characteristics of the cardiovascular parameters in 7–11-year-old boys residing in northern and southern Kazakhstan

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Kurzfassung: Vergleichendes Charakteristikum der Indikatoren des kardiovaskulären Systems von Jungen im Alter von 7–11 Jahren aus Nord- und Südkasachstan. Ein Indikator der menschlichen Gesundheit ist der Zustand des Herz-Kreislauf-Systems in Ruhe und nach Belastung. Zu diesem Zweck wurden Indikatoren für Herzfrequenz (HR), systolischen arteriellen Blutdruck (SAB) und diastolischen arteriellen Blutdruck (DAB) bei Jungen im Alter von 7–11 Jahren in den nördlichen (Pavlodar) und südlichen (Kyzylorda) Regionen Kasachstans untersucht. Basierend auf diesen Daten wurden die Berechnungen des Pulsdrucks (PP), des Doppelprodukts (DP), das die Effizienz des Herz-Kreislauf-Systems widerspiegelt, des Blutschlagvolumens (BSV) und des Blutminutenvolumens (BMV), des Indikators für die Durchblutungseffizienz (DBE) sowie des vegetativen Kérdö-Indexes (VKI), der das vegetative Gleichgewicht widerspiegelt, durchgeführt.

Die gemessenen Daten zeigen, dass die Funktionsfähigkeit des Herz-Kreislauf-Systems von Jungen im Alter von 7–11 Jahren, die in Kyzylorda leben, sowohl in Ruhe als auch nach normaler körperlicher Aktivität höher ist als die von Schülern in Pavlodar. Die festgestellten Unterschiede können in Bildungseinrichtungen und Genesungseinrichtungen genutzt werden, um als wissenschaftliche Grundlage für die Entwicklung medizinischer und pädagogischer Programme zur Stärkung der Gesundheit der Kinder zu dienen.

Schlüsselwörter: Körperbelastung, Funktionszustand des Körpers, Reserven.

Abstract. The state of the cardiovascular system at rest and after exercise is one of the health parameters. Heart rate (HR), systolic blood pressure (SBP) and diastolic blood pressure (DBP) were studied in 7–11-year-old boys in the northern (Pavlodar) and southern

(Kyzylorda) regions of Kazakhstan. Based on these data the following parameters were calculated: pulse pressure (PP), double product (DP), which reflects the cardiovascular system efficiency, systolic blood volume (SBV) and minute blood volume (MBV), blood circulation efficiency indicator (BCEI); Kerdo vegetative index (KVI), which reflects the autonomic balance. Obtained data indicate that the functional capabilities of the cardiovascular system of 7–11-year-old boys residing in Kyzylorda are higher, both at rest and after standard physical activity, than those of schoolchildren in Pavlodar. The revealed differences can be used in educational and recreational institutions, to serve as a scientific basis in the development of medical and educational programs to improve children's health. *Z Gefäßmed* 2020; 17 (2): 13–5.

Key words: physical activity, functional state of the body, reserves.

Introduction

Age-related features of the functional state of the cardiovascular system of pupils in the learning process are reliable indicators of the body adaptation capacity [1–8].

Heart rate (HR) is one of the informative and accessible indicators of the cardiac function. HR is the result of all regulatory impacts on the circulatory system [9–14]. HR at rest depends on the state of health, age, gender, body weight, physical activity, fitness, the state of the central nervous system, metabolic processes, day time and many other factors [15].

The purpose of this study is to evaluate the cardiovascular parameters in 7–11-year-old schoolchildren residing in Pavlodar and Kyzylorda, the northern and southern regions of the country.

Study objectives

- 1.) To investigate the functional features of the ontogenetic development of children in the ontogenesis residing in northern and southern Kazakhstan.
- 2.) To conduct a comparative analysis of the functional capabilities of children based on gender, age and place of residence (north, south).

This is the first study of the functional capabilities in 7–11-year-old schoolchildren residing in industrial cities.

