ORIGINAL ARTICLES. SPORT

Features of vascular regulation of students – future specialists in physical education and sports of different sports specializations with different body lengths

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Abstract

Purpose: to reveal the features of the indicators of the orthostatic test in students with different body lengths and different sport´s specializations, studying in the specialty "Physical education and sports".
Material and methods. The study involved 42 students who play sports at the amateur level. The following research methods were used in the work: method of analysis of literary sources; method of determining body length; orthostatic test method; method of determining stroke volume and minute blood volume.
Results. The influence of both factors (body length and sport) on the orthostatic test was significant for the following data: systolic blood pressure in the vertical position, diastolic blood pressure in the vertical position; change in diastolic blood pressure when changing body position from horizontal to vertical; Heart rate in vertical and horizontal positions; change in heart rate during the transition from horizontal to vertical position; stroke volume of blood in the vertical position; change in the stroke volume of blood during the transition from horizontal to vertical position; all indicators of minute volume of a blood-groove (p <0,005; p <0,01; p <0,001). The more significant influence of judo and football classes in comparison with running short and medium distances on the indicators of vegetative-vascular regulation was determined: the best indicators - in judo, the next place - in football, then - athletes. It was found that students with a body length of more than 190 cm have difficulty with vegetative-vascular regulation.
Conclusions. To improve the adaptive capacity of vascular regulation to change the position of the body from horizontal to vertical in tall athletes is effective to use any exercise, but the most effective exercises that activate aerobic and anaerobic glycolytic energy systems. Also useful are exercises that require frequent transitions from lying down (sitting) to standing position, as well as changes in the direction of movement.
Key words: orthostatic test, body length, athletes, students

Анотація

Крету М., Борисенко І.В., Ушмарова В.В., Гриньова В.М., Масіч В.В. Особливості вегетосудинної регуляції студентів – майбутніх фахівців з фізичного виховання і спорту різних спортивних спеціалізацій з різною довжиною тіла

Мета: виявити особливості показників ортостатичної проби у студентів з різною довжиною тіла і різних спортивних спеціалізацій, які навчаються за спеціальністю «Фізичне виховання і спорт».

Матеріал і методи. В дослідженні взяли участь 42 студента – майбутніх фахівців з фізичного виховання і спорту. В роботі застосовувались такі методи дослідження: метод аналізу літературних джерел; метод визначення довжини тіла; метод ортостатичної проби; метод розрахунку ударного об'єму крові та хвилинного об'єму крові.

Результати. Вплив обох факторів (довжина тіла і вид спорту) на показники ортостатичної проби виявився достовірним для наступних даних: систолічний артеріальний тиск у вертикальному положенні, діастолічний артеріальний тиск у вертикальному положенні; зміна діастолічного артеріального тиску при зміні положення тіла з горизонтального на вертикальне; ЧСС у вертикальному та горизонтальному положеннях; зміна ЧСС при переході з горизонтального у вертикальне положення; ударний обсяг крові у вертикальному положенні; зміна ударного обсягу крові при переході з горизонтального у вертикальне положення; все показники хвилинного обсягу кровотоку ($p<0,005$; $p<0,01$; $p<0,001$). Визначено більш суттєвий вплив занять дзюдо та футболом у порівнянні з заняттями бігом на короткі і середні дистанції на показники вегетосудинної регуляції: найліпші показники – у представників дзюдо, наступне місце – у представників футболу, потім – легкоатлети. Виявлено, що у студентів з довжиною тіла понад 190 см спостерігається утруднення вегетосудинної регуляції.

Висновки. Для поліпшення адаптаційних можливостей вегетосудинної регуляції до зміни положення тіла з горизонтального на вертикальне у високих спортсменів ефективним є застосування будь-яких фізичних вправ, але найбільш ефективні вправи, які активізують аеробні та анаеробні гліколітичні системи енергозабезпечення. Також корисними є вправи, які вимагають частих переходів з положень лежачи (сидячи) в положення стоячи, а також зміни напрямку рухів.

Ключові слова: ортостатичний тест, довжина тіла, спортсмени, студенти

Аннотация

Крету М., Борисенко И.В., Ушмарова В.В., Гринева В.Н., Масич В.В. Особенности вегетососудистой регуляции студентов – будущих специалистов по физическому воспитанию и спорту различных спортивных специализаций с разной длиной тела

Цель: выявить особенности показателей ортостатической пробы у студентов с разной длиной тела и разных спортивных специализаций, обучающихся по специальности «Физическое воспитание и спорт».

Материал и методы. В исследовании приняли участие 42 студента – будущих специалистов по физическому воспитанию и спорту. В работе использованы следующие методы исследования: метод анализа литературных источников; метод определения длины тела; метод ортостатической пробы; метод расчёта ударного объема и минутного объема крови.

Результаты. Влияние обоих факторов (длина тела и вид спорта) на показатели ортостатической пробы оказался достоверным для следующих данных: систолическое артериальное давление в вертикальном положении, диастолическое артериальное давление в вертикальном положении; изменение диастолического артериального давления при изменении положения тела из горизонтального в вертикальное ЧСС в вертикальном и горизонтальном положениях; изменение ЧСС при переходе из горизонтального в вертикальное положение; ударный объем крови в вертикальном положении; изменение ударного объема крови при переходе из горизонтального в вертикальное положение; все показатели минутного объема кровотока ($p <0,005$; $p <0,01$; $p <0,001$). Определены более существенное влияние занятий дзюдо и футболом по сравнению с занятиями бегом на короткие и средние дистанции на показатели вегетососудистой регуляции: лучшие показатели - у представителей дзюдо, следующее место - у представителей футболу, потом - легкоатлеты. Выявлено, что у студентов с длиной тела более 190 см наблюдается затруднение вегетососудистой регуляции.

