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## **BODY LENGTH, SPORTS SPECIALIZATION AND VEGETOVASCULAR REGULATION IN STUDENTS – FUTURE SPECIALISTS IN PHYSICAL EDUCATION AND SPORTS**



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EDUCATION AND SPORTS**

MONOGRAPH

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Cieślicka M., Ushmarova V., Grynyova V.

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The monograph purpose was 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". 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.

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.

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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# INTRODUCTION

*Cieślicka M.*

## **Topicality**

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.

## **Connection of work with scientific programs, plans, themes**

The study was conducted according to:

- research work funded by the state budget of the Ministry of Education and Science of Ukraine for 2019-2020. "Theoretical and methodological foundations of integrated technologies for self-improvement, harmonious physical, intellectual and spiritual development and the formation of a healthy lifestyle for people of all ages and social groups, including athletes and people with special needs"(№ state registration: 0119U100616);
- research work funded by the state budget of the Ministry of Education and Science of Ukraine for 2019-2020. "Theoretical and methodological foundations of technology development to restore the musculoskeletal system and functional status and injury prevention of different age groups in physical culture and sports" (№ state registration: 0119U100634); on the topic of the Department of Olympic and Professional Sports, Sports Games and Tourism of Kharkiv National Pedagogical University named after GS Frying pans for 2012-2026 "Development and substantiation of technologies for health promotion and harmonious development of people of different ages and social groups (state registration number 0121U110053).

**The aim of the study** – 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".



# **CHAPTER 1. ORTHOSTATIC TEST AS AN INDICATORS THE PHYNCTINAL STATE OF STUDENTS MAJORING IN "PHYSICAL EDUCATION AND SPORTS"**

*Grynyova V.*

## **1.1. Modern concepts of orthostatic regulation**

The idea to use the change of body position in space as an input for the study of the functional state of the organism is implemented in the practice of functional diagnostics (Buhr, Stack, & Luetkemeier, 2013; Nazar, Bicz, & Greenleaf, 1996; Pavy-Le Traon, Sigaud, Vasseur, Maillet, Fortrat, Hughson, et al., 1998). This test provides important information primarily in those sports that are characterized by a change in body position in space (gymnastics, rhythmic gymnastics, acrobatics, trampoline jumping, diving, high jump and the sixth, and more recently - and sports games) (Kozina, Slyusarev, 2002; Hynynen, Iglesias, Feriche, Calderon, Abalos, Vazquez et.al., 2012; Kubala, Smorawinski, Kaciuba-Uscilko, Nazar, Bicz, & Greenleaf, 1996; Lutfullin, & Al'metova, 2014; Lutfullin, & Al'metova, 2014) studied heart rate variability in twenty-seven young athletes (ice hockey) and found special autonomic mechanisms that function both in the supine position and during the orthostatic test, which is likely to be reflects the adaptation of the cardiovascular system to sports.

In all these sports, orthostatic stability is a necessary condition for athletic performance. Under the influence of systematic training orthostatic stability increases (Rodrigues, Goncalves, De Souza, & Da Silva Soares, 2014; Rodriguez, Iglesias, Feriche, Calderon, Abalos, Vazquez, et al., 2012; Vesterinen, & Nummela, 2018).

The indicators of orthostatic stability are influenced by various factors. Kubalaet.al. (1996) determined circulatory and hormonal parameters in endurance athletes and control subjects during orthostatic tolerability tests performed before and after three days of bed rest. Changes in heart rate and blood pressure due to bed rest were the same in both groups. However, hormonal changes in these two groups were

different: athletes decreased the activity of sympathoadrenal acid and increased the activity of renin in plasma. Untrained subjects had changes only in cortisol secretion.

Wi (Borysenko, Marian, & Kozina, 2020) 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.

Orthostatic reactions of the athlete's body are due to the fact that the transition of the body from horizontal to vertical in the lower half is deposited a significant amount of blood (Schafer, Olstad, & Wilhelm, 2015; Vesterinen, & Nummela, 2018; Wolthuis, Hull, Fischer, McAfoose, & Curtis, 1979). As a result, the venous return of blood to the heart deteriorates and blood emission decreases. Compensation for this adverse effect is mainly due to an increase in heart rate. In addition, an important role belongs to the change in vascular tone.

