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Adaptive changes of the cardiovascular system to physical exercise in the young males of the mountainous districts of Zakarpattia: the role of somatotype and component body composition

Introduction. The cardiovascular system performs a particularly important role in the adaptation of children, adolescents, and young adults to various environmental factors. During periods of rapid growth in children, adolescents, and young adults, significant variability in morphophysiological parameters and physical development is observed, largely influenced by somatotype. Changes in hormonal levels at different stages of ontogenesis result in significant morphofunctional differences, particularly in the cardiovascular system. Zakarpattia is a region with ecological and geographical features that determine the endocrine and morphofunctional status of people living in these territories.

The purpose of the study is to determine the peculiarities of the recovery of the cardiovascular function according to the indicators of the recovery of the heart rate and blood pressure after dosed physical exercise in young males of the mountainous districts of Zakarpattia, depending on the somatotype and the component composition of body mass.

Materials and methods. 124 young males aged 17-21, residents of the mountainous regions of Transcarpathia, participated in the study. The assessment of the dynamics of cardiovascular system indicators depending on the constitutional characteristics of body composition was carried out by methods of heart rate monitoring, sphygmomanometry, bicycle ergometry, determination of somatotype using caliper and bioimpedancemetry, as well as statistical processing of research materials using Microsoft Excel 2010 spreadsheets.

Results and discussions. The number of young males with increased diastolic pressure, which is regarded as a negative vascular reaction, after performing work with a power of 1 W per 1 kg of body mass was 7.26%, and after performing work with a power of 2 W per 1 kg of body mass, it was 2.42%. The "phenomenon of infinite tone", which disappeared within 1 minute after stopping work, was observed only after performing work with a power of 2 W per 1 kg of body weight in 41.13% of young males. The dynamics of changes in diastolic pressure during dosed exercise in the examined young males depended on the somatotype: the highest percentage of individuals with an increase in diastolic pressure appeared in endomesomorphs and in young males with a balanced somatotype, namely in 9.52% and 7.14%, respectively; depended on the component composition of body mass: in 5.26% of young males with a relatively normal content of skeletal muscles and in 6.2% of young males with a high relative fat content, we observed an increase in the level of diastolic pressure above the baseline, while in young males with high and very with a high relative content of the muscle component and in persons with a normal and low relative content of fat, no such changes were registered. The «phenomenon of infinite tone» was observed only in 50.0% of young males with a high relative fat content, who performed work under a cycle ergometric load with an intensity of 2 W per 1 kg of body mass.

Conclusions. The prevalence of the fat component and the relative decrease of the muscle component in the somatotype and component composition of the body of young males from mountainous districts causes a negative reaction of blood vessels, namely an increase in diastolic pressure above the initial level.

Key words: diastolic pressure, somatotype, young males.

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Адаптаційні зміни серцево-судинної системи до фізичних навантажень молоді гірських районів Закарпаття: роль соматотипу та компонентного складу маси тіла

Вступ. Серцево-судинна система відіграє особливо важливу роль в адаптації дітей, підлітків та молоді до різноманітних факторів зовнішнього середовища. У періоди швидкого росту у дітей, підлітків і молодих людей спостерігається значна варіабельність морфофізіологічних показників і фізичного розвитку, що значною мірою залежить від соматотипу. Зміни гормонального фону на різних етапах онтогенезу призводять до значних морфофункціональних відмінностей, зокрема в серцево-судинній системі. Закарпаття є регіоном з екологічними та географічними особливостями, що обумовлюють ендокринний та морфофункціональний статус осіб, які проживають на цих територіях.

Мета. Встановити особливості відновлення функції серцево-судинної системи за показниками відновлення частоти серцевих скорочень і артеріального тиску після дозованої фізичної роботи у юнаків гірських районів Закарпаття залежно від соматотипу та компонентного складу маси тіла.