Выводы. Для улучшения адаптационных возможностей вегетососудистой регуляции к изменению положения тела с горизонтального на вертикальное в высоких спортсменов эффективно применение любых физических упражнений, но наиболее эффективные упражнения, которые активизируют аэробные и анаэробные гликолитические системы энергообеспечения. Также полезны упражнения, которые требуют частых переходов из положений лежа (сидя) в положение стоя, а также изменения направления движения.

Ключевые слова: ортостатическая проба, длина тела, спортсмены, студенты

Introduction

Vegetovascular regulation is one of the main mechanisms for ensuring the normal functioning of the body [1-3]. One of the manifestations of vegetative-vascular regulation is vasoconstriction and dilation in response to external influences [4, 5]. One of the simplest and most accessible methods for determining the quality of vegetative-vascular regulation is the orthostatic test [6, 7]. The orthostatic test is based on determining the body's adaptation to a change in body position from horizontal to vertical [5–8].

In athletes, the orthostatic test is based on training-induced changes in the functioning of the autonomic nervous system [9–10]. The results of the orthostatic test are influenced by a combination of such external factors as psychological stress, sleep quality, latent diseases, changes in environmental parameters (temperature, altitude), and others [7–10]. The results of the orthostatic test help to optimize the training process and prevent fatigue in athletes [2, 10, 11].

Orthostatic test is performed on the basis of measurements of heart rate (HR) and blood pressure [4, 5]. Changes in heart rate and blood pressure reflect changes in the state of the autonomic nervous system and cardiovascular system. During this test, the indicators of heart rate and blood pressure are measured in the supine position, heart rate in the standing position. The indicators measured during the orthostatic test are a reliable criterion for the load on the autonomic nervous system.

Nazarenko [11] assessed the balance function in athletes and people who do not go in for sports before and after an active orthostatic test. The athletes showed a higher level of balance function in comparison with the control, which decreased to a much lesser extent after an active orthostatic test, which indicates a positive effect of sports on the stability of the statokinetic system. At the same time, statistically significant differences in the balance function between wrestlers and football players appear after an active orthostatic test. In studies [12] it was revealed that athletes - basketball players of taller stature adapt worse to orthostatic load in comparison with athletes of average and below average height.

It is also known [12–14] that in people of high body length, the change in performance during the transition from horizontal to vertical body position is more pronounced, because a larger volume of blood falls sharply to the lower extremities. This leads to the need for more pronounced adaptation mechanisms of heart rate and blood pressure. In our previous study [13], the increase in heart rate in tall people did not differ significantly from this figure in students of medium and below average body length. But blood pressure, both systolic and diastolic, is significantly higher in tall students compared to others. This fact can be regarded as a more pronounced adaptive response of students with a body length above 190 cm from the cardiovascular system and vascular regulation. These adaptive responses are not sufficient, because the magnitude of the shock volume of blood and minute volume of blood flow in the vertical position in students of high body length is significantly smaller compared to students with a body length of 150-175 cm [13, 14].

Iordanskaya, Buchina [10] revealed the features of orthostatic stability in the vegetative support of the organism's working capacity of highly qualified athletes. The authors examined a group of 203 people, of whom 109 were men and 94 were women in two sports, volleyball (104 athletes) and rowing (99 athletes). The authors have developed a program and criteria for assessing the operational diagnosis of the functional state of the autonomic nervous system, including an orthostatic test with an assessment of heart rate, blood pressure, electrocardiogram in terms of monitoring training and pre-competition loads of the annual training cycle. The interrelation of the level of orthostatic stability in the vegetative support of the working capacity of volleyball players was revealed, taking into account the growth indicators and the playing role. In tall volleyball players of diagonal and central blockers, symptoms of dysadaptation of the cardiovascular system in response to orthostasis are more often diagnosed. In the group of rowing athletes, the relationship between the level of orthostatic stability with age and gender was revealed: young men and juniors more often show symptoms of dysadaptation in response to orthostasis and extreme physical load on the CONCEPT rowing ergometer. It was revealed that the speed-power loads of male rowers are more often reflected in the appearance of hypertension and hypertensive reaction in the work "to failure" on the rowing ergometer. Prompt diagnosis of orthostatic autonomic stability reveals early symptoms of cardiovascular overstrain in a timely manner and serves as a signal for stress correction and recovery.

We [13, 14] found that students with a body length of more than 190 cm have difficulty with vegetative-vascular regulation. The effect of body length on the orthostatic test was also significant for the following data: systolic blood pressure in the vertical position, diastolic blood pressure in the vertical position; change in diastolic blood pressure when changing body position from horizontal to vertical; heart rate in vertical and horizontal positions; change in heart rate during the transition from horizontal to vertical position; stroke volume of blood in the vertical position; change in stroke volume of blood during the transition from horizontal to vertical position; all indicators of minute blood volume. However, the question of the joint influence of body length and sports specialization on the indicators of the orthostatic test has not been investigated. There was a significant positive relationship between body length and heart rate c in horizontal, vertical positions and changes in heart rate when changing body position from horizontal to vertical (r = 0.50-0.71). There was also a positive significant relationship between body length and the value of systolic pressure in the vertical position (r = 0.72); negative significant relationship between body length and the value of the stroke volume of blood in the vertical position (r = -0.65).

However, despite the presence of studies showing the effect of body length on the indicators of the orthostatic test in athletes from different sports, this issue remains open and requires additional research. Among athletes, a special place is occupied by students involved in various sports and studying in the specialty "Physical Education and Sports". This category of students is especially significant, since they not only improve their sports skills, but also must bring knowledge to their students in the future.

