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Short Communication

Auxological Status of Modern Primary School Students of Nizhny Novgorod Region

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Abstract

The article describes the characteristics of the resulting effector auxological morpho-functional status of primary school students, differentiated by gender and administrative-territorial characteristics.

The objectives of the study included studying the auxological status of children adolescents, and primary school students in the Nizhny Novgorod region in the context of the peculiarities of the exoenvironment of residence in urban and rural areas.

Materials and methods: Own data served as a source of anthropometry and physiometry indicators of the objective population of the region.

The analysis of anthropological indicators was carried out by discretizing data sets that state an objective picture of auxological indicators at the regional level, taking into account the peculiarities of anthropogenic loads characteristic of the place of residence of the observed population groups.

To quantify the values and statistical differences in indicators by age, gender, and administrative characteristics, the median, standard deviation, and criteria were used: Fisher, Wilks, and Mahalanobis, with an error of differences at $p < 0.05$.

Results: The stability of the age-sex evolution of auxological indicators is shown; the age-sex and territorial dimorphism of total body sizes is shown at 7-10 years of age, with residents of rural areas lagging in the observed indicators.

Hemodynamic indicators in both boys and girls significantly prevail among students living in the metropolis relative to their rural counterparts, except diastolic blood pressure.

Variance analytics shows differences in the distributions of anthropometry and hemodynamics, both by age and by the urbanization factor at $p < 0.001$.

In the observed age period, at the initial stage, hemodynamic indicators act primarily as modifiers of the metropolis and rural groups. From the age of ten, according to the standardized coefficients of discriminant functions, according to the first canonical variable, the division of series also occurs according to anthropometric characteristics, among which the greatest contribution to the division of groups is made by body weight and body length, and the hemodynamic characteristic - diastolic blood pressure - has also proven to be decisive.

Conclusion: Primary school students living in rural areas and in the metropolis of the Nizhny Novgorod region determine the observed indicators ambiguously; if residents of the metropolis state greater results for all observed auxological indicators, then rural peers demonstrate, while lagging in all observed indicators, greater indicators of diastolic blood pressure, which suggests a strain on adaptation mechanisms central character.

Introduction

The expediency of studying the basic patterns of age-related variability of the human population as a whole, solving one of the most pressing problems of auxology, has been repeatedly emphasized by the founders and leading representatives of both Russian and European human science, put forward by the British anthropologist, auxologist John Tanner, which involves the study of age-related variability in growth and development of children and adolescents under the influence of environmental factors [1-4].

Conducting research – observing the patterns of growth processes, their mathematical modeling, description, and interpretation; individual and population monitoring of growth processes as a reflection of living conditions, including in aspects of the level of urbanization of the habitat, is the key to a better understanding and explanation of the growth processes of micro populations and the population as a whole, as a reflection of living conditions within the range [5-8].

The development of models, approximations, and theoretical hypotheses that serve to better understand and explain growth processes includes the results of extensive longitudinal and cross-sectional experimental studies, measurement programs, and monitoring, followed by comparative analysis and presentation of modern assessment material [9-11].

Physiological adaptation is a set of physiological reactions that underlie the body's adaptation to changing environmental conditions and aimed at maintaining the relative constancy of its internal environment - homeostasis. The search for hygienic criteria for assessing the effectiveness of educational technologies from the point of view of preserving the health of children during schooling shows the high information content of indicators of children's physical development [5,12,13].

Materials and methods

The study of modern children was carried out over the 2022/23 academic year. Schoolchildren from the Nizhny Novgorod region took part in the observation; primary schoolchildren living in rural areas acted as the experimental group (n = 1396 viz., boys: 711, girls: 685). The control group was a representative group of peers in the metropolis of Nizhny Novgorod, studying in grades 1-3 (n = 1104 viz., boys: 535, girls: 569).

The main anthropological parameters of the auxological status of the morphofunctional adaptation of children are considered: anthropometric or total body dimensions - body length (BL), body weight (BW), chest circumference (CHC); physiometric or hemodynamic - systolic and diastolic blood pressure (SBP; DBP), heart rate (HR).

The formation of combination tables and statistical data processing were carried out in the Microsoft Access 2019 database management system using the Biostatics v statistical application programs. 4.03, Statistica v.6.0.