The results of the study improve the understanding of the impact of environmental factors on the growing and developing body in large industrial cities. Based on the obtained data, the functional capabilities in junior schoolchildren in relation to environmental living conditions were determined.

Materials and Methods

The schoolchildren were examined in February 2018. The study involved 100 boys from secondary school No. 22 of Pavlodar and 100 boys from secondary school No. 7 of Kyzylorda aged 7–11 years, 20 boys in each age group, which made it possible to compare the obtained data in age and regional terms. All examinations were carried out in the morning.

The cardiovascular system parameters were measured according to the method of stepergometry as the 2-stage Harvard step test. The step height was 20 cm [16].

Heart rate (HR, bpm) was assessed using a tonometer when measuring blood pressure.

Systolic (SBP mmHg) and diastolic (DBP mmHg) pressure was determined by the Korotkov method on the right shoulder using a CITIZEN cuff tonometer.

The pulse pressure (PP mmHg) was calculated according to the formula $PP = SBP - DBP$. The double product (DP, unit), evaluating the functional heart reserves was calculated by the formula: $DP = (HR \times SBP) : 100$.

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Table 1. Cardiovascular system parameters in 7–11-year-old boys residing in Pavlodar (P) and Kyzylorda (K) at rest

Parameters	Residence	Age, years				
		7	8	9	10	11
HR (bpm)	P	95.8 ± 1.0	93.4 ± 0.5*	91.5 ± 0.3*	87.1 ± 0.4	85.6 ± 0.4
	K	94.8 ± 0.4	92.8 ± 0.4*	90.6 ± 0.2*#	86.7 ± 0.6	84.4 ± 0.3#
SBP (mmHg)	P	93.0 ± 1.1	96.0 ± 1.1	98.1 ± 0.9	103.5 ± 1.1*	106.0 ± 1.1
	K	90.5 ± 0.5*	92.5 ± 1.0#	95.5 ± 1.1*	101.5 ± 1.3*	104.5 ± 1.1
DBP (mmHg)	P	58.0 ± 0.9	58.5 ± 0.8	59.5 ± 0.8	60.5 ± 0.5	62.5 ± 1.0
	K	52.5 ± 1.0#	53.5 ± 1.1#	56.0 ± 1.1#	58.0 ± 1.2	59.0 ± 1.2#
PP (mmHg)	P	35.0 ± 1.1	37.5 ± 1.0	38.6 ± 0.8	43.0 ± 1.1*	43.5 ± 1.1
	K	38.5 ± 0.9*	39.0 ± 0.7	39.5 ± 0.5	43.5 ± 1.1*	45.5 ± 1.1
DP (cond.units)	P	89.0 ± 1.0	89.7 ± 1.1	89.7 ± 0.8	103.5 ± 1.1*	106.0 ± 1.1
	K	85.8 ± 0.6*	85.8 ± 1.0#	86.5 ± 1.0#	101.5 ± 1.3*	104.5 ± 1.1
SBV (mL)	P	45.1 ± 1.0	49.3 ± 0.8*	52.4 ± 0.8	60.5 ± 0.5	62.5 ± 1.0
	K	49.9 ± 1.0#	53.5 ± 0.9*#	55.0 ± 0.8#	58.0 ± 1.2	59.0 ± 1.2#
MBV (mL)	P	4.3 ± 0.1	4.6 ± 0.1	4.8 ± 0.1	5.0 ± 0.1	5.1 ± 0.1
	K	4.7 ± 0.1#	4.9 ± 0.1#	5.0 ± 0.1	5.1 ± 0.1	5.3 ± 0.1
KVI (cond.units)	P	0.39 ± 0.01	0.37 ± 0.01	0.35 ± 0.01	0.3 ± 0.01*	0.27 ± 0.01*
	K	0.45 ± 0.01#	0.42 ± 0.01#	0.4 ± 0.01#	0.4 ± 0.01#	0.30 ± 0.01#
BCEI	P	97.1 ± 1.9	102.8 ± 1.4	107.2 ± 1.1	118.8 ± 1.5	123.8 ± 1.2
	K	95.5 ± 0.6	99.7 ± 1.2	105.4 ± 1.3	117.1 ± 1.8	123.8 ± 1.5

*compared to the previous age group ($p < 0.05$); #compared to schoolchildren residing in the northern and southern regions ($p < 0.05$).

