

## ORIGINAL RESEARCHES

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# CHARACTERISTICS OF FUNCTIONAL INDICATORS OF YOUNG MEN ENGAGED IN SPORTS, DEPENDING ON THE TYPE OF HEMODYNAMICS

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The aim of the study was to determine the characteristics of the functional indicators of the circulatory system of young men engaged in sports, depending on the type of hemodynamics. The scientific study was conducted on 42 athletes aged 14 to 19 years engaged in boxing and freestyle wrestling. All the examined persons were yakuts by nationality, were born and permanently resided on the territory of the Republic of Sakha (Yakutia). Of these, 22 athletes belonged to the adolescent age (14-16 years), 20 to the youth age (17-21 years). The anthropometric examination included the measurement of the overall dimensions of the body (length and body weight). The surface area of the body was calculated using the Mosteller formula. Changes in the parameters of the circulatory system characterize the functional capabilities of the body and the degree of adaptation to training loads. To assess the functional state of the circulatory system, the cardiac index, minute blood volume, systolic blood volume according to the Starr formula, the index of functional changes, average blood pressure, the coefficient of efficiency of blood circulation, the All-gover index, the double product, the coefficient of endurance according to the A. Kvaas formula and the Kerdo vegetative index were calculated. Statistical processing of the obtained data was carried out using parametric and nonparametric research methods, using the SPSS 17.0 application software package. The assessment of the functional state of the circulatory system was carried out taking into account the type of hemodynamics of the examined persons. The majority of the examined athletes had eukinetic – 42,9% and hyperkinetic – 47,6% types of hemodynamics. The hypokinetic type was determined only in 9,5 % of the examined athletes. Overall indicators of young men, depending on the type of hemodynamics, had no statistically significant differences. According to the Kerdo index, the predominance of the parasympathetic department of the autonomic nervous system was revealed in all the examined young men. Young men with hyperkinetic type of hemodynamics were characterized by high values of pulse pressure, heart rate, double product and coefficient of efficiency of blood circulation. The obtained results indicate the need to take into account the type of hemodynamics in the athlete's training process and the level of physical exertion.

**Keywords:** athletes, type of hemodynamics, blood pressure, index score.

**Introduction.** Classes in various sports exert significant loads on all systems of the human body, which leads to the stimulation of adaptive processes [6]. The most reactive is the circulatory system. The change in its parameters characterizes the functional capabilities of the body and the degree of adaptation to training loads [8]. When assessing the functional state of the circulatory system, an index assessment of hemodynamic parameters is widely used. Using the data of integral indicators of blood circulation, it is possible to determine the types of hemodynamics - eukinetic, hypokinetic and hyperkinetic [1]. Knowledge of hemodynamic types opens up prospects for a personalized approach in the training process to achieve higher sports results and reduce the risk of developing pathological processes in the body. The high level of the functional state of the circulatory system of athletes shows the reserve capabilities of the body to adapt

to high physical exertion. In this regard, the assessment of the functional state of the blood circulation of athletes and its adaptive reserves is one of the important issues of modern physiology and sports medicine.

**Purpose:** To characterize the functional parameters of the circulatory system of young men engaged in sports, depending on the type of hemodynamics.

**Materials and methods.** A morpho-functional examination was conducted on 42 students of the State Educational Institution of the Republic of Sakha (Yakutia) "School of Higher Sports Skills" engaged in boxing and freestyle wrestling. All the surveyed were males aged from 14 to 19 years, by nationality – yakuts permanently residing in the territory of Yakutia. According to the age classification of human ontogenesis, 22 subjects were considered to be adolescents (14-16 years old), and 20 subjects were considered to be adolescents (17-21 years old). The study was conducted after obtaining the voluntary informed consent of the participants. The criteria for exclusion from the scientific study were: refusal of examination, the presence of acute diseases and exacerbation of chronic diseases.

An anthropometric examination was carried out with the measurement of the overall dimensions of the body (length and body weight). The body length is determined by the Martin metal rod anthropometer with an accuracy of 1 mm,

the body weight is measured on medical scales with an accuracy of 100 g. All measurements were carried out in the morning, the data obtained were recorded in an individual survey card. According to the results of the anthropometric survey, the body surface area (BSA) was calculated using the Mosteller formula:

$$BSA = \sqrt{(\text{Body length} \times \text{Body weight}) / 3600}$$

To assess the functional state of the circulatory system, CI – cardiac index, MBV – minute blood volume, SBV – systolic blood volume, IFCh – index of functional changes, average blood pressure, CEBC – coefficient of efficiency of blood circulation, IA – Allgover index, DP – double product, EC – coefficient of endurance according to the formula of A. Kvaas, VKI – vegetative Kerdo index [2] were calculated.

Blood pressure was measured by an Omron M2 Basic automatic tonometer with an adapter (HEM-7121-ARU) in mmHg. Heart rate (HR) was calculated on the radial artery for 1 minute. Blood pressure measurement and pulse counting were carried out at rest. Pulse pressure (PP) is determined by the formula  $PP = SBP - DBP$ , where SBP is systolic blood pressure, DBP is diastolic blood pressure.