Purpose: to reveal the features of the indicators of the orthostatic test in students with different body lengths and different sport´s specializations, studying in the specialty "Physical education and sports".

Material and methods

Participants

The study involved 42 students who play sports at the amateur level. The number of students with a body length of more than 190 cm was 12 people. The number of students whose body length was 150-175 cm was 30 people. There were no students with a body length of 176-189 cm in the study. This was the basis for the division of students into such groups according to body length, because it is known that large values of body length (over 190 cm) negatively affect the adaptation of the cardiovascular system in the transition from horizontal to vertical position.

The study was conducted on the basis of H.S. Skovoroda Kharkiv National Pedagogical University.

Procedure

The following research methods were used in the work: method of analysis of literature sources; method of determining body length; orthostatic test method; method of determining stroke volume and minute blood volume; methods of statistical data processing (comparison of averages by the Student's method, multivariate analysis of variance and correlation analysis).

An orthostatic test measures heart rate and blood pressure. These values are measured in a horizontal position, then repeat these measurements in the subject after actively getting up in a vertical position at the 10th minute [15–18].

A natural reaction to the orthostatic test is an increase in heart rate. As a result, the minute volume of blood is slightly reduced. In well-trained athletes, heart rate is relatively small and ranges from 5 to 15 beats per minute. In young athletes, the reaction may be more pronounced. Systolic blood pressure either remains unchanged or even decreases slightly (by 2-6 mm.Hg); diastolic blood pressure naturally increases by 10-15% relative to its value in the horizontal position. If during a 10-minute study the systolic pressure approaches the initial values, the diastolic pressure remains elevated. Signs of orthostatic instability are a sharp drop in blood pressure and a very large increase in heart rate [9, 12].

Measurements of body length are performed in a standing position using a vertical height meter. The person stands on a wooden plane with his back to the vertical bar, touching her heels, buttocks, interscapular area with the shoulders set back (head not resting). The arms should be lowered along the torso, the abdomen - tightened, the heels - together, the socks - separately. The position of the head should be such that the upper edge of the earlobe and the lower edge of the orbit are in the same horizontal plane. The movable bar is attached to the head without pressure, but tightly.

The magnitude of the stroke volume depends on the force of the heart contraction and the amount of blood flowing to it during diastole through the veins. Stroke volume (SV) can be calculated by Starr's formula [12–14].

The minute blood volume (MBV) is determined by the stroke volume and heart rate, depending on the position of the human body, its sex, age, fitness, environmental conditions and many other factors.

Calculate the minute blood volume (MBV) according to the formula [12]:

MBV = SV × heart rate.

Statistical analysis

For each indicator, the arithmetic mean, standard deviation S (standard deviation), error of the mean (m) and estimation of the probability of discrepancies in the Student's t-test with the appropriate level of probability (p) were determined for groups of students involved in football, track and field, judo and for groups of students with body length above average (more than 190 cm) and average (below average) (150-175 cm). Differences and relationships were considered reliable at the significance level $p < 0.05$ [13, 14].

Multivariate analysis of variance was also used using a general linear model. The dependent values were heart rate, systolic and diastolic blood pressure, stroke volume and minute blood flow in horizontal and vertical positions, as well as the difference between these indicators in different body positions. Independent values were body length and sport. Body length of 150-175 cm was denoted by the number 1, body length greater than 190 cm was denoted by the number 2. There were no students with body length values of 175-190 cm in the study.

We also marked the conditional numbers of the sports that students were involved in: athletics - 1; football - 2; judo wrestling - 3) [13, 14].

For statistical processing of the obtained data were used computer programs Microsoft Excel "Data Analysis" - 2013, SPSS - 17.

Results

Comparison of orthostatic tests of students – representatives of different sports showed that the lowest values of heart rate in the horizontal position and in the vertical position of the body in judo. The same applies to blood pressure in the horizontal and vertical position ($p < 0.001$) (Table 1-3). The highest heart rate and blood pressure in students - athletes. According to these indicators, footballers occupy an intermediate place.

Table 1

Comparative characteristics of orthostatic test indicators of students involved in track and field and football

Indicators	Kind of sport	Statistical Indicators					
		N	$\bar{x}$	S	M	t	p
Systolic pressure (mm.Hg) in the horizontal position	track and field	18	115.67	3.40	0.80	5.15	0.000
	football	12	110.00	2.09	0.60		
Systolic pressure (mm.Hg) in the vertical position	track and field	18	130.67	0.97	0.23	2.13	0.043
	football	12	129.00	3.13	0.90		
Systolic pressure (mmHg) Difference	track and field	18	15.00	4.20	0.99	-3.22	0.003
	football	12	19.00	1.04	0.30		
Diastolic pressure (mm.Hg.) in the horizontal position	track and field	18	77.33	5.90	1.39	1.48	0.150
	football	12	74.00	6.27	1.81		
Diastolic pressure (mm.Hg.) in the vertical position	track and field	18	88.33	3.40	0.80	9.19	0.000
	football	12	79.00	1.04	0.30		
Diastolic pressure Difference (mm.Hg)	track and field	18	11.00	8.27	1.95	2.23	0.034
	football	12	5.00	5.22	1.51		
Heart rate (beats·min^{-1}) in the vertical position	track and field	18	69.33	2.11	0.50	3.79	0.001
	football	12	58.00	12.53	3.62		
Heart rate (beats·min^{-1}) in the vertical position	track and field	18	71.33	5.59	1.32	0.65	0.522
	football	12	69.50	9.92	2.86		
Heart rate (beats·min^{-1}) difference	track and field	18	5.33	0.49	0.11	-9.85	0.000