To quantify the values and statistical differences in indicators by age, sex, and administrative characteristics, the median (Me), standard deviation (±σ), degree of freedom (ss), Pearson correlation coefficient (r), Fisher criteria (F), Wilkes lambda (λU), Mahalanobis (D^2). Differences were considered statistically significant at $p \leq 0.05$ [14,15].

Results

Anthropometry indicators or total body sizes in children of primary education or the first age group of 7-10 years do not go beyond the regional age-ash standard [12]. With a more in-depth examination of the characteristics of anthropometry and hemodynamics in children, in the gradation of areas of residence with varying degrees of urbanization, it was revealed that children living in rural areas are significantly (at $p < 0.05$) inferior to their peers in the metropolis. In terms of body length, boys aged 7-10 years are lower in the range of 0.5% - 2.2%, the increase from seven to 10 years was 15.7 and 14.4 centimeters, respectively, in rural areas the increase was 1.3 cm more. Analysis of variance also shows significant differences (at $p < 0.001$) in favor of boys in the metropolis.

In terms of body weight, a tendentious predominance of the indicator was revealed at all ages, except for the age of eight, where rural boys are ahead of urban boys by 0.7 kilograms or 2.5%.

The values of the chest circumference indicator in urban people were ahead of the indicators of rural peers at the age of seven, tendentiously by 1.6% and at the age of nine and by 2.1% (at $p < 0.05$) significantly. At eight and ten years old, rural boys were ahead of urban boys by 0.2% - 1.1%. Variances based on age and level of urbanization are significantly different (at $p < 0.001$) in favor of maturation in the first case and heterochronicity of growth processes in the second.

Girls in the experimental group or living in rural areas are inferior in body length and weight to urban girls at all observed ages by 1.1% - 1.6% and 2.4% - 4.7%, respectively; these differences are significant at the age of eight and ten characters (at $p < 0.01$) in terms of body length and are insignificant in terms of body weight, and only at nine years old are women of the same age in the village ahead of city girls by 0.1% in length and 3.1% in body weight, only tendentiously.

Chest circumference indicators in rural girls are 0.2% - 1.0% less at the trend level up to the age of eight. At nine years of age, priority goes to rural children; they are larger by 2.1% (at $p < 0.05$) and tendentiously by 0.2% at ten years. Analysis of variance showed differences in distributions, both by age and by the urbanization factor (at $p < 0.001$), thereby characterizing them as significant (Table 1).

Psychometric indicators of hemodynamics in comparison of the experimental and control groups (Me±σ) revealed higher absolute values of systolic blood pressure among peers in the metropolis. The range of priority is expressed as 1.8% - 7.5%, except for the age of ten, this difference is significant, with $p < 0.01$. Also, rural children showed significantly lower heart rate values from 1.6% to 9.3% at $p < 0.01$, in contrast to the trend at the age of seven.

Diastole showed higher values in rural boys, their values were higher in the range of 7.1% - 13.7%, significantly higher at $p < 0.01$, except for the trend at the age of seven.

Girls, like boys, demonstrate a congruent pattern, i.e. an

Table 1: Comparative analysis of anthropometric indicators students in the experimental and control groups (Me±σ).

