Article

Assessment of anthropometric and hemodynamic parameters in young people in the cardiovascular system adaptation ability

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Abstract: The index of functional Changes (IFC) is a complex indicator based on the relationship between the heart rate of decrease and the associated risk of developing cardiovascular pathologies, as well as to study the state of vascular contractions, systolic and diastolic blood pressure, age, body weight and height. [2] The aim of the study is to compare the mechanisms of adaptation of the diseases of the cardiovascular system (CVS) in young men and women in the Russian Federation, to identify the main risk factors of the wall in young people depending on the functional reserves of the CVS. Materials and methods: The study includes 91 students aged 17 to 25 years. Heart rate (HR), systolic and diastolic blood pressure (SBP, DBP), height, body weight, waist and hip circumference were measured noninvasively in all participants. The ratio of waist and hip circumferences (RW/RH), body mass index (BMI) was calculated. The main tool in the study of vascular wall stiffness was photoplethysmography.
As a result of the research, an unequal distribution of IFC indicators between men and women was revealed. There were more women with a satisfactory level of adaptation, and men with the same level of IFC, therefore, less. These data indicate that men are most often at risk of developing CVS. The differences in the average values of the Kerdo index (IK). between men and women are statistically insignificant. Young people with a slight weight deficit and normal body weight have a greater potential for adaptation than people with excess body weight and obesity. According to photoplethysmography, the indicators of stiffness of vascular wall (VW) and the velocity of the pulse wave propagation through the vessels (VPWP) in young people with different adaptive reserves did not differ significantly.

Keywords: Adaptive potential, vascular wall stiffness, body mass index, anthropometry, photoplethysmography.

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1. Introduction

The cardiovascular system has adaptive capabilities, which are constantly spent on maintaining a balance between the body and the external environment [1]. The Functional Change Index (IFC) is a complex indicator that includes heart rate, blood pressure, age, body weight and height. IFC plays an important role in the body's adaptation to external factors [2]. Determining the state of the vascular wall is an urgent task for determining cardiovascular risk in patients with arterial hypertension and atherosclerosis.

Currently, diseases of the cardiovascular system (CVS) are the most common, "younger" pathology. In 2019, CVS was the main cause of 9.6 million deaths among men and 8.9 million deaths among women, which is about a third of all deaths in the world [3]. High body mass index and systolic blood pressure are risk factors for the development of CVS in middle age [4]. Early identification of risk factors and sexual characteristics of CVS adaptation is an important task of modern medicine [5].

2. Materials and Methods

The study was conducted from February to May 2023, 91 students aged 17 to 25 years took part in it, the average age of which was 19 ± 0.8 years. The sexual distribution was: (n=50) – women, (n=41) – men.

To assess the level of functioning of the cardiovascular system, the terminology of adaptation theory was used, according to which 3 groups of people are distinguished by health levels: with

satisfactory adaptation (IFC 1), with tension of adaptation mechanisms (IFC 2) and with unsatisfactory adaptation (IFC3). [6]

Heart rate (HR), systolic and diastolic blood pressure (SBP, DBP), height, body weight, waist and hip circumference were measured noninvasively in all participants. The ratio of waist and hip circumferences (RW/RH), body mass index (BMI) were calculated.

The functional change Index (IFC) was calculated using the R. Bayevsky formula:

IFC = 0.011*PR + 0.014*SBP + 0.008*DBP + 0.014*A + 0.09*BW – (0.009*H + 0.27), where IFC – the index of functional Changes; A – age, years; BW – body weight, kg; H – height, cm; SBP – systolic blood pressure, mmHg, DBP – diastolic blood pressure, mmHg; PR – pulse rate in 1 min.

Values of the adaptation index:

1.5-2.59 – satisfactory adaptation, that is, positive adaptation of the CVS to environmental conditions;

2.6-3.09 – tension of adaptation mechanisms;

3.1 and more – unsatisfactory adaptation.

Additionally, the Student coefficient was calculated (the number of degrees of freedom was calculated, and then the coefficient itself).

To assess the influence of the autonomic nervous system, the Kerdo index was used:

KI =(1-DB/HR) ×100%.

Normally, IR ranges from -10 to +10%: positive values of IR indicate a predominance of activity of the sympathetic nervous system, negative values indicate a predominance of tone of the parasympathetic nervous system.