The cardiac index is an indicator of the pumping function of the heart. The calculation of the cardiac index is made

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according to the formula:  $CI = MBV/BSA$ . The norm is the CI value in the range from 2,2 to 2,4 l/min/m<sup>2</sup>. According to the CI value, the type of hemodynamics was determined in all the examined patients. The hypokinetic type included persons with a CI value of less than 2,7 l/min/m<sup>2</sup>, the eukinetic type – with a CI value of 2,7 to 3,5 l/min/m<sup>2</sup>, the hyperkinetic type – with a CI of more than 3,5 l/min/m<sup>2</sup>.

The SBV is calculated according to the Starr formula:  $SBV = 90,97 + (0,54 \times PP) - (0,57 \times DBP) - (0,61 \times A)$ , where PP is the pulse pressure (mmHg.ct); DBP – diastolic blood pressure (mmHg.st); A – age in years. The MBV was calculated according to the formula:  $MBV = CS \times HR$  ml/min, where SV is the stroke volume of the heart (ml.); HR is the heart rate per minute (beats/min).

IFCh is calculated by the formula:  $IFCh = 0,011 \times HR + 0,014 \times SBP + 0,008 \times DBP + 0,014 \times A + 0,009 \times BW - 0,009 \times BL - 0,27$ , where HR is the resting heart rate (bpm), SBP is systolic blood pressure (mmHg), DBP is diastolic blood pressure (mmHg), A is age (years), BW is body weight (kg), BL is body length (cm). The value of IFCh up to 2,6 indicates the normal operation of the circulatory system, IFCh in the range from 2,6 to 3,1 – the stress of the function, IFCh from 3,1 to 3,5 – unsatisfactory function, from 3,5 and higher – the failure of the function of the circulatory system. The CEBC was determined by the formula:  $CEBC = (SBP - DBP) \times HR$ . CEBC characterizes the energy expenditure of the body to perform the work of the circulatory system.

The double product is calculated by the formula:  $DP = HR \times SBP / 100$ , conv. units, where HR is the heart rate for 1 minute, SBP is the systolic blood pressure. The value of DP equal to 90 and higher was estimated as "below average", from 76 to 89 conv. units – "average", equal to and less than 75 conv. units as "above average". The endurance coefficient was calculated using the formula:  $EC = HR \times 10 / (SBP - DBP)$ , conv.ed. The norm is the value of EC from 12 to 16 conv. units, the increase in the activity of the CVS (cardiovascular system) – a value less than 12, the reduced load on the cardiovascular system – more than 16 conv. units.

The VKI is defined by the formula:  $VKI = (1 - DBP/HR) \times 100$ , conv. units, the value of the VKI was regarded as "vagotonia" in the case of a negative index value, as "sympathicotonia" with its positive value. An index equal to zero indicated the equivalent activity of the sympathetic and parasympathetic parts of the autonomic nervous system.

Statistical processing was carried out using parametric and nonparametric research methods (SPSS 17,0). The distributions of features and the estimation of the distribution characteristics (mean, standard deviation, minimum, maximum) are calculated. The assessment of intergroup differences was carried out according to the Mann-Whitney U-criterion. To assess the inter-group differences in relative indicators, the Pearson criterion  $\chi^2$  was used. The differences were considered significant at  $p < 0,05$  [5].

**Results and discussion:** A total of 42 young men engaged in martial arts were examined. The distribution of young men by type of hemodynamics was as follows: 9,5% belonged to the hypokinetic type, 42,9% – to the eukinetic type and 47,6% – to the hyperkinetic type of hemodynamics ( $\chi^2 = 9,064$ ;  $p = 0,011$ ). The indicators we obtained are similar to the results of other studies, so, according to N.V. Olyashev and co-authors, the distribution of hemodynamic types among young men of the Arkhangelsk region was as follows: hypokinetic type – 15,4%, eukinetic type – 36,8%, hyperkinetic type – 47,8% [3]. Such a distribution of hemodynamic types among young men in the northern regions of Russia may indicate the intense work of the circulatory system. Mobilization of functional reserves of the cardiovascular system is one of the adaptive processes of the human body. Overall indicators of young men, depending on the type of hemodynamics, had no statistically significant differences. The body length of young hypokinetics was equal to  $164,0 \pm 4,61$  cm, body weight –  $56,5 \pm 2,88$  kg; eukinetics –  $165,0 \pm 8,80$  cm,  $55,3 \pm 8,83$  kg; hyperkinetics –  $163,6 \pm 7,71$  cm,  $53,1 \pm 7,17$  kg. The average value of the BSA of the surveyed was equal to  $1,57 \pm 0,14$  m<sup>2</sup> (minimum –  $1,34$  m<sup>2</sup>, maximum –  $1,86$  m<sup>2</sup>).

