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COMPARATIVE ANALYSIS OF PHYSICAL DEVELOPMENT STANDARDS OF STUDENTS IN NIZHNY NOVGOROD AND NIZHNY NOVGOROD OBLAST

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Annotation. The article presents the results of a comparative analysis of the standards for the physical development of students, developed in 1990, in 2017 and in 2019 for boys and girls of Nizhny Novgorod and Nizhny Novgorod Oblast. The differences found during the study confirm the need to use evaluation tables of different territorial levels, i.e. for students from Nizhny Novgorod and Nizhny Novgorod Oblast. The larger number of the examined in the development of the standard for students of Nizhny Novgorod Oblast allowed to create rating scales for each age and gender group, which makes it possible to obtain more informative results when evaluating the physical development of young boys and girls.

Keywords: students, centile method, standards of physical development, rating scales.

Introduction. Individual and collective estimation of the students' morphofunctional development is necessary to implement preventive and therapeutic measures for student groups. Scientific studies justify using the centile method in assessment of physical development (PD) of growing generation [1-2].

The centile method is the simplest non-parametric method in statistics. It may be used in an analysis of continuous values with distribution of any type, because it takes into account the real boundaries of the series for each attribute and does not shift the estimation towards underestimation or overestimation of the standard [3]. The centile scales show boundaries of a studied attribute, they include maximal and minimal values of each parameter. Application of such tables is easy and convenient. Each attribute is placed in a certain interval of the scale, which has its own name as an estimation of corresponding value of an index. There are 8 uneven centile intervals (CI), each of which has its own name. For example, 5CI or a median divides an order sample in half [4-5].

In Nizhny Novgorod Oblast (earlier called Gorky Oblast), physical development of schoolchildren and students is regularly monitored and standards are periodically adjusted [1-4, 6-8]. The first comprehensive monitoring

of students' health to develop PD standards was conducted in Gorky in the Ministry of Healthcare's targeted integrated program titled "Students' health". In 1987-1988, an anthropometric examination of students from 6 different universities of Gorky took place. Taking the results of the examination that included 1953 students into account, standards of PD were developed (published in 1990) using parametric and non-parametric methods of statistical analysis, which showed that for most of the studied attributes, the morphofunctional status formation in young men and women is completed by 20-21 years. The average values of body length in young men were 176.8 cm and 163.3 cm in young women, body mass – 71.0 kg and 60.1 kg respectively [1].

In 2013-2015, experts of the Privolzhsky Research Medical University (earlier called the Nizhny Novgorod State Medical Academy) conducted a study on PD of 2315 students (687 young men and 1628 young women) aged 17-30 years from 9 universities of Nizhny Novgorod, which included the generalized method in compliance with the unified PD research methodology. Results of the examination that included 1953 students served as a foundation for PD standards (published in 2017) based on the centile method [2, 7].

Studentship is a time interval that defines end of growing, hormonal and functional maturation of the body, its stabilization. The data obtained reflect transformation of these processes among the youth in connection with the global secular trend, which dictates the need for periodic examinations and adjustment of standards [7, 9].

There is an issue related to special and temporal limits. Temporal limits are based on PD indices, reflect changes in living conditions, motor activity, nutrition, health state, environment et al, depend on age and lifestyle. Spatial limits depend on genetic and ethnic features of the examined population group, which reflects a need to use rating tables of various territorial level differing not only by nationality, but also by place of residence: for urban and rural populations [7, 10].

Objective of the study – to conduct a comparative analysis of PD standards of students from Nizhny Novgorod and Nizhny Novgorod Oblast, which were developed in 1990, 2017 and 2019.

Methods and organization. In order to achieve the set task, we made a comparative analysis of 3 PD standards:

1 – the PD standards of Gorky students (1990) [1];

2 – the PD standards of Nizhny Novgorod students (2017) [7];

3 – the PD standards of students of Nizhny Novgorod Oblast (2019), developed by the authors in the dissertation research based on the results of a survey dated 2012-2017 of 7180 students aged 17-25 years [6].