Матеріали та методи. В дослідженні брали участь 124 юнаків від 17-21 року, мешканці гірських районів Закарпаття. Оцінку динаміки показників серцево-судинної системи залежно від конституційних характеристик складу тіла здійснювали методами моніторингу серцевого ритму, сфігмоманометрії, велоергометрії, визначення соматотипу із застосуванням каліперометрії та біоімпедансометрії, а також статистичної обробки матеріалів дослідження із застосуванням електронних таблиць Microsoft Excel 2010.

Результати та обговорення. Кількість юнаків із підвищеним діастолічним тиском, що розцінюється як негативна реакція судин, після виконання роботи потужністю 1 Вт на 1 кг маси тіла становила 7,26%, а після виконання роботи потужністю 2 Вт на

1 кг маси тіла 2,42%. «Феномен нескінченного тону», який зникав протягом 1-ої хв по припиненню роботи спостерігався лише після виконання роботи потужністю 2 Вт на 1 кг маси тіла у 41,13% юнаків. Динаміка змін діастолічного тиску при дозованих фізичних навантаженнях у обстежених юнаків залежала від соматотипу: найбільший відсоток осіб із підвищенням діастолічного тиску проявився у ендомезоморфів та у юнаків зі збалансованим соматотипом, а саме у 9,52% та 7,14% відповідно; залежала від компонентного складу маси тіла: у 5,26% юнаків з відносним нормальним вмістом скелетних м'язів та у 6,2% юнаків з високим відносним вмістом жиру ми спостерігали підвищення рівня діастолічного тиску вище вихідного, тоді як у юнаків з високим та дуже високим відносним вмістом м'язового компоненту та у осіб з нормальним та низьким відносним вмістом жиру таких змін не реєструвалося. «Феномен нескінченного тону» спостерігався лише у 50,0% юнаків з високим відносним вмістом жиру, які виконували роботу при велоергометричному навантаженні інтенсивністю 2 Вт на 1 кг маси тіла.

Висновки. Перевага жирового компоненту та відносне зменшення м'язового компоненту у соматотипі та компонентному складі тіла юнаків гірських районів викликає негативну реакцію судин, а саме підвищення діастолічного тиску вище вихідного рівня.

Ключові слова: діастолічний тиск, соматотип, юнаки.

Introduction. In the conditions of modern scientific and technological progress, the human body is under constantly influenced by various stressors, including meteogeographical factors, which requires enhancement of the adaptive mechanisms of the functioning of individual systems [1, 10, 13, 15]. The functioning of the organism in the process of adaptation to the environment occurs in the state of health and illness. However, adaptation can be carried out in pre-nosological conditions, which differ in the level of tension of the regulatory systems. The degree of stress of the regulatory systems determines the current functional state of an individual, which is necessary to maintain homeostasis [12, 14, 17, 18]. The cardiovascular system performs a particularly important role in the adaptation of children, adolescents, and young adults to various environmental factors. Therefore, it is extremely important to know the parameters of norm and variations in the development of the cardiovascular system of children and adolescents in modern conditions. During periods of rapid growth in children, adolescents, and young adults, significant variability in morphophysiological parameters and physical development is observed, largely influenced by somatotype. Changes in hormonal levels at different stages of ontogenesis result in significant morphofunctional differences, particularly in the cardiovascular system [4, 5, 7]. Zakarpattia is a region with ecological and geographical features that determine the endocrine and morphofunctional status of people living in these territories [3, 16].

The purpose of the study is to determine the peculiarities of the recovery of the cardiovascular function according to the indicators of the recovery of the heart rate and blood pressure after dosed physical exercise in young males of the mountainous districts of Zakarpattia, depending on the somatotype and the component composition of body mass.