Thus, in the basis of development of the various reactions connected with change of position of a body in space, the main role is played by the considered mechanisms. The degree of reduction of venous return of blood to heart at change of position of a body to a greater extent depends on a tone of large veins. If it is reduced, the increase in venous return may be so significant that the transition to an upright position due to a sharp deterioration in the blood supply to the brain may develop unconsciousness. Low venous tone can also cause fainting during prolonged stay in an upright position - orthostatic collapse (Vesterinen, & Nummela, 2018; Wolthuis, Hull, Fischer, JMcAfoose, & Curtis, 1979; Schafer, Olstad, & Wilhelm, 2015; Rodrigues, Goncalves, De Souza, & Da Silva Soares, 2014; Buhr, Stack, & Luetkemeier, 2013).

Orthostatic collapse is rare in people engaged in physical culture and orthostatic collapse is a fairly common phenomenon in people of high body length and asthenic physique. Most representatives of game sports, as well as some athletics, have a high body length and asthenic physique. In addition, the question of the peculiarities of the reaction to the orthostatic test of students majoring in "Physical Education and Sports" (Muszkieta, Napierala, Cieslicka, Zukow, Kozina, Iermakov, Górny, 2019). Therefore, the topical issue is to determine the characteristics of the reaction to the orthostatic test of students of different sports specializations with different body lengths.

The hypothesis was set in this study: 1 - students who play different sports, have different adaptive capabilities of vascular regulation; 2 - students whose body length exceeds 190 cm have less adaptive capacity for vascular regulation compared to students of average and below average body length.

A simple assessment of the orthostatic test for heart rate data continues to be refined. On the right, in such a case, it was given, a superb indicator, such as an increase in heart rate in the vertical position a hundred times the heart rate in the horizontal position, sometimes giving inaccurate data. This is especially important for athletes with bradycardia in the horizontal position of the body: their heart rate can increase by 30-25 beats / min without any sign of orthostatic instability. In connection with cym, it is recommended to evaluate the orthostatic test on the basis of the real heart rate in the vertical position of the body. For 10 minutes after reaching the heart rate, the heart rate does not exceed 89 beats / minute, the reaction is considered normal. Heart rate, equal to 90-95 beats / min, indicating a decrease in orthostatic stability, and heart rate, which exceeds 95 beats / min, - low stability to a change in the position of the body in space, with a possible development of orthostatic collapse. Such a difference to the assessment of orthostatic reactions of the foundations on the so-called principle of invariance, the essence of what is believed is that under the influx of that and the other infusion, which is overwhelming, indicators of the functioning of the vegetative systems of the body do not lie down (they lie down, at a small step) vinyatkovo current needs of the body [35,71].

The reaction to the orthostatic test is accompanied by the influx of sports

training. Moreover, all athletes, and not only representatives of these kinds of sports, have to change the position of the body and the obov'yazkovy element.

In the literature, it is noted that orthostatic collapse occurs rarely in people who are engaged in physical culture and sports. It is noted, however, that in people of high stature and asthenic stature, orthostatic collapse is often the case. Osk?lki most basketball players may have high growth and asthenic stature, then the phenomenon of orthostatic collapse (another name - gravitational shock) is quite clear for them. When speaking with athletes who showed an inadequate response to an orthostatic test, it was found that they often experience orthostatic collapse in them during sudden transitions from sitting to lying to standing.

According to the literature, orthostatic hypotension and orthostatic collapse are an abnormal, pathological phenomenon. So, v?domy fahivets in dan?y oblast? L.?. Osadchy [63] writes that a decrease in the systemic arterial pressure is often accompanied by congestion, broken eyesight, drinkability and loss of awareness during the rapt transition of a person from a horizontal (sitting) position to a vertical one. Physiological effects of changes in the position of the body as a result of increased hydrostatic pressure in the veins and arteries of the lower part of the body and a decrease in the vessels of the upper half of the body and in the form of a redistribution of the blood mass.

Cerebral blood circulation of lesions in the presence of a hydrostatic squeeze in the vascular system is related to the same pressure of the factor both on the intravascular and on the extravascular (near the spinal canal) vice. In their minds, the cerebral larvae are under the control of the systemic arterial pressure and, therefore, the decrease in the rest of the negaino vede to a change in the arterio-venous gradient

Therefore, regardless of the presence of nerve and humoral mechanisms, which reduce the pressure of the cerebral vessels and alter the infusion of systemic arterial pressure [63], the only factor in boosting cerebral blood flow is adequate arterial pressure [63].