The study was carried out using the generalized method among students from Nizhny Novgorod (Privolzhsky Research Medical University and Lobachevsky University, whose

main place of residence are the districts of Nizhny Novgorod Oblast), Arzamas (Arzamas branch of the Lobachevsky University, Arzamas Polytechnic University, Arzamas branch of the Russian University of Cooperation) during the educational process when studying the disciplines of the medical and physical education block and during preventive examinations in the Health Centers.

The anthropometric measurements included identification of body length (BL), body mass (BM), chest girth (CG), vital capacity (VC), right hand dynamometry (RHD), systolic and diastolic blood pressure (sBP and dBP), heart rate (HR), respiration tests on inhale and exhale [3, 11].

Taking the examination results into account, we created a personalized database, the statistical data processing was carried out with EXCEL v 8.00 and Version 4.03 Primer of Biostatistics. To fulfill the objectives of the study, the centile method was used. The chi-square test (χ^2) was applied to assess the reliability of the results. The differences deemed statistically significant if $p < 0.05$.

Results and discussion. The examined students from Nizhny Novgorod Oblast (2012-2017) were estimated according to two aforementioned standards, we also conducted the comparative analysis of the obtained results.

Analysis of PD indices demonstrated deviation from the reference in distribution of centile rating of total body dimensions. Distribution of BL and BM indices assessed according to the 2017 standards were close to reference values. However, when evaluating BL according to the 1990 standards, we can notice a right-sided displacement, which means that modern young men and women are taller than 30 years ago (table 1).

Table 1

Distribution of morphological indices' rating, %

CI	Ref	BL				BM				CG			
		young men		young women		young men		young women		young men		young women	
		1	2	1	2	1	2	1	2	1	2	1	2
1	3%	2.5	7.8	2.2	2.5	3.9	2.6	4.1	0.9	3.2	1.2	4.9	12.9
2	7%	5.9	4.6	4.6	5.3	9.1	9.5	10.2	3.7	8.0	21.8	10.0	17.0
3	15%	10.5	13.6	5.9	10.2	16.6	2.1	21.0	9.2	13.9	19.4	15.8	14.2
4	25%	16.5	29.3	16.2	23.2	26.4	26.5	24.9	36.7	25.2	13.0	22.6	18.3

Table 1 (continued)

5	25%	32.5	20.9	26.0	33.5	24.4	20.6	19.4	21.6	22.5	27.7	21.4	18.4
6	15%	16.6	12.1	23.1	14.8	9.6	11.8	11.0	12.1	15.6	12.1	11.2	12.3
7	7%	10.7	9.2	11.9	6.5	4.8	6.4	7.4	12.2	6.8	4.2	9.9	4.2
8	3%	4.8	2.5	10.1	3.9	5.1	1.5	2.1	3.6	4.8	0.5	4.1	2.7
Statistical data		$\chi^2=10.06$ p=0.023		$\chi^2=9.09$ p=0.036		$\chi^2=2.37$ p=0.68		$\chi^2=13.72$ p=0.004		$\chi^2=16.62$ p=0.001		$\chi^2=9.09$ p=0.036	

Note: CI – centile interval; BL – body length; BM – body mass; CG – chest girth; Ref – reference; 1 – rating according to the 1990 standards; 2 – rating according to the 2017 standards

Left-sided asymmetry in rating distribution was revealed both in young men and women in CG and RHD indices (which means that low values of such indices are predominant), as well as in BM index in young men according to the 2017 standards. The right-sided asymmetry in

students is characterized by the rating distribution of sBP, as well as VC in young women according to the 1990 standards (tables 2, 3).

There was a significant deviation from the reference of dBP's rating distribution associated with uneven CI in the 1990 and 2017 standards (table 3).