	football	12	11.50	2.61	0.75		
Stroke volume (ml) in a horizontal position	track and field	18	60.27	8.79	2.07	-0.46	0.649
	football	12	61.60	5.85	1.69		
Stroke volume (ml) in the vertical position	track and field	18	56.17	4.19	0.99	-7.73	0.000
	football	12	65.60	0.42	0.12		
Stroke volume (ml) difference	track and field	18	11.77	3.37	0.79	4.18	0.000
	football	12	6.00	4.18	1.21		
Minute blood volume ($1 \cdot min^{-1}$) in a horizontal position	track and field	18	4.17	0.55	0.13	1.74	0.093
	football	12	3.64	1.11	0.32		
Minute blood volume ($1 \cdot min^{-1}$) in the vertical position	track and field	18	3.98	0.03	0.01	-3.92	0.001
	football	12	4.56	0.62	0.18		
Minute blood volume Difference ($1 \cdot min^{-1}$)	track and field	18	0.51	0.18	0.04	-3.23	0.003
	football	12	0.92	0.49	0.14		
Body Length	track and field	18	178.33	12.24	2.89	-0.15	0.882
	football	12	179.00	11.49	3.32		

That is, the adaptive capabilities of the cardiovascular system and vegetative-vascular regulation when changing the position of the body from horizontal to vertical in our study were found in students who are engaged in judo. This somewhat contradicts the literature on the best adaptive capabilities of long- and medium-distance running. In our study, athletes were representatives of short and medium distance running. It was found that their adaptive capacity when changing body position is significantly lower compared to football and judo.

Table 2

Comparative characteristics of orthostatic test indicators of students engaged in track and field and judo

Indicators	Kind of sport	Statistical Indicators					
		N	$\bar{x}$	S	M	t	p
Systolic pressure (mm.Hg) in the horizontal position	track and field	18	115.67	3.40	0.80	6.80	0.000
	judo	12	105.00	5.22	1.51		
Systolic pressure (mm.Hg) in the vertical position	track and field	18	130.67	0.97	0.23	73.36	0.000
	judo	12	110.00	0.00	0.00		
Systolic pressure (mmHg) difference	track and field	18	15.00	4.20	0.99	5.80	0.000
	judo	12	5.00	5.22	1.51		
Diastolic pressure (mm.Hg.) in the horizontal position	track and field	18	77.33	5.90	1.39	3.34	0.002
	Judo	12	66.00	12.53	3.62		
Diastolic pressure (mm.Hg.) in the vertical position	track and field	18	88.33	3.40	0.80	22.97	0.000
	Judo	12	65.00	1.04	0.30		
Diastolic pressure Difference (mm.Hg)	track and field	18	11.00	8.27	1.95	-0.83	0.415
	Judo	12	13.00	1.04	0.30		
Heart rate (beats$\cdot min^{-1}$) in the vertical position	track and field	18	69.33	2.11	0.50	29.15	0.000
	Judo	12	48.50	1.57	0.45		

Heart rate (beats·min^{-1}) in the vertical position	track and field	18	71.33	5.59	1.32	7.26	0.000
	Judo	12	59.50	0.52	0.15		
Heart rate (beats·min^{-1}) difference	track and field	18	5.33	0.49	0.11	-20.12	0.000
	Judo	12	11.00	1.04	0.30		
Stroke volume (ml) in a horizontal position	track and field	18	60.27	8.79	2.07	-1.66	0.108
	Judo	12	67.90	16.40	4.73		
Stroke volume (ml) in the vertical position	track and field	18	56.17	4.19	0.99	-12.31	0.000
	Judo	12	71.50	1.15	0.33		
Stroke volume (ml) difference	track and field	18	11.77	3.37	0.79	-3.83	0.001
	Judo	12	16.80	3.76	1.09		
Minute blood volume (1·min^{-1}) in a horizontal position	track and field	18	4.17	0.55	0.13	3.22	0.003
	Judo	12	3.32	0.90	0.26		
Minute blood volume (1·min^{-1}) in the vertical position	track and field	18	3.98	0.03	0.01	-22.13	0.000
	Judo	12	4.25	0.03	0.01		
Minute blood volume Difference (1·min^{-1})	track and field	18	0.51	0.18	0.04	-1.91	0.067
	Judo	12	0.94	0.93	0.27		
Body Length	track and field	18	178.33	12.24	2.89	5.43	0.000
	Judo	12	159.00	1.04	0.30		

We can explain the results by the fact that both football and judo are a load of mixed aerobic-anaerobic orientation, while running short and medium distances is mainly a job that requires creatine-phosphate and glycolytic mechanisms of energy supply.

Table 3

Comparative characteristics of orthostatic test indicators of students involved in football and judo

Indikators	Kind of sport	Statistical Indikators					
		N	$\bar{x}$	S	m	t	p
Systolic pressure (mm.Hg) in the horizontal position	Football	12	110.00	2.09	0.60	3.08	0.005
	Judo	12	105.00	5.22	1.51		
Systolic pressure (mm.Hg) in the vertical position	football	12	129.00	3.13	0.90	21.01	0.000
	Judo	12	110.00	0.00	0.00		
Systolic pressure (mmHg) difference	football	12	19.00	1.04	0.30	9.11	0.000
	Judo	12	5.00	5.22	1.51		
Diastolic pressure (mm.Hg.) in the horizontal position	football	12	74.00	6.27	1.81	1.98	0.061
	Judo	12	66.00	12.53	3.62		
Diastolic pressure (mm.Hg.) in the vertical position	football	12	79.00	1.04	0.30	32.83	0.000
	Judo	12	65.00	1.04	0.30		
Diastolic pressure Difference (mm.Hg)	football	12	5.00	5.22	1.51	-5.20	0.000
	Judo	12	13.00	1.04	0.30		
Heart rate (beats·min^{-1}) in the vertical position	football	12	58.00	12.53	3.62	2.61	0.016
	judo	12	48.50	1.57	0.45		