Research methodology and methods. 124 young males aged 17-21 who live in the mountainous districts of Zakarpattia participated in the study. The examined individuals made up 52.5% of the total number of the examined young males. For conducting the constatative experiment, carried out at the Department of Surgical Dentistry and Clinical Disciplines of Uzhhorod National University, monitoring of heart rate was performed using the TOPCOM HB 8M00 chest pulse sensor and sphygmomanometry. Observation, registration and analysis of adaptive changes in functional indicators of the cardiovascular system were carried out during bicycle ergometry after two loads of 1 W/kg and 2 W/kg with a 5-minute interval immediately after work and three times after its completion (at 1, 2, and 3 minutes) [2, 9, 11]. The somatotype was determined using the Heath-Carter method using the «Digital Body Fat Caliper», a tape measure and a «Digital Caliper 150 mm» electronic caliper [6]. The component body composition was determined by the bioelectrical impedance method, assessing the total fat content component according to the criteria of H.D. McCarthy and D. Gallagher, and the muscle component according to Omron Healthcare, using the Body Composition Monitor «OMRON BF511» device [8]. The statistical analysis of the research results was performed using Microsoft Excel 2010 electronic spreadsheets, enabling the analysis of measurements and calculations of obtained values.

Presentation of the main research material. Table 1 shows the dynamics of heart rate recovery in young males from the mountainous districts of Zakarpattia after physical exercise mainly in aerobic (with stimulation of aerobic) and anaerobic (with stimulation of anaerobic lactic) metabolism.

In the first minute of the recovery period, the decrease in heart rate almost did not depend on the intensity of the exercise. However, the dependence between the intensity of exercise and the degree of decrease in heart rate was observed later. Thus, in young males with a heart rate of 130-140 bpm^{-1} 120 s it decreased on average by 37.2±0.45 bpm^{-1} after the completion of exercise, while in males with a heart rate of 180-190 bpm^{-1} it decreased by 55.9±0.34 bpm^{-1}. After 180 s of recovery period after working in the aerobic mode of energy supply (HR 130-140 bpm^{-1}) the decrease was 38,6±0,47 bpm^{-1} on average, and upon the completion of the exercise with the stimulation of anaerobic processes (180-190 bpm^{-1}) it was 56,8±0,30 bpm^{1}. Moreover, from 120 s to 180 s of the recovery period, the decrease in heart rate slowed down significantly, regardless of the mode of energy supply of muscle work.

Table 1

Dynamics of heart rate recovery after exercise in young males from mountainous districts, n=124

Increase in HR during exercise, bpm^{-1}	Decrease in HR (bpm^{-1}) after the completion of exercise, M±m					
	after 10 s	after 20 s	after 30 s	after 60 s	after 120 s	after 180 s
130-140	10,2±0,23	18,6±0,29	30,4±0,32	33,2±0,43	37,2±0,45	38,6±0,47
180-190	12,8±0,27	22,6±0,29	31,4±0,30	43,8±0,32	55,9±0,34	56,8±0,30

A positive reaction of the arterial vessels to bicycle work should be considered as an increase in systolic blood pressure (SBP) and a decrease or stability of diastolic blood pressure (DBP). Due to the peculiarities of determining blood pressure using the Riva-Rocci method, in some individuals, there is a phenomenon known as the «phenomenon of infinite tone», which manifests itself as the disappearance of Korotkoff sounds when the needle of the sphygmomanometer falls to zero. Although, as is known, lowering DBP to zero level is incompatible with life. In reality, in cases of registering the «phenomenon of infinite tone», DBP corresponds to a value of approximately 50 mm. Hg. An important aspect of our research was the analysis of the reaction of arterial vessels to dosed physical exercise in young males from the mountainous districts of Zakarpattia, table 2. 7.26% of young males had increased diastolic pressure, which is regarded as a negative reaction of blood vessels, after performing the exercise with a power of 1 W per 1 kg of body weight; however, the number of such individuals slightly decreased to 2.42% after performing the exercise with a power of 2 W per 1 kg of body weight. The «phenomenon of infinite tone», which disappeared within 1 minute after the cessation of the exercise, considers it as a physiological reaction of the arterial vessels to exercise, was observed only in 41.13% of young males after performing the exercise with a power of 2 W per 1 kg of body weight.