Table 2

Distribution of physiometric indices' rating, %

CI	Ref	VC				RHD			
		young men		young women		young men		young women	
		1	2	1	2	1	2	1	2
1	3%	3.2	0.9	1.2	0.3	17.6	9.5	18.0	11.2
2	7%	10.1	8.6	6.4	2.8	22.1	9.8	15.8	8.4
3	15%	11.7	12.9	8.8	7.8	24.0	18.4	17.5	11.9
4	25%	24.6	17.1	11.1	17.2	15.5	29.4	20.1	24.9
5	25%	22.4	26.1	30.2	30.3	12.6	15.2	12.3	18.9
6	15%	15.7	22.2	20.8	25.1	4.7	11.0	10.1	9.8
7	7%	7.3	8.4	10.4	10.0	2.3	3.0	2.6	11.1
8	3%	4.9	3.7	11.1	6.4	1.3	3.6	3.7	3.8
Statistical data		$\chi^2=4.07$ p=0.34		$\chi^2=4.01$ p=0.33		$\chi^2=15.78$ p=0.002		$\chi^2=12.25$ p=0.008	

Note: CI – centile interval; VC – vital capacity; RHD – right hand dynamometry; Ref – reference; 1 – rating according to the 1990 standards; 2 – rating according to the 2017 standards

Table 3

Distribution of hemodynamic indices' rating, %

CI	Ref	HR				sBP				dBP			
		young men		young women		young men		young women		young men		young women	
		1	2	1	2	1	2	1	2	1	2	1	2
1	3%	3.7	1.7	4.3	2.4	0.2	4.3	1.6	2.1	0.3	1.1	2.1	3.2
2	7%	2.0	5.2	5.3	4.2	1.9	3.1	1.1	4.1	0.3	4.7	0.3	3.3
3	15%	17.2	7.7	18.4	10.6	1.6	18.1	15.7	19.4	3.8	28.7	1.7	12.9
4	25%	15.9	41.5	14.5	26.4	30.3	43.5	8.5	24.4	3.0	37.2	13.5	13.7
5	25%	27.9	25.3	31.4	27.0	20.8	10.4	27.6	19.0	56.4	16.5	9.4	27.9
6	15%	22.5	11.7	14.2	18.6	31.9	11.7	17.7	17.6	7.3	6.8	41.1	23.0
7	7%	6.0	3.9	10.3	7.8	11.3	5.1	14.6	7.9	18.1	3.8	6.3	12.0
8	3%	4.9	2.9	1.6	3.0	2.0	3.7	13.2	5.3	10.8	1.1	25.7	3.9
Statistical data		$\chi^2=20.84$ p<0.001		$\chi^2=6.86$ p=0.10		$\chi^2=33.35$ p<0.001		$\chi^2=16.24$ p=0.001		$\chi^2=88.56$ p<0.001		$\chi^2=42.21$ p<0.001	

Note: CI – centile interval; HR – heart rate; sBP – systolic blood pressure; dBP – diastolic blood pressure; 1 – rating according to the 1990 standards; 2 – evaluation according to the 2017 standards

Asymmetry in distribution of centile rating and revealed features of the morphofunctional indices of modern students from Nizhny Novgorod Oblast prove that the region needs its own standards.

During the study we also compared PD standards for students of Nizhny Novgorod (2017) and Nizhny Novgorod Oblast (2019). A number of students participating in examinations for developing standards for Nizhny Novgorod was 2315 people aged 17-30 years, for developing standards for Nizhny Novgorod Oblast – 7180 people aged 17-25 years. Higher number of the examined allowed creating scales for each age group (tables 4-9).

When comparing distribution of BL and BM, we were able to note a greater variability of these indices among students of Nizhny Novgorod (tables 4, 5).

When comparing medians (5CI), we found that young men and women of Nizhny Novgorod Oblast have higher VC, but lower RHD compared to students of Nizhny Novgorod (tables 6, 7).

Comparative analysis of hemodynamic indices demonstrated higher values of sBP and dBP in young men of Nizhny Novgorod (table 8).

Among young women, values of hemodynamic parameters (sBP, dBP and HR) were higher in female students of Nizhny Novgorod Oblast (table 9).