Systolic blood volume (SBV) was calculated according to the Starr formula: $SBP = 40 + 0.5 PP - 0.6 DBP + 3.2 B$, where B is age (years).

For an integral assessment of the state of the circulation, the minute blood volume (MBV) was calculated by the formula: $MBV = SBV \times HR$.

Kerdo Vegetative Index, which reflects the balance of autonomic adaptation processes, was calculated by the formula: $KVI = (1 - DBP/HR) \times 100$.

Blood circulation efficiency index (BCEI) was calculated by the formula: $BCEI = (SBP/HR) \times 100$ [16]. This indicator judges the quality of the response of the cardio-respiratory system to load.

The results were assessed using methods of mathematical statistics based on arithmetic means (M) and their errors ($\pm m$). The significance of differences in average values between age groups and cities was considered by the Independent Samples t-Test at a level of $p < 0.05$ [17].

Results and Discussion

A comparative analysis of the studied cardiovascular parameters of schoolchildren (Table 1) showed that the studied parameters (HR, SBP, DBP, DP) of 7–11-year-old boys residing in Pavlodar at rest are higher than those in schoolchildren residing in Kyzylorda, while PP values in schoolchildren from Pavlodar at this age are lower compared with peers in another studied area.

SBV and MBV among 7–9-year-old schoolchildren in Pavlodar are also lower, and they are rising compared to the level of schoolchildren in Kyzylorda by the age of 10–11 years. Based on the described regional differences we can suggest higher

functional reserves of the cardiovascular system in boys of the southern region of the republic.

This is also evidenced by the cardiovascular system reserve (“double product”) which characterizes the systolic heart work. The lower DP at rest, the higher the maximum aerobic capacity and, consequently, the level of the individual somatic health [18].

In general, HR decreases, and SBP, DBP, DP, PP, SBV and MBV increase with age in both groups of schoolchildren. The state of autonomic regulatory mechanisms is a key factor in the organism adaptation to environmental conditions [19].

Based on the analysis of Table 1, it can be concluded that the Kerdo Vegetative Index (KVI) is higher in Kyzylorda schoolchildren compared with Pavlodar peers, which means their predominant sympathetic nervous system tones. This parameter decreases as a result of decreased tone of the sympathetic nervous system with age.

In general, BCEI increases in both groups of schoolchildren with age.

No differences between schoolchildren in both areas were found.

The similar CVS studies of schoolchildren under standard physical activity (Table 2) showed that the studied parameters (HR, SBP, DBP, DP) of 7–11-year-old boys residing in Pavlodar, are higher than those parameters in schoolchildren from Kyzylorda, while schoolchildren from Kyzylorda at this age have higher PP values compared to peers in the northern area.

PP values in 7–11-year-old schoolchildren in both regions increase with age.

Table 2. Cardiovascular system parameters in 7–11-year-old boys residing in Pavlodar and Kyzylorda under standard step-ergometric physical activity.