Heart rate (beats·min^{-1}) in the vertical position	football	12	69.50	9.92	2.86	3.49	0.002
	judo	12	59.50	0.52	0.15		
Heart rate (beats·min^{-1}) difference	football	12	11.50	2.61	0.75	0.62	0.544
	judo	12	11.00	1.04	0.30		
Stroke volume (ml) in a horizontal position	football	12	61.60	5.85	1.69	-1.25	0.223
	judo	12	67.90	16.40	4.73		
Stroke volume (ml) in the vertical position	football	12	65.60	0.42	0.12	-16.72	0.000
	judo	12	71.50	1.15	0.33		
Stroke volume (ml) difference	football	12	6.00	4.18	1.21	-6.66	0.000
	judo	12	16.80	3.76	1.09		
Minute blood volume (1·min^{-1}) in a horizontal position	football	12	3.64	1.11	0.32	0.78	0.442
	judo	12	3.32	0.90	0.26		
Minute blood volume (1·min^{-1}) in the vertical position	football	12	4.56	0.62	0.18	1.68	0.107
	judo	12	4.25	0.03	0.01		
Minute blood volume Difference (1·min^{-1})	football	12	0.92	0.49	0.14	-0.07	0.944
	judo	12	0.94	0.93	0.27		
Body Length	football	12	179.00	11.49	3.32	6.01	0.000
	judo	12	159.00	1.04	0.30		

Significant influence of both body length and sport on most indicators of orthostatic test was found (Table 4). The results of analysis of variance confirmed the results of comparing the averages of the Student's t-test. The influence of sport on heart rate, systolic and diastolic pressure, as well as the calculated values of stroke volume and minute blood flow in the supine and standing positions was significant for almost all indicators ($p < 0.05$; $p < 0.001$) (Table 4). The only exception is the rate of stroke blood volume in the horizontal position ($p > 0.05$) (Table 4). Thus, the analysis of variance confirmed the results of comparing the means of the Student's t-test for the best effect on vascular regulation and the state of the cardiovascular system in judo. Short and medium distance running by students at the level of mass discharges has a less pronounced effect on orthostatic test performance. Football classes occupy an intermediate place between judo and athletics in terms of impact on vascular regulation.

Body length also significantly affects the indicators of vascular regulation (Table 4). There is a significant effect of body length on systolic blood pressure in the standing position, diastolic blood pressure in the supine and standing positions, heart rate in the supine and standing positions, stroke blood volume in the standing position, minute blood flow in the supine and standing positions ($p < 0.001$) (Table 4).

The influence of both factors (body length and sport) on the orthostatic test was also significant for the following data: systolic blood pressure in the vertical position, diastolic blood pressure in the vertical position; change in diastolic blood pressure when changing body position from horizontal to vertical; Heart rate in vertical and horizontal positions; change in heart rate during the transition from horizontal to vertical position; stroke volume of blood in the vertical position; change in the stroke volume of blood during the transition from horizontal to vertical position; all indicators of minute volume of a blood-groove ($p < 0.005$; $p < 0.01$; $p < 0.001$).

The influence of both factors (body length and sport) on the orthostatic test was also significant for the following data: systolic blood pressure in the vertical position, diastolic blood pressure in the vertical position; change in diastolic blood pressure when changing body position from horizontal to vertical; Heart rate in vertical and horizontal positions; change in heart rate during the transition from horizontal to vertical position; stroke volume of blood in the vertical position; change in the stroke volume of blood during the transition from horizontal to vertical position; all indicators of minute volume of a blood-groove ($p < 0.005$; $p < 0.01$; $p < 0.001$).

Table 4

Indicators of multivariate analysis of variance of the influence of sport and body length on the orthography of students (Tests of Between-Subjects Effects)

Source	Dependent Variable	Tests of Between-Subjects Effects				
		Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	Systolic pressure (mm.Hg) in the horizontal position	888.000a	4	222	16.695	0.000
	Systolic pressure (mm.Hg) in the vertical position	3560.571b	4	890.143	2744.607	0.000
	Systolic pressure (mmHg) difference	1280.571c	4	320.143	19.742	0.000
	Diastolic pressure (mm.Hg.) in the horizontal position	1373.143d	4	343.286	5.484	0.001
	Diastolic pressure (mm.Hg.) in the vertical position	4053.000e	4	1013.25	430.922	0.000
	Diastolic pressure Difference (mm.Hg)	806.143f	4	201.536	6.81	0.000
	Heart rate (beats·min^{-1}) in the vertical position	4994.143g	4	1248.536	1184.508	0.000
	Heart rate (beats·min^{-1}) in the vertical position	2452.286h	4	613.071	92.21	0.000
	Heart rate (beats·min^{-1}) difference	437.571i	4	109.393	269.836	0.000
	Stroke volume (ml) in a horizontal position	824.096j	4	206.024	1.786	0.152
	Stroke volume (ml) in the vertical position	1959.673k	4	489.918	128.314	0.000
	Stroke volume (ml) difference	1027.783l	4	256.946	44.508	0.000
	Minute blood volume (1·min^{-1}) in a horizontal position	19.290m	4	4.823	12.729	0.000
	Minute blood volume (1·min^{-1}) in the vertical position	6.619n	4	1.655	2065.344	0.000
	Minute blood volume Difference (1·min^{-1})	4.784o	4	1.196	4.536	0.004
Intercept	Systolic pressure (mm.Hg) in the horizontal position	438703.7	1	438703.7	32991.95	0.000
	Systolic pressure (mm.Hg) in the vertical position	556475	1	556475	1715798	0.000
	Systolic pressure (mmHg) difference	6993.204	1	6993.204	431.248	0.000
	Diastolic pressure (mm.Hg.) in the horizontal position	194326.9	1	194326.9	3104.531	0.000
	Diastolic pressure (mm.Hg.) in the vertical position	225666.2	1	225666.2	95972.97	0.000
	Diastolic pressure Difference (mm.Hg)	3104.92	1	3104.92	104.915	0.000
	Heart rate (beats·min^{-1}) in the vertical position	124863.2	1	124863.2	118460	0.000
	Heart rate (beats·min^{-1}) in the vertical position	163461	1	163461	24585.6	0.000
	Heart rate (beats·min^{-1}) difference	3048.124	1	3048.124	7518.705	0.000
	Stroke volume (ml) in a horizontal position	137842.2	1	137842.2	1194.89	0.000
	Stroke volume (ml) in the vertical position	141439	1	141439	37044.27	0.000
	Stroke volume (ml) difference	4050.128	1	4050.128	701.567	0.000