In such a right, in the hoisan, the wig of compensatory Mechanismi cannot be wrapped in the orthostasis of the orthostasis of an arterial dress, saying the brainlets,

Scho Viklika? "Unprofit" Chi "Unwitting Stan" (at the sealing of V?d, the symptom of the brazed blood circuit) . In the scientific literature, "nepritomnist" (chi "syncopia", "collapse") is recognized as the most important element of the syndrome, which is designated as "orthostatic hypotension". Under this term, it becomes clear that in case of any disruption of circulatory homeostasis, a change in body position is the main pathogenetic mechanism of illness, and the main manifestation is a decrease in the average arterial pressure

An early description of orthostatic hypotension to lie Piorre R. [according to 21], who, having stung an ailing person, had lost the ability to sleep, in a horizontal position, after which all the symptoms of insomnia arose. Diseases with adrenal insufficiency are described, in those who had a standing position, they had worsened eyesight and loss of vision, moreover, attacks were negligible when they moved to the supine position.

Since then, hundreds of additional warnings of various symptoms and states that are accompanied by orthostatic hypotension have been published.

Nilin and Levander [according to 33] divided ailments with orthostatic hypotension into two groups, which in principle differ from each other both in terms of the mechanism of guilt and in terms of symptoms. Looking at these groups becomes a significant interest for understanding pathological orthostatic reactions.

The 1st group is characterized by the strength of the vasoregulatory mechanisms after the transition from the vertical position; orthostatic hypotension due to tachycardia, peripheral vasoconstriction and other indications of increased activity of the sympathetic nervous system. stop does not seem to be significant for a healthy person to an increase in the excretion of catecholamines during the period of orthostasis [33]. After a short-hour (1-10 minutes) resting in a standing position in these ailments, an insomnia becomes developed ("vasovaginal syncope"), which is accompanied by vomiting, confusion, profuse sweating, bradycardia, and a decrease in arterial pressure to low values. This type of pathological orthostatic reaction is associated with the displacement of an unusually large amount of blood in the lower half of the body [63], and with a small external volume of blood in some individuals, which lead to

characteristic changes in the constitution [21], and in combination. This is the so-called arterial orthostatic anemia, sympathotonic orthostatic hypotension. Vaughn often manifests itself in the presence of hypovolemia, anemia, varicose veins, vaginost, viduzhanni after a trivial bed rest, with experimentally induced passive orthostasis in some healthy appearance. This form of orthostatic hypotension can also be caused by congestion of vasoactive drugs (nitrites, various neuroleptics) and post-infection camps.

The 2nd group of ailments is affected by the fact that after the transition from the vertical position in them, there is a significant (by 40-50 mm Hg) decrease in the median arterial pressure and loss of visibility, which is due to a change in cerebral blood flow to a critical value, approximately 30 ml xv per 100 m of brain tissue [63]. In such ailments, there is no superfluous deposition of blood in the lower limbs [63]. This group is characterized by a lack of compensatory mechanisms of a sympathetic nature (tachycardia, peripheral vasoconstriction), which confirms the daily increase in the excretion of catecholamines [22]. At the same time, the reactions of the peripheral vessels to the mystic temperature infusions are saved in them (heat causes vasodilation, cold causes vasoconstriction). It is characteristic that, when the heart rate changes in the heart rate, the sympathetic form of hypotonia is more than 20 in the average, and the asympto- tonic form is less than 10 beats in patients with ailments [37].

Theoretically, ailments can be the result of damage to the reflex arc, which regulates arterial pressure, through the shrinkage of the advancing nerve structures: a) afferent endings in the region of the bifurcation of the carotid artery of the aortic arch; b) spinal efferent tract; c) sympathetic ganglion nerves; d) vegetative centers (double brain, hypothalamus, spinal cord).

As for the presence of carotid sinus receptors, the increased sensitivity of these receptors in patients with orthostatic hypotension has been shown [63]. Some of these patients had aneurysms in the area of ??one of both carotid sinuses. In others - puffs, which robbed a vice on the whole area. Traumatic edema of the spinal cord, which is accompanied by a break in the afferent knee of the spinal reflex arc, leads to postural hypotension [36]. Evidence of the localization of lesions of the peripheral sympathetic

nervous system (peripheral sympathetic nerves, ganglia) serve as a guard against ailments who underwent surgical sympathectomy with the method of treatment of hypertensive ailments [29].

Thus, at the basis of the pathogenetic mechanism, which, when manifesting the 1st type of orthostatic hypotension, lies the presence of venoconstriction and other (m'ulcer, tissue) mechanisms, which change in great minds (in healthy appearance) the feet of blood deposition.

The basis of the 2nd type of orthostatic hypotension is the neuropathy of the autonomic nervous system, the main reason is the lack of function of the sympathetic eye, which can be both primary (with urticaria of the central nervous system), and secondary (with recurrence of diseases).