Table 4

Comparative analysis of univariate centile scales of morphological indices of young men
of Nizhny Novgorod and Nizhny Novgorod Oblast

Indices, standards, age		Centile intervals							min-max	
		2CI	3CI	4CI	5CI	6CI	7CI	8CI		
BL	1	17-21 years	168	170	175	179	183	186	190	150-200
		22 and older	168	172	176	180	183	186	194	164-198
	2	17 years	164	167	172	176	179	183	186	160-190
		18 years	164	169	173	177	181	185	188	160-193
		19 years	165	170	175	178	181	185	189	161-194
		20 years	165	170	176	179	183	185	190	159-195
		21 and older	164	169	175	179	184	186	191	160-196
BM	1	17-21 years	54.2	59.6	64.3	70.1	76.5	85.4	95.2	45.1-145.0
		22 and older	58.6	63.9	70.3	76.1	84.6	97.5	105.7	56.5-125.2
	2	17 years	55	57	60	65	71	78	87	49-94
		18 years	57	59	62	68	73	80	89	50,8-99
		19 years	57	59	63	69	75	83	90	52-113
		20 years	58	61	65	70	76	86	91	52,7-119
		21 and older	59	62	66	71	78	90	95	51,4-123
CG	1	17-21 years	80	88.1	91.5	93.5	98.6	105.4	114.1	75.7-119.5
		22 and older	80.1	86.5	90.7	95.3	102.7	114	120.8	78.2-124.6
	2	17 years	81	83	86	90	95	98	104	71-114
		18 years	82	84	87	91	96	102	105	76-113
		19 years	83	85	88	92	96	103	106	74-115
		20 years	84	87	90	94	97	103	108	75-117
		21 and older	85	87	90	95	99	105	109	79-121

Note: CI – centile interval; BL – body length; BM – body mass; CG – chest girth; 1 – standards of physical development of students from Nizhny Novgorod (1990); 2 – standards of physical development of students from Nizhny Novgorod Oblast (2019)

Table 5

Comparative analysis of univariate centile scales of morphological indices of young women of
Nizhny Novgorod and Nizhny Novgorod Oblast

Indices, standards, age			Centile intervals							min-max
			2CI	3CI	4CI	5CI	6CI	7CI	8CI	
BL	1	17-20 years	154	158	161	165	170	174	177	145-184
		21 years and older	155	158	162	166	170	174	178	139-189
	2	17 years	154	158	161	165	168	171	174	149-179
		18 years	154	158	162	166	169	173	175	150-181
		19 years	155	158	163	166	171	174	177	151-181
		20 years	156	160	164	166	171	174	178	147-184
		21 and older	154	159	162	166	171	174	178	151-183
BM	1	17-20 years	44.6	47.2	50.7	55.4	60.9	65.5	75.2	35.4-105.1
		21 years and older	45.6	48.3	52.9	56.3	63.5	69.7	82.6	41.6-106.2
	2	17 years	46	48	51	54	58	66	72	41.5-82.0
		18 years	47	49	52	55	61	68	73	41-95.7
		19 years	48	50	53	55	63	70	73	40.2-97.7
		20 years	49	51	54	56	64	70	74	42-96.7
		21 and older	49	52	55	57	65	72	77	43.4-107
CG	1	17-20 years	77	80	81	84	88	93	97	75,0-106,6
		21 years and older	70.7	73.2	78.8	83.5	88.4	93.7	100.4	66.4-124.4
	2	17 years	73	75	77	80	84	89	92	65-102
		18 years	74	75	78	80	85	90	93	63-108
		19 years	74	75	78	81	86	91	93	64-106
		20 years	75	77	79	83	87	92	95	66-104
		21 and older	75	77	80	83	88	93	96	68-111

Note: CI – centile interval; BL – body length; BM – body mass; CG – chest girth; 1 – standards of physical development of students from Nizhny Novgorod (1990); 2 – standards of physical development of students from Nizhny Novgorod Oblast (2019)