	Minute blood volume ($1\cdot min^{-1}$) in a horizontal position	483.904	1	483.904	1277.286	0.000
	Minute blood volume ($1\cdot min^{-1}$) in the vertical position	634.008	1	634.008	791360.4	0.000
	Minute blood volume Difference ($1\cdot min^{-1}$)	21.647	1	21.647	82.09	0.000
Kind of sport	Systolic pressure (mm.Hg) in the horizontal position	631.75	2	315.875	23.755	0.000
	Systolic pressure (mm.Hg) in the vertical position	2467	2	1233.5	3803.292	0.000
	Systolic pressure (mmHg) difference	945.75	2	472.875	29.161	0.000
	Diastolic pressure (mm.Hg.) in the horizontal position	427	2	213.5	3.411	0.044
	Diastolic pressure (mm.Hg.) in the vertical position	3172	2	1586	674.506	0.000
	Diastolic pressure Difference (mm.Hg)	349	2	174.5	5.896	0.006
	Heart rate (beats$\cdot min^{-1}$) in the vertical position	4441.75	2	2220.875	2106.984	0.000
	Heart rate (beats$\cdot min^{-1}$) in the vertical position	1588	2	794	119.423	0.000
	Heart rate (beats$\cdot min^{-1}$) difference	418.75	2	209.375	516.458	0.000
	Stroke volume (ml) in a horizontal position	140.507	2	70.254	0.609	0.549
	Stroke volume (ml) in the vertical position	1642.17	2	821.085	215.05	0.000
	Stroke volume (ml) difference	636.077	2	318.039	55.091	0.000
	Minute blood volume ($1\cdot min^{-1}$) in a horizontal position	11.741	2	5.871	15.496	0.000
	Minute blood volume ($1\cdot min^{-1}$) in the vertical position	2.603	2	1.302	1624.679	0.000
	Minute blood volume Difference ($1\cdot min^{-1}$)	2.996	2	1.498	5.681	0.007
Body length	Systolic pressure (mm.Hg) in the horizontal position	15.429	1	15.429	1.16	0.288
	Systolic pressure (mm.Hg) in the vertical position	42.857	1	42.857	132.143	0.000
	Systolic pressure (mmHg) difference	6.857	1	6.857	0.423	0.520
	Diastolic pressure (mm.Hg.) in the horizontal position	289.714	1	289.714	4.628	0.038
	Diastolic pressure (mm.Hg.) in the vertical position	96.429	1	96.429	41.01	0.000
	Diastolic pressure Difference (mm.Hg)	51.857	1	51.857	1.752	0.194
	Heart rate (beats$\cdot min^{-1}$) in the vertical position	685.714	1	685.714	650.549	0.000
	Heart rate (beats$\cdot min^{-1}$) in the vertical position	189	1	189	28.427	0.000
	Heart rate (beats$\cdot min^{-1}$) difference	34.714	1	34.714	85.629	0.000
	Stroke volume (ml) in a horizontal position	248.919	1	248.919	2.158	0.150
	Stroke volume (ml) in the vertical position	56.679	1	56.679	14.845	0.000
	Stroke volume (ml) difference	8.297	1	8.297	1.437	0.238
	Minute blood volume ($1\cdot min^{-1}$) in a horizontal position	6.432	1	6.432	16.977	0.000
	Minute blood volume ($1\cdot min^{-1}$) in the vertical position	2.403	1	2.403	2999.62	0.000