Indicator	Age (years)	Regions:						Statistics:	
		Village experimental group			Megapolis control group			±Δ	*p* =
		n	Me	±σ	n	Me	±σ	Abs./%	
Boys:									
BL	7	108	123,4	6,25	106	126,2	5,34	-2,8/ -2,2	**0,01**
	8	187	129,2	5,53	144	129,9	5,94	-0,7/-0,5	0,24
	9	230	133,8	6,44	127	136,7	6,10	-2,9/-2,1	**0,01**
	10	186	139,1	6,60	158	140,6	5,71	-1,5/-1,1	**0,02**
Statistics:		F village (experiment) = 166,37; cc = 3/710; *p* = 0,001 F metropolis(control) = 166,11; cc = 3/534; *p* = 0,001							
BW	7	108	24,1	4,92	106	25,6	4,63	-1,5/-5,8	0,32
	8	187	28,6	6,31	144	27,9	5,58	+0,7/+2,5	**0,03**
	9	230	31,2	7,09	127	32,9	7,67	-1,7/-5,2	0,21
	10	186	34,3	8,45	158	35,4	8,69	-1,1/-3,1	0,08
Statistics:		F village (experiment) = 166,37; cc = 3/710; *p* = 0,001 F metropolis(control) = 166,11; cc = 3/534; *p* = 0,001							
CHC	7	108	60,3	4,58	106	61,3	4,31	-1,0/ -1,6	0,08
	8	187	63,6	5,27	144	62,9	5,15	+0,7/+1,1	0,29
	9	230	65,7	6,21	127	67,1	6,68	-1,4/-2,1	**0,05**
	10	186	68,3	7,75	158	68,2	7,41	+0,1/+0,2	**0,04**
Statistics:		F village (experiment) = 41,86; cc = 3/710; *p* = 0,001 F metropolis(control) = 36,97; cc = 3/534; *p* = 0,001							
Girls:									
BL	7	113	123,5	5,52	107	124,8	5,20	-1,3/-1,1	0,07
	8	185	127,6	6,19	162	129,4	5,76	-1,8/-1,4	**0,01**
	9	199	134,3	7,04	161	134,2	6,02	+0,1/+0,1	0,98
	10	188	138,1	7,16	139	140,4	6,65	-2,3/-1,6	**0,01**
Statistics:		F village (experiment) = 166,37; cc = 3/710; *p* = 0,001 F metropolis(control) = 148,08; cc = 3/534; *p* = 0,001							
BW	7	113	24,2	5,35	107	24,8	4,77	-0,6/-2,4	0,32
	8	185	26,8	6,42	162	27,8	6,95	-1,0/-3,1	0,17
	9	199	30,8	7,18	161	29,9	5,77	+0,9/+3,1	0,23
	10	188	32,8	7,39	139	34,4	7,45	-1,6/-4,7	**0,06**
Statistics:		F village (experiment) = 50,05; cc = 3/710; *p* = 0,001 F metropolis(control) = 50,21; cc = 3/534; *p* = 0,001							
CHC	7	113	59,6	5,02	107	60,2	6,36	-0,6/-1,0	0,40
	8	185	61,6	5,49	162	61,7	6,26	-0,1/-0,2	0,94
	9	199	64,5	6,01	161	63,2	5,53	+1,3/+2,1	**0,04**
	10	188	66,9	6,58	139	66,8	6,83	+0,1/+0,2	0,84
Statistics:		F village (experiment) = 26,39; cc = 3/710; *p* = 0,001 F metropolis(control) = 46,00; cc = 3/534; *p* = 0,001							

increase in hemodynamic indicators in urban relative to rural ones in terms of systole and pulse, and also an increase in diastolic blood pressure in rural relative to urban ones.

Analysis of variance showed differences in the distributions of hemodynamic parameters, both by age and by the urbanization factor (at $p < 0.001$), thereby characterizing them as significant (Table 2).

Correlations of the observed indicators revealed the following patterns of interdependence depending on the place of residence: the largest statistically significant correlation is shown between body length and weight - for boys 0.73/0.76 and 0.69/0.71 for girls, between body weight and chest circumference 0.88/0.92 and 0.85/0.90, which characterizes body weight as a determining factor in ascertaining individual and group anthropometry indicators.

Hemodynamic parameters revealed more moderate correlations both with anthropometric characteristics and among themselves, at the level of significant, medium, and weak correlations.

It is indicative that in urban children these connections are for the most part closer and more conditioned among themselves in the context of anthropometry and weaker in the context of hemodynamics. This indicates more intense interactions between these systems of the children's bodies under the pressure of urbanization (Table 3).

To identify an objective picture of the genesis of anthropological, auxological (anthropometric, psychometric-hemodynamic) components included in the standard group of indicators of physical development, defined by the tradition of pediatrics and hygiene, a series of multivariate analysis (canonical discriminant analysis) was carried out.

Table 2: Comparative analysis of hemodynamic parameters of children experimental and control groups (Me±σ).