Parameters	Residence	Age, years				
		7	8	9	10	11
HR (bpm)	P	166.0 ± 1.3	165.3 ± 0.4	163.1 ± 0.9	161.1 ± 0.9*	159.0 ± 0.9
	K	152.6 ± 0.9#	152.0 ± 1.0#	150.0 ± 0.8#	149.1 ± 0.6#	148.4 ± 0.6#
SBP (mmHg)	P	120.5 ± 0.5	122.5 ± 1.9	124.8 ± 1.1	126.5 ± 1.3	135.0 ± 1.5*
	K	118.5 ± 0.8#	119.5 ± 0.5	122.5 ± 1.4*	125.0 ± 1.1	131.0 ± 1.2*#
DBP (mmHg)	P	58.5 ± 1.1	59.5 ± 0.9	60.0 ± 1.0	60.5 ± 0.5	64.0 ± 1.1*
	K	53.5 ± 1.1#	54.0 ± 1.1#	56.5 ± 1.5	55.5 ± 1.1	59.5 ± 1.4#
PP (mmHg)	P	62.0 ± 1.2	63.0 ± 1.8	64.8 ± 1.1	66.0 ± 1.3	71.0 ± 1.6*
	K	65.0 ± 1.4	65.5 ± 1.1	66.0 ± 1.7	66.5 ± 1.1	71.5 ± 1.3*
DP (cond.units)	P	200.0 ± 1.8	202.4 ± 3.2	203.5 ± 1.9	203.8 ± 2.6*	214.7 ± 2.9
	K	180.8 ± 1.7#	181.7 ± 1.5#	184.0 ± 2.5#	186.3 ± 2.0#	194.4 ± 1.9#
SBV (mL)	P	58.3 ± 1.2	61.4 ± 1.1	65.2 ± 1.0*	68.7 ± 0.8*	72.3 ± 1.2*
	K	62.8 ± 1.3#	66.0 ± 1.2	67.9 ± 1.6	70.2 ± 1.0	75.3 ± 1.3*
MBV (mL)	P	9.7 ± 0.2	10.1 ± 0.2	10.6 ± 0.2	11.1 ± 0.2	11.5 ± 0.2
	K	9.6 ± 0.2	10.0 ± 0.2	10.2 ± 0.2	10.4 ± 0.1#	11.2 ± 0.2*
KVI (cond.units)	P	0.65 ± 0.01	0.64 ± 0.01	0.63 ± 0.01	0.62 ± 0.01*	0.60 ± 0.01*
	K	0.65 ± 0.01#	0.65 ± 0.01#	0.62 ± 0.01#	0.61 ± 0.01#	0.60 ± 0.01*#
BCEI	P	72.7 ± 0.6	74.1 ± 1.2	76.5 ± 0.7	78.6 ± 0.8	84.9 ± 1.0*
	K	77.7 ± 0.7#	78.7 ± 0.6#	81.6 ± 1.0*#	83.9 ± 0.8#	88.3 ± 0.9*#

*compared to the previous age group ($p < 0.05$); #compared to schoolchildren residing in the northern and southern regions ($p < 0.05$).

SBV in 7–11-year-old schoolchildren in Pavlodar is lower compared with schoolchildren in Kyzylorda. MBV in 7–11-year-old schoolchildren in Pavlodar is higher compared with schoolchildren in Kyzylorda.

Based on the values of the Kerdo Vegetative Index (KVI) we can conclude that this parameter decreases with age in both groups of schoolchildren.

In general, BCEI increases in both groups of schoolchildren with age. The studied BCEI values in Kyzylorda are higher than in schoolchildren from Pavlodar. Kyzylorda schoolchildren had higher BCEI after exercises than Pavlodar peers.

Conclusion

1.) The study of the cardiovascular system of 7–11-year-old boys in Kyzylorda and Pavlodar showed differences in the functional state of the cardiovascular system between peers in the northern and southern climatic zones. Children of the southern region of Kazakhstan (Kyzylorda) are characterized by higher functional capabilities of the cardiovascular system compared to peers living in the northern region of Kazakhstan (Pavlodar).

2.) Schoolchildren in Pavlodar had higher cardiovascular stresses (HR, SBP, DBP, DP) and fewer reserves compared to peers residing in Kyzylorda, which means the strenuous heart work.

Conflict of Interest

The authors declare that there is no conflict of interest.

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