	Minute blood volume Difference (1·min^{-1})	0.693	1	0.693	2.63	0.113
Kind of sport· Body length	Systolic pressure (mm.Hg) in the horizontal position	42.857	1	42.857	3.223	0.081
	Systolic pressure (mm.Hg) in the vertical position	84	1	84	259	0.000
	Systolic pressure (mmHg) Difference	6.857	1	6.857	0.423	0.520
	Diastolic pressure (mm.Hg.) in the horizontal position	207.429	1	207.429	3.314	0.077
	Diastolic pressure (mm.Hg.) in the vertical position	21	1	21	8.931	0.005
	Diastolic pressure Difference (mm.Hg)	360.429	1	360.429	12.179	0.001
	Heart rate (beats·min^{-1}) in the vertical position	1344	1	1344	1275.077	0.000
	Heart rate (beats·min^{-1}) in the vertical position	1296.429	1	1296.429	194.991	0.000
	Heart rate (beats·min^{-1}) Difference	51.857	1	51.857	127.914	0.000
	Stroke volume (ml) in a horizontal position	183.639	1	183.639	1.592	0.215
	Stroke volume (ml) in the vertical position	92.61	1	92.61	24.255	0.000
	Stroke volume (ml) difference	326.469	1	326.469	56.551	0.000
	Minute blood volume (1·min^{-1}) in a horizontal position	9.219	1	9.219	24.334	0.000
	Minute blood volume (1·min^{-1}) in the vertical position	2.46	1	2.46	3070.976	0.000
	Minute blood volume Difference (1·min^{-1})	2.627	1	2.627	9.964	0.003
Error	Systolic pressure (mm.Hg) in the horizontal position	492	37	13.297	-	-
	Systolic pressure (mm.Hg) in the vertical position	12	37	0.324	-	-
	Systolic pressure (mmHg) Difference	600	37	16.216	-	-
	Diastolic pressure (mm.Hg.) in the horizontal position	2316	37	62.595	-	-
	Diastolic pressure (mm.Hg.) in the vertical position	87	37	2.351	-	-
	Diastolic pressure Difference (mm.Hg)	1095	37	29.595	-	-
	Heart rate (beats·min^{-1}) in the vertical position	39	37	1.054	-	-
	Heart rate (beats·min^{-1}) in the vertical position	246	37	6.649	-	-
	Heart rate (beats·min^{-1}) Difference	15	37	0.405	-	-
	Stroke volume (ml) in a horizontal position	4268.31	37	115.36	-	-
	Stroke volume (ml) in the vertical position	141.27	37	3.818	-	-
	Stroke volume (ml) difference	213.6	37	5.773	-	-
	Minute blood volume (1·min^{-1}) in a horizontal position	14.018	37	0.379	-	-
	Minute blood volume (1·min^{-1}) in the vertical position	0.03	37	0.001	-	-
	Minute blood volume Difference (1·min^{-1})	9.757	37	0.264	-	-
Total	Systolic pressure (mm.Hg) in the horizontal position	518862	42	-	-	-
	Systolic pressure (mm.Hg) in the	652344	42	-	-	-

	vertical position					
	Systolic pressure (mmHg) Difference	9294	42	-	-	-
	Diastolic pressure (mm.Hg.) in the horizontal position	228384	42	-	-	-
	Diastolic pressure (mm.Hg.) in the vertical position	266262	42	-	-	-
	Diastolic pressure Difference (mm.Hg)	5982	42	-	-	-
	Heart rate (beats·min^{-1}) in the vertical position	156954	42	-	-	-
	Heart rate (beats·min^{-1}) in the vertical position	193656	42	-	-	-
	Heart rate (beats·min^{-1}) difference	3642	42	-	-	-
	Stroke volume (ml) in a horizontal position	170884.4	42	-	-	-
	Stroke volume (ml) in the vertical position	170086.6	42	-	-	-
	Stroke volume (ml) difference	6851.22	42	-	-	-
	Minute blood volume (1·min^{-1}) in a horizontal position	631.834	42	-	-	-
	Minute blood volume (1·min^{-1}) in the vertical position	756.172	42	-	-	-
	Minute blood volume Difference (1·min^{-1})	38.022	42	-	-	-
Corrected Total	Systolic pressure (mm.Hg) in the horizontal position	1380	41	-	-	-
	Systolic pressure (mm.Hg) in the vertical position	3572.571	41	-	-	-
	Systolic pressure (mmHg) difference	1880.571	41	-	-	-
	Diastolic pressure (mm.Hg.) in the horizontal position	3689.143	41	-	-	-
	Diastolic pressure (mm.Hg.) in the vertical position	4140	41	-	-	-
	Diastolic pressure Difference (mm.Hg)	1901.143	41	-	-	-
	Heart rate (beats·min^{-1}) in the vertical position	5033.143	41	-	-	-
	Heart rate (beats·min^{-1}) in the vertical position	2698.286	41	-	-	-
	Heart rate (beats·min^{-1}) difference	452.571	41	-	-	-
	Stroke volume (ml) in a horizontal position	5092.406	41	-	-	-
	Stroke volume (ml) in the vertical position	2100.943	41	-	-	-
	Stroke volume (ml) difference	1241.383	41	-	-	-
	Minute blood volume (1·min^{-1}) in a horizontal position	33.308	41	-	-	-
	Minute blood volume (1·min^{-1}) in the vertical position	6.648	41	-	-	-
	Minute blood volume Difference (1·min^{-1})	14.541	41	-	-	-

a. R Squared =0.643 (Adjusted R Squared = 0.605); b. R Squared =0.997 (Adjusted R Squared =0.996); c. R Squared =0.681 (Adjusted R Squared =0.646); d. R Squared =0.372 (Adjusted R Squared =0.304); e. R Squared =0.979 (Adjusted R Squared =0.977); f. R Squared =0.424 (Adjusted R Squared =0.362); g. R Squared =0.992 (Adjusted R Squared =0.991); h. R Squared =0.909 (Adjusted R Squared =0.899); i. R Squared =0.967 (Adjusted R Squared =0.963); j. R Squared =0.162 (Adjusted R Squared =0.071); k. R Squared =0.933 (Adjusted R Squared =0.925); l. R Squared =0.828 (Adjusted R Squared =0.809); m. R Squared =0.579 (Adjusted R Squared =0.534); n. R Squared =0.996 (Adjusted R Squared =0.995); o. R Squared =0.329 (Adjusted R Squared =0.256)

Discussion

The purpose of the work set in this study was fully confirmed. It has been shown that students who engage in different sports have different adaptive capabilities in terms of vascular regulation. It was also shown that students with a body length greater than 190 cm have less adaptive capacity for vascular regulation compared to students of medium and below average body length.