Indicator	Age (years)	Regions:						Statistics:	
		Village experimental group			Megapolis control group			±Δ	*p* =
		n	Me	±σ	n	Me	±σ	Абс./%	
		Boys:							
SPB	7	108	94,1	10,83	106	101,7	9,41	-7,6/-7,5	0,01
	8	187	97,5	10,67	144	104,9	9,97	-7,4/-7,1	0,01
	9	230	101,7	10,38	127	106,1	10,63	-4,4/-4,2	0,01
	10	186	103,2	10,53	158	105,1	10,68	-1,9/-1,8	0,11
Statistics:		F village (experiment) = 22,48; cc = 3/710; *p* = 0,001 F metropolis(control) = 3,78; cc = 3/534; *p* = 0,01							
DPB	7	108	62,4	7,99	106	60,2	8,85	+2,2/+3,7	0,06
	8	187	64,2	7,95	144	59,7	8,25	+4,5/+7,1	0,01
	9	230	67,3	8,70	127	61,1	8,14	+6,2/+10,2	0,01
	10	186	68,6	9,19	158	60,3	7,73	+8,3/+13,7	0,01
Statistics:		F village (experiment) = 17.48; cc = 3/710; *p* = 0,00 F metropolis(control) = 0.54; cc = 3/534; *p* = 0,675							
HR	7	108	87,2	11,75	106	88,6	11,17	-1,4/-1,6	0,36
	8	187	86,3	12,28	144	88,9	11,29	-2,6/-2,9	0,05
	9	230	82,9	11,81	127	91,4	11,86	-8,5/-9,3	0,01
	10	186	81,4	11,42	158	86,8	11,92	-5,4/-6,2	0,01
Statistics:		F village (experiment) = 8.27; cc = 3/710; *p* = 0,001 F metropolis(control) = 3.52; cc = 3/534; *p* = 0,01							
Girls:									
SPB	7	113	95,5	10,74	107	101,9	10,22	-6,4/-6,3	0,01
	8	185	97,5	10,75	162	103,4	10,11	-5,9/-5,7	0,01
	9	199	102,9	9,98	161	105,2	10,32	-2,3/-2,2	0,04
	10	188	104,8	10,55	139	105,5	9,98	-0,7/-0,6	0,54
Statistics:		F village (experiment) = 27.46; cc = 3/710; *p* = 0,001 F metropolis(control) = 3.35; cc = 3/534; *p* = 0,01							
DPB	7	113	62,5	8,31	107	59,8	8,01	+2,7/+4,5	0,01
	8	185	64,7	8,12	162	60,6	7,07	+4,1/+6,8	0,01
	9	199	67,5	8,93	161	61,1	8,04	+6,4/+10,5	0,01
	10	188	70,3	9,81	139	61,2	7,91	+9,1/+14,8	0,01
Statistics:		F village (experiment) = 21.93; cc = 3/710; *p* = 0,001 F metropolis(control) = 0.90; cc = 3/534; *p* = 0,40							
HR	7	113	88,8	13,74	107	91,9	12,62	-3,1/-3,4	0,07
	8	185	85,9	11,92	162	92,3	11,77	-6,4/-6,9	0,01
	9	199	85,8	12,87	161	90,5	11,84	-4,7/-5,2	0,01
	10	188	84,8	13,69	139	91,8	12,72	-7,0/-7,6	0,01
Statistics:		F village (experiment) = 2.18; cc = 3/710; *p* = 0,08 F metropolis(control) = 0.69; cc = 3/534; *p* = 0,559							

Table 3: Correlation matrix (r) of indicators of boys and girls in primary education depending on place of residence (rural/urban)

Indicators:	BL	BW	CHC	SPB	DPB	HR
Boys:						
BL	-	**0,73/0,76**	**0,62/0,67**	**0,39/0,23**	**0,29/0,10**	-0,12/-0,03
BW	**0,69/0,71**	-	**0,88/0,92**	**0,38/0,37**	**0,29/0,28**	-0,05/0,06
CHC	**0,63/0,56**	**0,85/0,90**	-	**0,35/0,35**	**0,27/0,26**	-0,02/0,09
SPB	**0,40/0,23**	**0,37/0,34**	**0,36/0,33**	-	**0,63/0,65**	**0,13/0,23**
DPB	**0,33/0,14**	**0,30/0,25**	**0,31/0,24**	**0,61/0,65**	-	**0,08/0,24**
HR	-0,06/-0,02	0,02/0,05	0,03/0,07	**0,15/0,23**	**0,13/0,25**	-
Girls:						

Note: highlighted in bold – significant correlations, at $p < 0.05$.