Table 6

Comparative analysis of univariate centile scales of physiometric indices of young men of Nizhny
Novgorod and Nizhny Novgorod Oblast

Indices, standards, age			Centile intervals							min-max
			2CI	3CI	4CI	5CI	6CI	7CI	8CI	
VC	1	17-21 years	2.0	2.5	3.0	3.5	4.2	5.0	5.6	1.3-6.6
		22 years and older	2.5	3.2	3.7	4.2	4.7	5.4	6.0	1.7-6.4
	2	17 years	2.0	2.4	2.8	3.6	4.3	4.8	5.0	1.8-5.9
		18 years	2.0	2.5	3.0	3.7	4.3	4.9	5.2	1.9-6.1
		19 years	2.0	2.5	3.2	3.8	4.4	5.0	5.3	2.0-6.6
		20 years	2.2	2.5	3.2	3.9	4.5	5.3	5.6	2.0-6.3
		21 and older	2.6	2.8	3.5	4.1	4.6	5.4	5.6	1.9-6.9
RHD	1	17-21 years	30	35	40	45	50	57	60	11-80
		22 and older	37	40	42	50	55	60	64	20-75

Table 6 (continued)

RHD	2	17 years	24	30	35	40	42	47	52	13-64
		18 years	25	30	36	40	44	49	53	15-71
		19 years	26	30	36	41	45	50	55	18-74
		20 years	27	32	36	43	48	53	57	16-75
		21 and older	30	33	38	45	52	60	64	17-77

Note: CI – centile interval; VC – vital capacity; RHD – right hand dynamometry; 1 – standards of physical development of students from Nizhny Novgorod (1990); 2 – standards of physical development of students from Nizhny Novgorod Oblast (2019)

Table 7

Comparative analysis of univariate centile scales of physiometric indices of young women of Nizhny Novgorod and Nizhny Novgorod Oblast

Indices, standards, age			Centile intervals							min-max
			2CI	3CI	4CI	5CI	6CI	7CI	8CI	
VC	1	17-20 years	1.4	1,8	2,2	2.7	3.2	3.6	4.0	0.9-5.0
		21 years and older	1.9	2.2	2,6	3.0	3.3	3.7	4.2	1.0-6.3
	2	17 years	1.7	1.9	2,3	2.9	3.3	3.6	3.8	1.4-5.1
		18 years	1.8	2.2	2,6	3.0	3.4	3.7	4.0	1.7-5.6
		19 years	1.9	2.2	2,6	3.1	3.4	3.8	4.1	1.6-5.4
		20 years	2.0	2.2	2,8	3.1	3.5	3.8	4.1	1.7-5.7
		21 and older	2.0	2.2	2,8	3.1	3.5	3.8	4.1	1.5-5.3
RHD	1	17-20 years	18	20	21	25	30	32	38	10-60
		21 years and older	16	20	22	25	30	33	38	10-57
	2	17 years	13	14	18	22	28	31	34	10-53
		18 years	14	16	20	23	28	33	35	11-55
		19 years	15	18	21	24	28	33	35	12-54
		20 years	16	18	21	25	31	35	37	11-52
		21 and older	14	17	20	23	30	35	38	10-58

Note: CI – centile interval; VC – vital capacity; RHD – right hand dynamometry; 1 – standards of physical development of students from Nizhny Novgorod (1990); 2 – standards of physical development of students from Nizhny Novgorod Oblast (2019)

Table 8

Comparative analysis of univariate centile scales of hemodynamic indices of young men of Nizhny Novgorod and Nizhny Novgorod Oblast

Indices, standards, age			Centile intervals							min-max
			2CI	3CI	4CI	5CI	6CI	7CI	8CI	
HR	1	17-21 years	57	63	69	77	82	89	95	48-122
		22 years and older	58	63	68	73	78	84	92	48-108
	2	17 years	62	70	75	78	82	88	94	54-117
		18 years	62	67	72	77	81	86	92	52-115
		19 years	60	65	72	75	78	84	91	50-114
		20 years	60	65	70	74	77	84	88	51-108
		21 and older	60	64	70	73	77	84	88	44-112
sBP	1	17-21 years	101	107	115	122	126	132	139	85-148
		22 and older	103	109	113	121	124	131	138	86-150