Our data confirmed the results of other authors [4, 9, 10], that in athletes orthostatic instability associated with decreased venous tone develops relatively rarely. However, when conducting orthostatic tests, it can sometimes be detected [12]. Therefore, the use of orthostatic tests to assess the functional state of the body of athletes is considered appropriate.

A natural reaction to the orthostatic test is an increase in heart rate [1, 4, 6]. Due to this, the minute volume of blood flow is reduced slightly. In well-trained athletes, heart rate is relatively small and ranges from 5 to 15 beats • min-1. In young athletes, the reaction may be more pronounced [9]. Systolic blood pressure either remains unchanged or even decreases slightly (by 2-6 mm Hg); diastolic blood pressure naturally increases by 10-15% relative to its value in the horizontal position. If during 10 - minute research systolic pressure approaches initial values, arterial pressure remains raised.

Signs of orthostatic instability are a sharp drop in blood pressure and a very large increase in heart rate [4]. But at the present stage, a simple assessment of the orthostatic sample according to heart rate continues to be refined. The fact is that such a seemingly reliable indicator, which is the increase in heart rate in the vertical position relative to the heart rate in the horizontal position, sometimes gives inaccurate data. This is especially true for athletes with bradycardia in a horizontal position: their heart rate can increase by 30-25 beats • min1 without any signs of orthostatic instability. In this regard, it is recommended to evaluate the orthostatic test on the basis of the actual heart rate in the vertical position of the body. If the heart rate does not exceed 89 beats per minute for 10 minutes, the reaction is considered normal. A heart rate of 90-95 beats • min-1 indicates a decrease in orthostatic stability, and a heart rate exceeding 95 beats • min-1 indicates low resistance to changes in body position in space, at which orthostatic collapse is possible. This approach to the assessment of orthostatic reactions is based on the so-called principle of invariance, the essence of which is that under the influence of a perturbing effect, the performance of the body's autonomic systems do not depend (or depend to a small extent) on baseline and are determined exclusively current needs of the organism [4, 12].

The response to the orthostatic test improves under the influence of sports training [10, 11]. And this applies to all athletes, not just those sports in which a change of body position is a mandatory element.

According to the literature [2, 4, 8], orthostatic hypotension and orthostatic collapse are abnormal, pathological phenomena. Osadchy [4] writes that a decrease in systemic blood pressure is often accompanied by dizziness, blurred vision, sweating and even loss of consciousness with a sudden transition from horizontal (or sitting) to a vertical position. Physiological effects of this change in body position are the result of increased hydrostatic pressure in veins and the arteries of the lower and lowering - in the vessels of the upper half of the body and the corresponding redistribution of blood mass.

Cerebral circulation is protected from fluctuations in hydrostatic pressure in the vascular system due to the same pressure of this factor on both intravascular and extravascular (in the spinal canal) pressure. Under these conditions, the cerebral tie is under the control of systemic blood pressure and therefore a decrease in the latter immediately leads to a decrease in the arteriovenous gradient

Therefore, despite the presence of nervous and humoral mechanisms that reduce the resistance of cerebral vessels and prevent the effects of oscillations of systemic arterial suppression [4], an essential factor in maintaining cerebral blood flow is adequate blood pressure [4].

Thus, in those individuals in whom the orthostatic is written off above the compensatory mechanisms can not prevent a significant decrease in blood pressure, decreased cerebral blood flow, which causes "fainting" or "unconsciousness" (depending on the intensity of the above symptoms of cerebral circulatory disorders). In the scientific literature, "fainting" (or "syncope", "collapse") entered as the most important element of the syndrome, referred to as "orthostatic hypotension". This term refers to such conditions in which the violation of circulatory homeostasis during a change in body position is the main pathogenetic mechanism of the disease, and the main manifestation - low average blood pressure [4].Thus, we obtained results that confirm the results of the literature on the difficult vascular regulation of tall people [12–14]. In addition, these results are clarified by the fact that a significant increase not only in diastolic blood pressure, but also systolic, in the transition from horizontal to vertical position. But these changes are insufficient for the adaptation to changes in body position in tall students was similar to students whose body length does not exceed the average.

Based on the results, the following recommendations can be made: to improve the adaptive capacity of vascular regulation to change body position from horizontal to vertical, it is effective to use any exercise, but the most effective exercises that activate aerobic and anaerobic glycolytic energy systems. In addition, exercises that require frequent transitions from lying down (sitting) to standing position, as well as changes in the direction of movement are useful [19, 20].

Conclusions

1. The influence of both factors (body length and sport) on the orthostatic test was significant for the following data: systolic blood pressure in the vertical position, diastolic blood pressure in the vertical position; change in diastolic blood pressure when changing body position from horizontal to vertical; Heart rate in vertical and horizontal positions; change in heart rate during the transition from horizontal to vertical position; stroke volume of blood in the vertical position; change in the stroke volume of blood during the transition from horizontal to vertical position; all indicators of minute volume of a blood-groove ($p<0.005$; $p<0.01$; $p<0.001$).

2. The more significant influence of judo and football classes in comparison with running short and medium distances on the indicators of vegetative-vascular regulation was determined: the best indicators - in judo, the next place - in football, then - athletes. It was found that students with a body length of more than 190 cm have difficulty with vegetative-vascular regulation. To improve the adaptive capacity of vascular regulation to change the position of the body from horizontal to vertical in tall athletes is effective to use any exercise, but the most effective exercises that activate aerobic and anaerobic glycolytic energy systems. Also useful are exercises that require frequent transitions from lying down (sitting) to standing position, as well as changes in the direction of movement.

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Conflict of interest

The authors declare that there is no conflict of interest.

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