Statistical data analysis (Statistics 13).

Photoplethysmography was the main tool in the study of vascular wall stiffness. AngioCode 301 is a mobile health tracker that allows you to assess the state of the cardiovascular system.

Vascular stiffness is an assessment of the condition of the arteries, the analysis of the parameter allows you to assess the risk of capillary damage and blood microcirculation disorders in various organs.

Stress level is a characteristic of the state of the centers regulating the cardiovascular system. Also known as the heart rate variability index.

The relative duration of systole. The ratio of the duration of systole and the total duration of the cardiac cycle (ED%) reflects the features of the working cycle of the myocardium.

The velocity of the pulse wave propagation through the vessels with a finite velocity depends on the elastic properties and geometry of the blood vessel.

3. Results and discussion

In the study conducted in groups 2 and 3, the number of men prevailed (59.1% and 76.5%), the average age of the subjects in all three groups was 20 years. The unequal distribution of IFC indicators between men and women was revealed. There were more women with a satisfactory level of adaptation - 37 people (74%), and men with the same level of IFC, therefore, less – 15 people (36.6%). The tension of adaptation mechanisms was also distributed unequally: women in this group were 18% (9 people), and men – 31.7% (13 people). 4% of women (4 people) and 31.7% of men (13 people) turned out to have an unsatisfactory level of IFC.

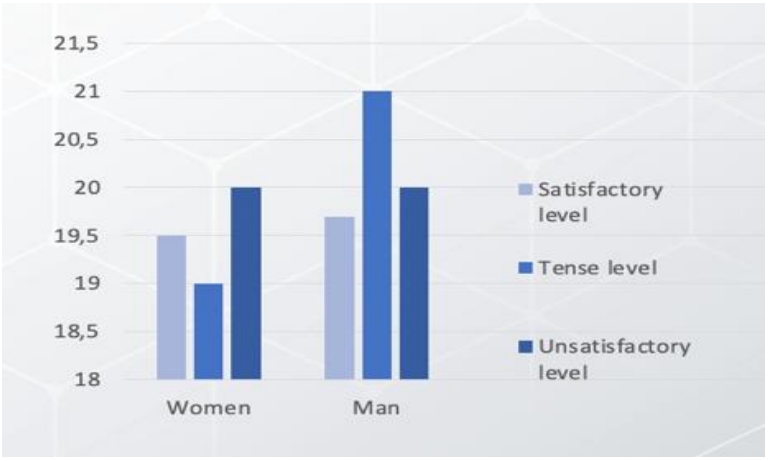

Figure 1. Average age of different sex groups with different IFC.

The calculation of the criterion χ2 revealed significant differences between the groups ($p<0.05$). These data indicate that men are most often at risk of developing CVS. Consequently, the data obtained in the study indicate a significant role of the gender factor in the ability of the CVS

to adapt to different types of stress, and a reduced level of adaptation in men relative to women was also found.

Indicators of body weight and height in men are higher than in women, which is consistent with classical anthropological concepts. At the same time, the calculation of BMI revealed a non-physiological increase in the body mass index in men. Thus, 29.3% of overweight men (12 people), and 10% of women (5 people), obese men - 9.8% (4 people), women - 6% (3 people) turned out to be overweight. These data indicate that there are more men with a higher BMI than women, which affects the level of IFC and correlates with a low ability to adapt to environmental factors.

When analyzing the body mass index (BMI) in the context of the IFC, there were significant differences between the first (20.0± 0.6) and the third group (28.3±0.6), in the second group the BMI was 22.7±0.6.

Also, assessing the waist–hip index (WHI), differences in the indicators of the first (WHI = 0.74±0.01) were found and the second group (WHI = 0.8 ±0.01), in the third group WHI was 0.83± 0.01.

When determining hemodynamic parameters, it was found that the pulse values of the second (89±1.5) and third groups (94±1.6), which were already characterized by a violation of the mechanisms of adaptation of the cardiovascular system, significantly differed from those of the group (78±1.6) with normal exercise tolerance ($p<0.05$). When analyzing blood pressure in all three groups, the following values were obtained: SBP: IFC 1 = 117 ± 11, IFC 2 = 131 ± 8, IFC 3 = 146 ± 16. DBP: IFC 1 = 74 ± 8, IFC 2 = 81 ± 5, IFC 3 = 86 ± 8 mm Hg.