Yakscho at simpatoton?chn?y form? sposter?gayutsya lishe funkts?onaln? zm?ni of Garnier prediction, then asimpatoton?chna form chast?she viyavlya?tsya at seryoznih Parvin neurogenic torn down scho harakterizuyutsya r?znimi neyrodogichnimi symptoms (loss p?tlivost?, zm?ni regul'yats'y d?yalnost? intestine, sechovogo m?hura, ekstrakpiram?dn? torn down). The manifestation in patients with a form of orthostatic hypotension of chronic disorders of the functions of the autonomic nervous system [63] has been reported, which are manifested in twisted reflex reactions to cold stimuli, Valsalvi's test, m'yazove zusily, rozumové vantagennia.

Chronic insufficiency of the sympathetic nervous system is not associated with daily vasoconstriction on fatigue, but it also manifests itself as a decrease in plasma pressure and heart productivity. Decreased cardiac output may play an important role in this disease, as a result of a decrease in stroke rate and low blood flow from the left duodenum in these diseases at rest [24].

Physical methods of treating orthostatic hypotension are based on a folded vice on the lower part of the body, straightened opposite to the hydrostatic vice. It is demonstrated to stop the water immersion, which is ahead of it, showing a postural decrease in the arterial pressure and other characteristics x for orthostatic hypotension symptoms [13]. A gradient of hydrostatic pressure is established between the most deep balls of the water (at the ankle) and the surface of the water, the degree of pressure is

0. To this, the pressure in the veins of the knee decreases with orthostasis, which can be achieved with a degree of success, in direct proportion Zastosuvannya protitisku is also the basis of anti-gravitational outbuildings such as elastic panchos and navit suits, stuck in aviation and astronautics. Inflatable cuffs give an anti-gravity effect in the fall, as they have a vice of at least 40 mm Hg. [26]. The external pressure on the veins of the lower leg and the ventral pressure is especially effective, as it happens with short bony muscles, which leads not only to a change in the capacity of the veins, but also to the venous blood to the heart with an inactive valve. Without elastic attachments, robbing the protitis on the veins of the leg, in ailments with orthostatic hypotension, the arterial pressure was folded when sitting 160/110 mm. rt. Art., when standing 100/70 mm Hg. Art., and when walking 80/60 mm Hg. Art. In case of zastosuvanni appointments of anti-gravity attachments, the indications are generally equal 160/115, 150/105 and 150/100 mm Hg. [26]. With the help of orthostatic hypotension, it is also easy to get used to (head on the mountain), which allows the rapid movement of blood into the lower veins.

A special place in the treatment of orthostatic hypotension is occupied by the removal of sympathomimetic agents and venoconstrictor cavities [35]. In such a rank, you can put it, that in basketball players there was a symptomatic form of orthostatic hypotension, to which it was accompanied by tachycardia, drinking and insufficiency. symptoms characteristic of this form.

## **1.2. Methodology for determining orthostatic balance**

### **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]:

$$\text{MBV} = \text{SV} \times \text{heart rate}.$$

### **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 each indicator, the arithmetic mean, standard deviation  $S$  (standard deviation), error of the mean ( $m$ ) and estimation of the probability of discrepancies of indicators by Student's  $t$ -test with the corresponding level of probability ( $p$ ) were determined. The comparison was made for groups of students involved in football, track and field sportsmen, judo, as well as for groups of students with body length above average (more than 190 cm) and medium (below average) (150-175 cm). Differences and relationships were considered reliable at a significance level of  $p < 0.05$ .

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. Numbers of the sports that students were involved in: track and field - 1; football - 2; judo wrestling - 3. For statistical processing of the obtained data were used computer programs Microsoft Excel "Data Analysis" - 2013, SPSS - 17.

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

## CHAPTER 2. RESULTS OF DETERMINING THE INFLUENCE OF BODY LENGTH AND SPORTS SPECIALIZATION ON ORTHOSTATIC STABILITY OF STUDENTS - FUTURE SPECIALISTS IN THE FIELD OF PHYSICAL EDUCATION AND SPORTS

*Ushmarova V.*

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 <sup>-1</sup> ) 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 <sup>-1</sup> ) 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 <sup>-1</sup> ) 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 (l·min <sup>-1</sup> ) 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 (l·min <sup>-1</sup> ) 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 (l·min <sup>-1</sup> )	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·min <sup>-1</sup> ) 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 <sup>-1</sup> ) 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 <sup>-1</sup> ) 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 (l·min <sup>-1</sup> ) 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 (l·min <sup>-1</sup> ) 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 (l·min <sup>-1</sup> )	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 <sup>-1</sup> ) 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 <sup>-1</sup> ) 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 <sup>-1</sup> ) 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 (l·min <sup>-1</sup> ) 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 (l·min <sup>-1</sup> ) 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 (l·min <sup>-1</sup> )	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 ( $p < 0.005$ ;  $p < 0.01$ ;  $p < 0.001$ ).