The blood pressure indicators of young men of the hypokinetic type of hemodynamics were: SBP –  $115,0 \pm 4,12$  mmHg, DBP –  $71,0 \pm 6,92$  mmHg, PP –  $44,0 \pm 6,93$  mmHg. Similar parameters of young men of eukinetics were equal – SBP –  $115,11 \pm 11,04$  mmHg, DBP –  $62,56 \pm 7,56$  mmHg, PP –  $52,56 \pm 10,90$  mmHg. The blood pressure indicators of hyperkinetic boys were equal – SBP –  $121,40 \pm 6,24$  mmHg, DBP –  $64,0 \pm 8,73$  mmHg, PP –  $57,40 \pm 6,91$  mmHg. The heart rate in individuals with the hypokinetic type was  $58,0 \pm 8,08$  beats per 1 min., with the eukinetic type –  $66,22 \pm 9,37$  beats per 1 min., with the hyperkinetic type –  $87,30 \pm 10,29$  beats per 1 min. A comparative analysis of the obtained blood pressure parameters revealed significantly high values

of pulse pressure in hyperkinetic boys, in contrast to hypokinetic hemodynamic type boys ( $p = 0,002$ ). It was determined that the heart rate of young men in all the examined groups had significant differences ( $p < 0,001$ ). The lowest heart rate value was registered in persons with hypokinetic type, the highest value – in hyperkinetics.

The study of the vegetative index of Kerdo among the students of Yakutia revealed the heterogeneity of the distribution of types of vegetative regulation [4, 7]. In the group we studied, the predominance of the parasympathetic division of the autonomic nervous system was revealed in all the examined young men. Vagotonics are characterized by lower heart rate and SBP values, which indicates a more economical operation of the circulatory system. According to IFCh and EC, all the examined young men have good functional capabilities of the circulatory system (Table). The obtained data indicate stable mechanisms of adaptation of the examined group, as well as successful compensation of unfavorable lifestyle factors by mobilizing internal reserves of the body.

The differences in the indicators of the functional state of the circulatory system depending on the type of hemodynamics were determined. Thus, the assessment of DP showed that in persons with hyperkinetic type, the average value of DP was  $105,94 \pm 13,51$  conv. units. The obtained DP indicators were significantly higher than similar parameters of persons with hypokinetic and eukinetic types, which indicates low aerobic capabilities of young men with hyperkinetic type of hemodynamics. DP characterizes the efficiency of the heart as a whole, the level of tolerance to physical exertion, as well as the adequacy and lability in the work of the CVS.

CEBC characterizes the costs of the body for hemodynamics. The average values of CEBC in young men with eukinetic and hyperkinetic types of hemodynamics were significantly higher than normal, which indicates that the physical exertion presented does not correspond to the functional capabilities of the body of these groups of young men. The value of the MBV in hyperkinetic boys was equal to  $6508,54 \pm 889,80$  ml in 1 min., which is higher than normal indicators.

**Conclusions:** The conducted study of the functional parameters of the circulatory system of 42 young men engaged in martial arts revealed the heterogeneity of the examined group by types of hemodynamics. The majority of the examined individuals had eukinetic and hyperkinet-

## Parameters of the circulatory system of young men. depending on the type of hemodynamics

| Parameters | Hypokinetic type (n=4) | Eukinetic type (n=18) | Hyperkinetic type (n=20) | Statistical significance of difference. p*                                      |
|------------|------------------------|-----------------------|--------------------------|---------------------------------------------------------------------------------|
|            | 1                      | 2                     | 3                        |                                                                                 |
| IFCh       | 1.82±0.15              | 1.81±0.24             | 2.12±0.19                | p <sub>1-3</sub> =0.029;<br>p <sub>2-3</sub> =0.001                             |
| EC         | 13.65±3.98             | 13.23±4.08            | 15.50±3.12               | p <sub>2-3</sub> =0.013                                                         |
| DP         | 66.70±9.26             | 76.18±12.15           | 105.94±13.51             | p <sub>1-3</sub> <0.001; p <sub>2-3</sub> <0.001                                |
| CEBC       | 2510.0±46.18           | 3437.44±609.32        | 4988.40±716.58           | p <sub>1-2</sub> =0.002;<br>p <sub>1-3</sub> <0.001;<br>p <sub>2-3</sub> <0.001 |
| SBV        | 51.80±10.88            | 65.95±13.97           | 70.03±13.85              | p <sub>1-2</sub> =0.04;<br>p <sub>1-3</sub> =0.01                               |
| MBV        | 3574.53±7.71           | 4753.42±446.33        | 6508.54±889.80           | p <sub>1-2</sub> =0.002;<br>p <sub>1-3</sub> <0.001;<br>p <sub>2-3</sub> <0.001 |

ic types. The length and body weight of young men of different types of hemodynamics did not significantly differ. According to the Kerdo index, the predominance of the parasympathetic department of the autonomic nervous system was revealed in all the examined young men. Significant differences in the functional parameters of the circulatory system depending on the type of hemodynamics were revealed. Young men with hyperkinetic type were characterized by high values of pulse pressure, heart rate, DP and CEBC, which indicates a low level of oxygen supply to the body to adequately meet energy needs during physical exertion, as well as, possibly, a discrepancy between physical exertion and the functional capabilities of the body of this group of young men. Thus, in the training process, it is necessary to take into account the type of hemodynamics of the athlete and the level of physical exertion on the circulatory system.

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