When analyzing blood pressure based on the high frequency of occurrence of high normal and pathological values of DBP in the third and second groups and the reliability of differences in the average group values relative to the first group, it was found that the vascular wall in this sample of individuals is involved in the process of maladaptation.

Table 1. Hemodynamic parameters in 3 study groups. * - all indicators were statistically significant, $p<0.05$.

Indicator	Categories	Systolic blood pressure		p
		M ± SD	95% ДИ	
SBP	IFC 1	117 ± 11	114 – 120	P1,2< 0,001*
	IFC 2	131 ± 8	127 – 134	P2,3< 0,001*
	IFC 3	146 ± 16	138 – 154	P1,3< 0,001*
DBP	IFC 1	74 ± 8	72 – 76	P1,2< 0,001*
	IFC 2	81 ± 5	78 – 83	P2,3=0,036 *
	IFC 3	86 ± 8	82 – 91	P1,3< 0,001*

When calculating the Kerdo index, the predominance of the sympathetic nervous system over the parasympathetic was noted in all groups.

In the first group of SNS: total – 56% (29), increased activity 25% (13), norm 31% (16); PNS: total 44% (23), increased activity 19% (10), norm 25% (13).

In the second group: SNS: total 77% (17), increased activity 32% (7), norm 45% (10); PNS: total 23% (5), increased activity 5% (1), norm 18% (4).

In the third group: SNS: total 64% (10), increased activity 18% (3), norm 47% (8); PNS: total 36% (6), increased activity 18% (3), norm 18% (3).

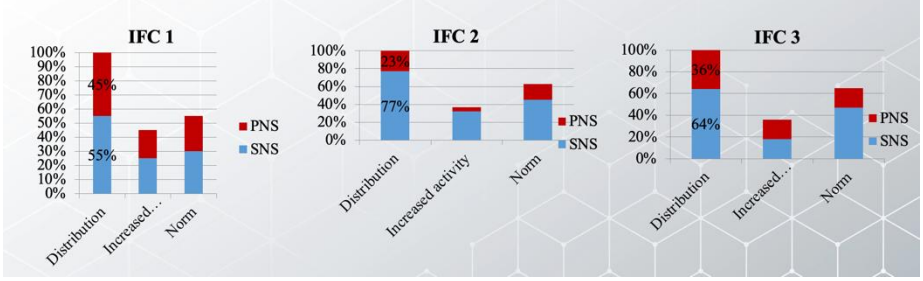

Figure 2. Calculation of the Kerdo index in three study groups. Horizontally: distribution, increased activity, norm. Vertically: in red - the parasympathetic nervous system, in blue – the sympathetic nervous system.

During the study, the following indicators were analyzed: vascular wall stiffness, systole duration, stress index and pulse wave propagation velocity.

Table 2. Analysis of the main indicators: vascular wall stiffness, duration of systole, stress index and pulse wave propagation velocity in 3 study groups. * - statistically significant indicators, p<0.05.

Indicator	Categories	Indicator		p
		Me	$Q_1 - Q_3$	
Vascular wall stiffness, %	IFC 1	-13,7	-20,3 – -7,8	0,358
	IFC 2	-16,4	-20,9 – -8,4	
	IFC 3	-16,2	-19,7 – -11,3	
Duration of systole, %	IFC 1	33	32 – 34	0,180
	IFC 2	34	32 – 34	
	IFC 3	33	32 – 35	
Stress Index, y.e.	IFC 1	94	52 – 147	0,006*
	IFC 2	117	84 – 242	
	IFC 3	197	98 – 374	
Pulse wave propagation speed, м/с	IFC 1	9,32	8,70 – 10,35	0,490
	IFC 2	9,86	9,10 – 10,49	
	IFC 3	9,97	8,95 – 10,32	

Vascular wall prestige: IFC 1 = -13.7 ±1.2 %; IFC 2 = -16.4±1.2%;IFC 3 = -16.2±1.2%; p = 0.358.