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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	888.000 a	4	222	16.695	0.000
	Systolic pressure (mm.Hg) in the vertical position	3560.57 1b	4	890.143	2744.60 7	0.000
	Systolic pressure (mmHg) difference	1280.57 1c	4	320.143	19.742	0.000
	Diastolic pressure (mm.Hg.) in the horizontal position	1373.14 3d	4	343.286	5.484	0.001
	Diastolic pressure (mm.Hg.) in the vertical position	4053.00 0e	4	1013.25	430.922	0.000
	Diastolic pressure Difference (mm.Hg)	806.143 f	4	201.536	6.81	0.000
	Heart rate (beats·min <sup>-1</sup> ) in the vertical position	4994.14 3g	4	1248.53 6	1184.50 8	0.000
	Heart rate (beats·min <sup>-1</sup> ) in the vertical position	2452.28 6h	4	613.071	92.21	0.000
	Heart rate (beats·min <sup>-1</sup> ) difference	437.571 i	4	109.393	269.836	0.000
	Stroke volume (ml) in a horizontal position	824.096 j	4	206.024	1.786	0.152
	Stroke volume (ml) in the vertical position	1959.67 3k	4	489.918	128.314	0.000
	Stroke volume (ml) difference	1027.78 3l	4	256.946	44.508	0.000

Intercept	Minute blood volume ( $l \cdot min^{-1}$ ) in a horizontal position	19.290 m	4	4.823	12.729	0.000
	Minute blood volume ( $l \cdot min^{-1}$ ) in the vertical position	6.619n	4	1.655	2065.34 4	0.000
	Minute blood volume Difference ( $l \cdot min^{-1}$ )	4.784o	4	1.196	4.536	0.004
	Systolic pressure (mm.Hg) in the horizontal position	438703. 7	1	438703. 7	32991.9 5	0.000
	Systolic pressure (mm.Hg) in the vertical position	556475	1	556475	171579 8	0.000
	Systolic pressure (mmHg) difference	6993.20 4	1	6993.20 4	431.248	0.000
	Diastolic pressure (mm.Hg.) in the horizontal position	194326. 9	1	194326. 9	3104.53 1	0.000
	Diastolic pressure (mm.Hg.) in the vertical position	225666. 2	1	225666. 2	95972.9 7	0.000
	Diastolic pressure Difference (mm.Hg)	3104.92	1	3104.92	104.915	0.000
	Heart rate (beats $\cdot min^{-1}$ ) in the vertical position	124863. 2	1	124863. 2	118460	0.000
	Heart rate (beats $\cdot min^{-1}$ ) in the vertical position	163461	1	163461	24585.6	0.000
	Heart rate (beats $\cdot min^{-1}$ ) difference	3048.12 4	1	3048.12 4	7518.70 5	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	37044.2 7	0.000
	Stroke volume (ml) difference	4050.12 8	1	4050.12 8	701.567	0.000
	Minute blood volume ( $l \cdot min^{-1}$ ) in a horizontal position	483.904	1	483.904	1277.28 6	0.000
	Minute blood volume ( $l \cdot min^{-1}$ ) in the vertical position	634.008	1	634.008	791360. 4	0.000
	Minute blood volume Difference ( $l \cdot min^{-1}$ )	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	3803.29 2	0.000
	Systolic pressure (mmHg) difference	945.75	2	472.875	29.161	0.000

Body length	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·min <sup>-1</sup> ) in the vertical position	4441.75	2	2220.875	2106.984	0.000
	Heart rate (beats·min <sup>-1</sup> ) in the vertical position	1588	2	794	119.423	0.000
	Heart rate (beats·min <sup>-1</sup> ) 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 (l·min <sup>-1</sup> ) in a horizontal position	11.741	2	5.871	15.496	0.000
	Minute blood volume (l·min <sup>-1</sup> ) in the vertical position	2.603	2	1.302	1624.679	0.000
	Minute blood volume Difference (l·min <sup>-1</sup> )	2.996	2	1.498	5.681	0.007
	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
Body length	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·min <sup>-1</sup> ) in the vertical position	685.714	1	685.714	650.549	0.000