Time series of the root of the first canonical variable KP-1, graded by age from 7 to 10 years of age, for boys and girls, show:

- For boys of seven to eight years of age, based on the standardized coefficients of discriminant functions, according to the first canonical variable (CP-1), the division of the series occurred according to hemodynamic characteristics, whereas at seven years these are boys with reduced systolic and increased diastolic, and at eight years, vice versa. At nine years of age, heart rate is added as a significant group separator. At the age of ten, anthropometric characteristics are added as a group modifier: at one extreme there are boys with increased body weight, decreased chest circumference values, and increased systolic blood pressure and pulse with simultaneously decreased diastolic pressure. The differences in this context between boys living in the metropolis and the village are statistically significant at $p < 0.001$ and objectively high values of Mahalanobis distances (D2 = 2.375) (Table 4).

- For girls of seven to eight years of age, standardized coefficients of discriminant functions of canonical variables showed a division of series according to hemodynamic characteristics, where at seven years these are girls with reduced systolic and increased diastolic, at eight years of age, on the contrary, with lower diastole and increased systole (with D2 = 2.43; $p < 0.001$). However, in girls, already at the age of nine, the anthropometric indicator - chest circumference - is added as a significant separator of groups. At the age of ten, both anthropometric and hemodynamic characteristics act as a group modifier: at one pole there are girls with increased body weight, a narrowed or racialized chest circumference, with increased systolic blood pressure and pulse with simultaneously decreased diastolic pressure. The differences in this context between girls living in a metropolis and a village are statistically significant at $p < 0.001$ and objectively high, representative (D2 = 2.396) values of the Mahalanobis distances (Table 4).

Conclusion

Thus, an analysis of the main parameters of the auxological status of rural and urban children of primary school age showed that, in general, the indicators are consistent with the modern regional standard of physical development of children and adolescents.

However, rural children of primary education, for the most part, at the level of patterns, differ from their urban peers in terms of total body size in terms of shorter height and light weight, increased chest circumference in boys only at the age of eight and ten years, in girls at the age of nine and ten years.

Rural children have lower systolic and higher diastolic blood pressure. At the same time, their heart rate is in a more optimal range and also differs in the direction of underestimation relative to students in the metropolis.

In rural children, a significant increase in diastole relative to rural children may indicate the assumption of a more intense and ergotropic process of adaptation of the functions of the cardiovascular and autonomic nervous system, with subsequent sympathetic manifestations of body functions.

Multivariate intergroup, discriminant canonical analysis revealed that from the point of view of functions, the hemodynamic sign, in particular diastolic blood pressure, shows itself to be decisive throughout the entire period of second childhood or primary education, while the division of series according to anthropometry signs begins to occur only from the age of ten and the greatest Contribution to the separation of groups, ranked, is made by body mass and length.

Table 4: Standard coefficients for canonical variables in factor gradation – "Rural/Megapolis" (boys/girls).

Indicators:	Standard coefficients for canonical variables							
	Boys				Girls			
	Years							
	7	8	9	10	7	8	9	10
	The root of the first canonical variable (KP-1)							
BL	-0,34	0,17	0,44	-0,01	-0,10	0,33	0,02	0,22
BW	0,08	-0,26	-0,32	**0,52**	0,04	0,26	0,28	**0,56**
CHC	0,11	0,02	0,22	**-0,57**	-0,03	-0,29	**-0,46**	**-0,53**
SPB	**-1,18**	**1,20**	**0,73**	**0,73**	**-1,09**	**1,04**	**0,77**	**0,54**
DPB	**0,96**	**-1,11**	**-1,10**	**-1,15**	**0,99**	**-1,15**	**-1,11**	**-1,09**
HR	-0,02	0,05	0,56	0,45	-0,12	0,46	0,42	0,42
λ U	0,719	0,628	0,285	0,637	0,781	0,624	0,723	0,632
D^2	1,547	2,395	3,038	2,375	1,107	2,43	1,491	2,396
***P* =**	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001

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