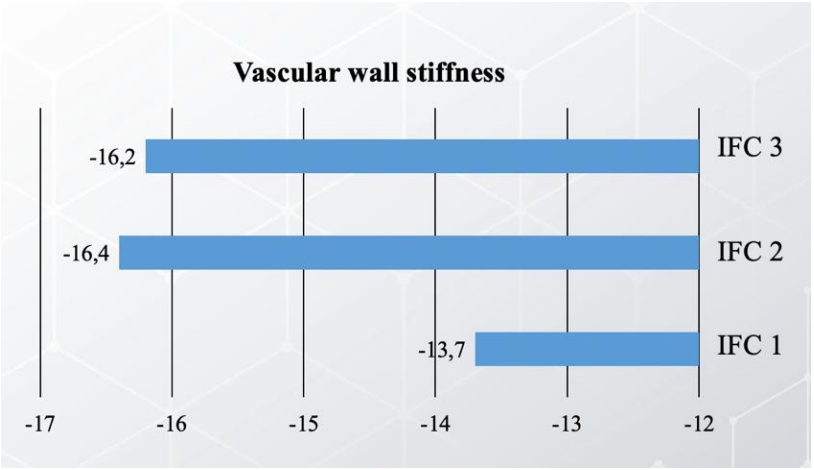

Figure 3. Stiffness of the vascular wall in the three groups being excised. The highest value is typed in IFC 2.

Stress index: CPI 1 = 94±14 c.u; CPI 2 =117±13 c.u; CPI 3 = 197±14 c.u; p = 0.006.

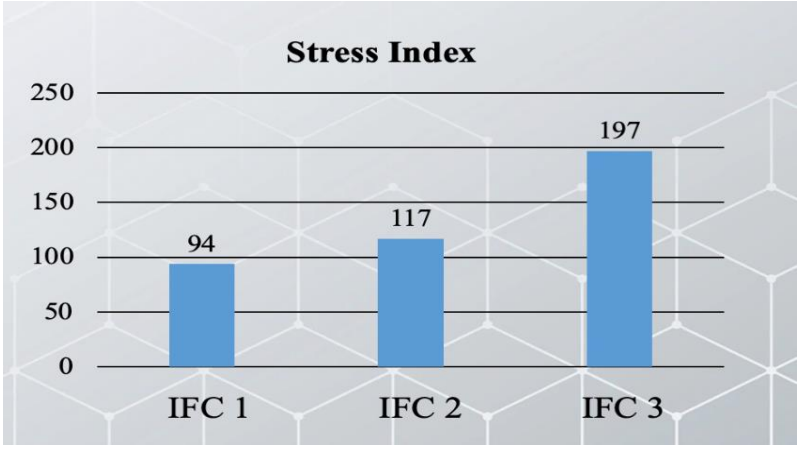

Figure 4. Stress index in the three study groups. The highest value is observed in IFC 3.

Duration of systole: IFC 1 = 33=0.3 %; And F2 = 34=0.3 %; IFC 3 = 33=0.3 %; p = 0.18.

Pulse wave propagation velocity: IFC 1 = 9.32±0.1 m/s; IFC 2 = 9.86±0.1 m/s; IFC 3 = 9.97±0.1 m/s; z = 0.49.

4. Conclusions

The state of the vascular wall in young people did not depend on the functional reserves of the CVS: according to photoplethysmography, the parameters of the stiffness of the VW and VPWP did not differ significantly in young people with different adaptive reserves. Impaired adaptation of the cardiovascular system correlates with high heart rate, high blood pressure and stress index (according to FPG). Violations of the mechanisms of adaptation of the cardiovascular system in young men are more common than in women. The adaptive response of the CVS to various influences depends on BMI. Young people with a slight weight deficit and normal body weight have a greater potential for adaptation than people with excess body weight and obesity.

Application of artificial intelligence:

The article is written without the use of artificial intelligence technologies.

Author Contributions: Conceptualization, T.V.; methodology, T.V. and S.M.; formal analysis, T.V., S.M, V.T; investigation, V.T., S.M; data curation, V.T.; writing—original draft preparation, S.M., V.T, T.V..; writing—review and editing, S.M.; visualization, V.T.; supervision, T.V.; project administration, T.V. All authors have read and agreed to the published version of the manuscript.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Conflicts of Interest: The authors declare no conflict of interest.

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