Kind of sport· Body length	Heart rate (beats·min <sup>-1</sup> ) in the vertical position	189	1	189	28.427	0.000
	Heart rate (beats·min <sup>-1</sup> ) 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 (l·min <sup>-1</sup> ) in a horizontal position	6.432	1	6.432	16.977	0.000
	Minute blood volume (l·min <sup>-1</sup> ) in the vertical position	2.403	1	2.403	2999.62	0.000
	Minute blood volume Difference (l·min <sup>-1</sup> )	0.693	1	0.693	2.63	0.113
	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 <sup>-1</sup> ) in the vertical position	1344	1	1344	1275.077	0.000
	Heart rate (beats·min <sup>-1</sup> ) in the vertical position	1296.429	1	1296.429	194.991	0.000
	Heart rate (beats·min <sup>-1</sup> ) 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 (l·min <sup>-1</sup> ) in a horizontal position	9.219	1	9.219	24.334	0.000

	Minute blood volume ( $l \cdot min^{-1}$ ) in the vertical position	2.46	1	2.46	3070.97 6	0.000
	Minute blood volume Difference ( $l \cdot min^{-1}$ )	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 $\cdot min^{-1}$ ) in the vertical position	39	37	1.054	-	-
	Heart rate (beats $\cdot min^{-1}$ ) in the vertical position	246	37	6.649	-	-
	Heart rate (beats $\cdot min^{-1}$ ) 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 ( $l \cdot min^{-1}$ ) in a horizontal position	14.018	37	0.379	-	-
	Minute blood volume ( $l \cdot min^{-1}$ ) in the vertical position	0.03	37	0.001	-	-
	Minute blood volume Difference ( $l \cdot min^{-1}$ )	9.757	37	0.264	-	-
Total	Systolic pressure (mm.Hg) in the horizontal position	518862	42	-	-	-
	Systolic pressure (mm.Hg) in the vertical position	652344	42	-	-	-
	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 <sup>-1</sup> ) in the vertical position	156954	42	-	-	-
	Heart rate (beats·min <sup>-1</sup> ) in the vertical position	193656	42	-	-	-
	Heart rate (beats·min <sup>-1</sup> ) 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 (l·min <sup>-1</sup> ) in a horizontal position	631.834	42	-	-	-
	Minute blood volume (l·min <sup>-1</sup> ) in the vertical position	756.172	42	-	-	-
	Minute blood volume Difference (l·min <sup>-1</sup> )	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 <sup>-1</sup> ) in the vertical position	5033.143	41	-	-	-



Heart rate (beats·min <sup>-1</sup> ) in the vertical position	2698.28 6	41	-	-	-
Heart rate (beats·min <sup>-1</sup> ) difference	452.571	41	-	-	-
Stroke volume (ml) in a horizontal position	5092.40 6	41	-	-	-
Stroke volume (ml) in the vertical position	2100.94 3	41	-	-	-
Stroke volume (ml) difference	1241.38 3	41	-	-	-
Minute blood volume (l·min <sup>-1</sup> ) in a horizontal position	33.308	41	-	-	-
Minute blood volume (l·min <sup>-1</sup> ) in the vertical position	6.648	41	-	-	-
Minute blood volume Difference (l·min <sup>-1</sup> )	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)

We found that in different groups there is a different severity of adaptive responses to the orthostatic test in terms of blood pressure and heart rate (Borysenko, et.al., 2020). Thus, when comparing students with different body lengths revealed significant differences in systolic blood pressure in students of the two groups (Table 1). The increase in systolic blood pressure in students whose body length is above 190 cm, significantly higher than in students whose body length does not exceed 175 cm ( $p < 0.01$ ) (table 1). With regard to diastolic blood pressure, in students whose body length is above 190 cm, this figure is significantly higher ( $p < 0.01$ ) in both horizontal and vertical position (Table 1). Stroke volume of blood in tall (body length more than 190 cm) students in the standing position is significantly less compared to this figure

of students with a body length of 150-175 cm. The same applies to the minute volume of blood flow (Table 6).