When analyzing the dynamics of changes in diastolic pressure during dosed physical exercise in young males from the mountainous districts of the Zakarpattia region depending on the somatotype, we found that the highest percentage of individuals with an increase in diastolic pressure in response to physical exercise with a power of 1 W per 1 kg of body weight was manifested in endomesomorphs and in young males with a balanced somatotype, 9.52% and 7.14%, respectively, (Table 3). During a cycling ergometric exercise with an intensity of 1 W per 1 kg of body weight, the number of individuals with a decrease in diastolic pressure was lower due to an increase in the number of those who had the «phenomenon of infinite tone». At the same time, only in endomesomorphs and young males with a balanced somatotype (4.8% and 3.57% of individ-

Table 2

The types of changes in diastolic pressure during dosed physical exercise in young males from mountainous districts, n=124

Load capacity	Type of diastolic pressure changes, mm.Hg, M±m							
	Below the initial level		Equal to the initial level		"Phenomenon of infinite tone"		Above the initial level	
	Number of persons, %	DBP, mm.Hg, M±m	Number of persons, %	DBP, mm.Hg, M±m	Number of persons, %	DBP, mm.Hg, M±m	Number of persons, %	DBP, mm.Hg, M±m
1 W·kg^{-1}	66,13	59,4±0,91	26,61	76,2±1,91	-	-	7,26	85,0±1,19
2 W·kg^{-1}	56,45	60,2±1,01	-	-	41,13		2,42	93,0±8,79

Note: * – the data were not presented numerically

Table 3

The types of changes in diastolic pressure during dosed physical exercise in young males from mountainous districts depending on somatotype, n=124

Load capacity	Type of diastolic pressure changes, mm.Hg, M±m							
	Below the initial level		Equal to the initial level		"Phenomenon of infinite tone"		Above the initial level	
	Number of persons, %	DBP, mm.Hg, M±m	Number of persons, %	DBP, mm.Hg, M±m	Number of persons, %	DBP, mm.Hg, M±m	Number of persons, %	DBP, mm.Hg, M±m
Endomesomorphs (n=42)								
1 W·kg^{-1}	61,9	54,0±2,02	28,57	84,2±1,85	-	-	9,52	86,7±2,80
2 W·kg^{-1}	47,62	68,8±1,85	-	-	47,62	*	4,76	100,0±2,65
Mesomorphs (n=29)								
1 W·kg^{-1}	72,41	63,8±1,77	24,14	75,0±4,54	-	-	3,45	85,0
2 W·kg^{-1}	68,97	55,5±1,85	-	-	31,03	*	-	-
Mesoectomorphs (n=19)								
1 W·kg^{-1}	78,95	61,7±1,92	15,8	75,0±4,18	-	-	5,26	90,0
2 W·kg^{-1}	63,16	54,2±3,24	-	-	36,84	*	-	-
Ectomorphs (n=6)								
1 W·kg^{-1}	50,00	58,3±16,7	33,3	75,0±8,85	-	-	16,7	90,0
2 W·kg^{-1}	66,67	62,5±5,60	-	-	33,3	*	-	-
Balanced somatotype (n=28)								
1 W·kg^{-1}	60,71	60,3±2,43	32,14	67,2±5,35	-	-	7,14	81,5±0,88
2 W·kg^{-1}	50,00	59,3±2,03	-	-	46,43	*	3,57	80,0

Note: * – the data were not presented numerically

uals, respectively), the diastolic pressure level was higher than the initial level. Among young males of other somatotype groups, there were no individuals with an increase in diastolic pressure in response to physical exercise with a power of 2 W per 1 kg of body weight.

As evidenced by the data in Table 4, the functional capabilities of the cardiovascular system based on the indicator of changes in diastolic pressure depended on the content of the muscle component. Thus, only among young males with a relatively normal content of this component (33.3 – 39.3%), 5,26% of individuals had a diastolic pressure level above the initial level. On the other hand, among young males with a high and very high relative content of the muscle component, no individuals were registered with an increase in diastolic pressure after dosed exercise on a cycle ergometer with a power of 2 W per 1 kg of body weight.

The «phenomenon of infinite tone» was observed in young males who performed exercise under a cycle ergometric load with an intensity of 2 W per 1 kg of body weight, regardless of the content of the muscle component.