Table 8 (continued)

sBP	2	17 years	98	105	110	115	120	127	131	87-139
		18 years	100	107	112	117	121	128	133	89-145
		19 years	102	107	114	118	123	128	136	90-149
		20 years	102	110	115	119	125	131	137	91-148
		21 and older	104	110	115	120	125	134	137	90-150
dBP	1	17-21 years	56	63	74	80	84	87	92	50-96
		22 and older	62	67	72	80	85	89	93	50-104
	2	17 years	60	63	70	73	75	81	84	50-89
		18 years	61	66	70	74	77	80	85	52-96
		19 years	63	66	70	75	80	84	86	51-97
		20 years	64	69	72	76	80	85	88	53-96
		21 and older	64	69	72	77	80	85	90	55-98

Note: CI – centile interval; HR – heart rate; sBP – systolic blood pressure; dBP – diastolic blood pressure; 1 – standards of physical development of students from Nizhny Novgorod (1990); 2 – standards of physical development of students from Nizhny Novgorod Oblast (2019)

Table 9

Comparative analysis of univariate centile scales of hemodynamic indices
of young women of Nizhny Novgorod and Nizhny Novgorod Oblast

Indices, standards, age			Centile intervals						min-max	
			2CI	3CI	4CI	5CI	6CI	7CI	8CI	
HR	1	17-20 years	58	63	69	77	82	89	96	54-116
		21 years and older	58	64	69	72	80	85	94	52-116
	2	17 years	62	68	75	80	84	89	95	55-110
		18 years	61	65	71	79	84	89	92	51-121
		19 years	60	65	70	77	82	88	91	54-117
		20 years	60	65	70	76	82	88	90	52-101
		21 and older	59	64	70	75	80	88	90	51-108
sBP	1	17-20 years	91	98	106	113	118	123	130	80-142
		21 years and older	93	98	105	112	117	123	129	82-145
	2	17 years	93	99	103	110	117	122	125	84-137
		18 years	95	100	104	111	118	124	128	83-140
		19 years	96	100	105	112	120	125	130	84-141
		20 years	97	101	107	113	120	125	130	88-143
		21 and older	98	102	109	114	120	125	130	81-145
dBP	1	17-20 years	57	60	66	70	74	80	85	42-92
		21 years and older	59	64	67	71	78	82	86	50-95
	2	17 years	58	60	66	70	76	80	83	51-88
		18 years	58	61	67	71	76	80	83	51-91
		19 years	59	61	68	72	78	80	84	50-94
		20 years	60	64	69	73	78	80	84	49-92
		21 and older	60	64	69	74	78	80	84	41-94

Note: CI – centile interval; HR – heart rate; sBP – systolic blood pressure; dBP – diastolic blood pressure; 1 – standards of physical development of students from Nizhny Novgorod (1990); 2 – standards of physical development of students from Nizhny Novgorod Oblast (2019)

Conclusion. Therefore, according to results of the comparative analysis of the 1990 standards, as well as the 2017 and 2019 standards, the following conclusions can be drawn:

1. Considering spatial limits of the PD standards and revealed differences, there is a need to use rating tables of various territorial level for students from Nizhny Novgorod and Nizhny Novgorod Oblast.

2. In order to assess PD, we recommend the centile method that is applied for an analysis

of continuous values with distribution of any type, since it takes into account the real boundaries of the series for each characteristic and does not shift the estimation towards underestimation or overestimation of the standard

Higher number of the examined students of Nizhny Novgorod Oblast allowed creating rating scales for each age and gender group, which provided a possibility to gain more informative results while evaluating PD of young men and women.

Conflict of interest. The authors declare no conflict of interest.

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