*Table 6*

Comparative characteristics of orthostatic test indicators of student-athletes  
with different anthropometric data (body length)

Indexes	Body length	Statistical indicators					
		N	$\bar{x}$	S	m	t	p
Systolic pressure in the horizontal position, mmHg	>190	12	113.50	1.57	0.45	1.82	0.077
	150-175	30	110.00	6.56	1.20		
Systolic pressure in the vertical position, mmHg	>190	12	131.00	1.04	0.30	3.28	0.002
	150-175	30	121.60	9.83	1.80		
Systolic pressure Difference, mmHg	>190	12	17.50	2.61	0.75	2.75	0.009
	150-175	30	11.60	7.21	1.32		
Diastolic pressure in the horizontal position, mmHg	>190	12	79.00	1.04	0.30	2.72	0.010
	150-175	30	70.80	10.34	1.89		
Diastolic pressure in the vertical position, mmHg	>190	12	86.00	6.27	1.81	3.15	0.003
	150-175	30	76.20	9.97	1.82		
Diastolic pressure Difference, mmHg.	>190	12	7.00	7.31	2.11	-1.76	0.085
	150-175	30	11.00	6.37	1.16		
Heart rate in the vertical position, beats·min <sup>-1</sup>	>190	12	59.00	13.58	3.92	-0.42	0.678
	150-175	30	60.60	10.14	1.85		
Heart rate in the vertical position, beats·min <sup>-1</sup>	>190	12	68.50	8.88	2.56	0.54	0.595
	150-175	30	67.00	7.90	1.44		
	>190	12	9.50	4.70	1.36	0.97	0.339

Heart rate difference, beats·min <sup>-1</sup>	150-175	30	8.40	2.62	0.48		
Stroke volume in a horizontal position, ml	>190	12	57.85	1.93	0.56	-1.89	0.066
	150-175	30	64.82	12.64	2.31		
Stroke volume in the upright position, ml	>190	12	58.90	7.42	2.14	-2.67	0.011
	150-175	30	64.98	6.38	1.16		
Stroke volume, Difference, ml	>190	12	8.95	1.10	0.32	-2.01	0.051
	150-175	30	12.60	6.20	1.13		
Minute blood volume a horizontal position, l·min <sup>-1</sup>	>190	12	3.44	0.90	0.26	-1.56	0.126
	150-175	30	3.91	0.88	0.16		
Minute blood volume in the upright position, l·min <sup>-1</sup>	>190	12	3.97	0.02	0.00	-2.74	0.009
	150-175	30	4.32	0.44	0.08		
Minute blood volume Difference, l·min <sup>-1</sup>	>190	12	0.85	0.56	0.16	0.68	0.503
	150-175	30	0.71	0.61	0.11		
Body length, cm	>190	12	192.50	2.61	0.75	16.67	0.000
	150-175	30	165,20	5,40	0,99		

Significantly lower values of stroke volume and minute blood flow in tall students compared to students of medium body length indicate insufficient adaptation to changes in body position in tall students compared to students with a body length of 150-175 cm.

In tall students there is no significantly greater difference in heart rate when changing body position from horizontal to vertical compared with students of average and below average body length, and the change in heart rate is within normal limits (Table 6).

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 ( $p < 0,001$ ). The highest heart rate and blood pressure in students - track and field sportsmen. According to these indicators, footballers occupy an intermediate place.

To more accurately confirm the results of the impact of various sports on the performance of orthostatic samples, a multivariate analysis of variance was performed using a general linear model (Table 7).

*Table 7*

Indicators of multivariate analysis of variance of the influence of kinds of sport and body length on the orthography of students-athletes (multivariate tests)

Effect		Multivariate Tests(c)				
		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	1,000	1632000,00	2,000	36,000	0,000
	Wilks' Lambda	0,000	1632000,00	2,000	36,000	0,000
	Hotelling's Trace	90689,733	1632000,00	2,000	36,000	0,000
	Roy's Largest Root	90689,733	1632000,00	2,000	36,000	0,000
Kind of sport	Pillai's Trace	1,229	29,503	4,000	74,000	0,000
	Wilks' Lambda	0,002	376,356a	4,000	72,000	0,000
	Hotelling's Trace	367,969	3219,730	4,000	70,000	0,000
	Roy's Largest Root	367,667	6801,843b	2,000	37,000	0,000
Body length	Pillai's Trace	0,868	118,697a	2,000	36,000	0,000
	Wilks' Lambda	0,132	118,697a	2,000	36,000	0,000
	Hotelling's Trace	6,594	118,697a	2,000	36,000	0,000
	Roy's Largest Root	6,594	118,697a	2,000	36,000	0,000
Kind of sport * Body length	Pillai's Trace	0,930	238,011a	2,000	36,000	0,000
	Wilks' Lambda	0,070	238,011a	2,000	36,000	0,000
	Hotelling's Trace	13,223	238,011a	2,000	36,000	0,000
	Roy's Largest Root	13,223	238,011a	2,000	36,000	0,000

a. Exact statistic

b. The statistic is an upper bound on F that yields a lower bound on the significance level.

c. Design: Intercept; kind of sport; body length; kind of sport \* body length

Significant influence of both body length and sport on most indicators of orthostatic test was found (Table 2). 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 7). The only exception is the rate of stroke blood volume in the horizontal position ( $p > 0.05$ ) (Table 7).