As evidenced by the data in Table 5, the adaptation of the cardiovascular system according to the indicator of changes in diastolic pressure depended on the fat content. Only in 6.2% of young males with a high relative fat content (19.9-24.9%) increase in diastolic pressure above the initial level was observed, while in young males with a normal and low relative fat content, no individuals were registered with an increase in diastolic pressure after exercise on a bicycle ergometer with a power of 2 W per 1 kg of body weight. The «phenomenon of infinite tone» was observed only in young males who performed exercise under a cycle ergometric load with an intensity of 2 W per 1 kg of body weight. The largest number of such individuals (50.0%) was found among young males with a high relative fat content.

Conclusions. Differences in the response of arterial vessels to dosed physical activity depending on the soma-

Table 4

The types of changes in diastolic pressure during dosed physical exercise in young males from mountainous districts depending on the muscle content of the body composition, n=124

Load capacity	Type of diastolic pressure changes, mm.Hg, M±m							
	Below the initial level		Equal to the initial level		"Phenomenon of infinite tone"		Above the initial level	
	Number of persons, %	DBP, mm.Hg, M±m	Number of persons, %	DBP, mm.Hg, M±m	Number of persons, %	DBP, mm.Hg, M±m	Number of persons, %	DBP, mm.Hg, M±m
Normal skeletal muscle content (33,3 – 39,3 %), n=76								
1 W·kg^{-1}	72,4	58,0±1,19	23,9	81,1±1,33	-	-	3,95	83,0±1,67
2 W·kg^{-1}	57,9	58,1±1,38	-	-	36,8	*	5,26	95,0±5,61
High skeletal muscle content (39,4 – 44,0 %), n=39								
1 W·kg^{-1}	74,4	64,3±1,86	23,08	77,8±2,38	-	-	2,6	90,0
2 W·kg^{-1}	71,8	60,0±1,91	-	-	28,2	*	-	-
Very high skeletal muscle content (> 44,0 %), n=9								
1 W·kg^{-1}	55,6	62,0±4,29	33,33	76,7±12,6	-	-	11,11	80,0
2 W·kg^{-1}	55,6	63,0±4,29	-	-	44,44	*	-	-

Note: * – the data were not presented numerically

Table 5

The types of changes in diastolic pressure during dosed physical exercise in young males from mountainous districts depending on the fat content of the body composition, n=124

Load capacity	Type of diastolic pressure changes, mm.Hg, M±m							
	Below the initial level		Equal to the initial level		"Phenomenon of infinite tone"		Above the initial level	
	Number of persons, %	DBP, mm.Hg, M±m	Number of persons, %	DBP, mm.Hg, M±m	Number of persons, %	DBP, mm.Hg, M±m	Number of persons, %	DBP, mm.Hg, M±m
Low fat content (< 8,0 %), n=7								
1 W·kg^{-1}	71,4	61,0±4,29	14,3	75,0	-	-	14,3	90,0
2 W·kg^{-1}	57,1	57,5±5,61	-	-	42,9	*	-	-
Normal fat content (8,0 – 19,9 %), n=101								
1 W·kg^{-1}	71,3	60,4±1,0	24,8	73,8±2,27	-	-	3,9	82,5±2,80
2 W·kg^{-1}	62,4	57,5±1,09	-	-	37,6	*	-	-
High fat content (19,9 – 24,9 %), n=16								
1 W·kg^{-1}	56,2	55,6±4,76	37,5	78,3±5,3	-	-	6,3	90,0
2 W·kg^{-1}	43,8	70,0±3,02	-	-	50,0	*	6,2	110,0

Note: * – the data were not presented numerically

totype and component composition of the body were found in young males from mountainous districts of Zakarpattia. Thus, with load capacity of 1 W per 1 kg of body weight, the highest percentage of those in whom diastolic pressure increased during physical exercise was observed among young males of endomesomorphic and balanced somatotypes. Dosed exercise on a bicycle ergometer with a load capacity of 2 W per 1 kg of body weight caused an increase in diastolic pressure only in young males with a high relative fat content and normal relative skeletal muscle content. That is, the prevalence of the fat component and the relative decrease of the muscle component in the somatotype and component composition of the body of young males from mountainous districts causes a negative reaction of blood vessels, namely an increase in diastolic pressure above the initial level.

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