Body length also significantly affects the indicators of vascular regulation (Table 2). 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 volume in the standing position, minute blood flow in the supine and standing positions ( $p < 0,001$ ) (Table 7).

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 ( $p < 0,005$ ;  $p < 0,01$ ;  $p < 0,001$ ).

## **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  $\cdot$  min<sup>-1</sup>. 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  $\cdot$  min<sup>-1</sup> 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  $\cdot$  min<sup>-1</sup> indicates a decrease in orthostatic stability, and a heart rate exceeding 95 beats  $\cdot$  min<sup>-1</sup> 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].

The hypothesis presented 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.

A more pronounced increase in systolic and diastolic pressure in tall students compared with students of medium and below average body length indicates the activation of mechanisms of adaptation to changes in body position. It is known that (Kozina, Slyusarev, 2002; Borysenko, Marian, & Kozina, 2020) that in people of high body length the change in performance in the transition from horizontal to vertical position. This leads to more pronounced adaptation mechanisms of heart rate and blood pressure. In our study, the increase in heart rate in tall people does 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 than in others. This fact can be seen as a more pronounced adaptive response of students



with a body length above 190 cm from the cardiovascular system and vascular regulation. adaptive reactions are not sufficient, because the values of the shock volume of blood and the minute volume of blood flow in the vertical position in students of high lengths and the body is significantly smaller compared to students with a body length of 150-175 cm.

We can explain the obtained results by the fact that sports games (Lutfullin, & Al'metova, 2014) and judo (Rodrigues, Goncalves, De Souza, & Da Silva Soares, 2014; Kozina, Z., Goloborodko, Boichuk, , ... Drachuk, Stsiuk, 2018) is a load of mixed aerobic-anaerobic orientation, while running short and medium distances is mainly a job , which requires creatine-phosphate and glycolytic mechanisms of energy supply.

It is known (Rodrigues, Goncalves, De Souza, & Da Silva Soares, 2014) that mixed loads (aerobic and glycolytic) have the greatest impact on the cardiovascular system. It can be concluded that in this case, the load on the cardiovascular system, which provide football and judo, have a greater impact on the adaptive capacity of vegetative-vascular regulation compared to loads exclusively running, mixed creatine-phosphate and In addition, judo training requires a large number of changes in body position, rapid transitions from horizontal to vertical position, and vice versa. changes in the direction of movement, which also requires changes in body position (tilts, turns, "rolls", etc.). exerts a certain load on vestibular stability. And so we can conclude that football and judo have a training effect on vegetative-vascular regulation is greater than exclusively running exercises.

On the other hand, our study did not involve qualified athletes, but athletes of amateur level, mass categories according to the classification in Ukraine. Therefore, our results can be considered as a basis for similar studies involving qualified athletes to obtain more detailed information on the impact of exercise from different sports on vascular regulation, which is reflected in the orthostatic test. This is planned in further research.

## 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.

3. It was found that the increase in systolic blood pressure during the transition from horizontal to vertical position in students whose body length is above 190, significantly higher than in students whose body length does not exceed 175 cm ( $p < 0,01$ ). diastolic blood pressure, then in students whose body length is above 190 cm, this figure is significantly higher ( $p < 0.01$ ) both horizontally and vertically. Stroke volume of blood in tall (body length more than 190 cm) students in the standing position is significantly less compared to this figure of students with a body length of 150-175 cm. The same applies to the minute volume of blood flow.

4. The lowest values of heart rate in the horizontal position and in the vertical position of the body in judo wrestling. The same applies to blood pressure in the horizontal and vertical position ( $p < 0,001$ ). The highest heart rate and blood pressure in track and field students-sportsmen. According to these indicators, footballers occupy

an intermediate place. 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 ( $p < 0,05$ ;  $p < 0,001$ ). The only exception is indicator of stroke volume of blood in the horizontal position ( $p > 0,05$ ).

5. It was revealed by the results of analysis of variance that body length significantly affects the indicators of vascular regulation. 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 volume in the standing position, minute blood flow in the supine and standing positions ( $p < 0,001$ ). 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 ( $p < 0,005$ ;  $p < 0,01$ ;  $p < 0,001$ ).

6. The results of a more significant impact of judo and football in comparison with running short and medium distances on the indicators of vascular regulation: the best indicators - in judo, the next place - in football, then – in track and field sportsmen. 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, 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 (sitting) to standing positions, as well as changes in the direction of movement are useful.

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