HEART PUMPING FUNCTION OF BOYS WITH VARIOUS MOTOR ACTIVITY LEVELS DURING PROGRESSIVE LOAD

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Introduction. The problem of the influence of different motor activity (MA) on the functional status of cardiovascular system is one of the vital ones in sports physiology. According to the literature data, significant morphofunctional changes take place in the body of the ones with different MA. The functional status of the circulatory system of elite athletes who train for various purposes differs significantly due to physiological suitability for the given sport. However, there is a lack of studies of the specifics of the response of the heart pumping function of boys with various MA to the veloergometric stress test. Therefore we paid special attention to this issue.

The purpose of the study was to reveal regular responses of the heart pumping function of boys with different MA to the veloergometric stress test.

Materials and methods. The studies, conducted in the laboratory of functional diagnostics of the physical education department of Kazan State Agrarian University, involved male students of two universities and athletes: Kazan State Agricultural University, Kazan Federal University and athletes, engaged in athletics, ranked from class I to Master of Sports. The number of subjects was 100. Depending on the mode of MA, all subjects were divided into three groups: boys aged 17 - 20 years of Kazan State Agricultural University (Group I, with low MA, without sports grades and the ones involved in physical culture according to the university curriculum, n = 43); male students aged 19 - 21 years of the faculty of physical education of Kazan Federal University (Group II, with average MA, n = 27); athletes aged 17 - 22 years (group III, with high MA, n = 30).

Results and discussion. The obtained results of the heart pumping function are presented in Table 1, showing that in the pre-work-out state the lowest heart rate values (HR) were observed in the group of boys with high MA, as regular classes of physical education and sport lead to improvement of the work of the circulatory system, displayed primarily in the heart rate fall. In this group HR ranged 66,24 ± 1,83 bpm. However, HR fall at rest does not reduce the efficiency of blood circulation, but, on the contrary, extends the range of heart functionalities. The study of the only one indicator, heart rate, does not give a full idea of heart work. Therefore, we studied the indicators related to the power characteristic of

cardiovascular system: stroke volume and minute volume. These values were more significant in the groups of boys with average and high MA, rather than in the group of boys with low MA (Tab. 1).

The indicators of the heart pumping function give essential information for the analysis of loads of different power. Thus, with increasing power of work performed on the cycle ergometer, a significant rise of minute volume (MV) was observed, which was 3 times as many compared to the pre-work-out level and amounted to 15,03 ± 0,55 l/min in the group of boys with high MA. According to V.L. Karpman et al. (1982), the ratio of the value of cardiac output at work and its value in the pre-work-out state can give the idea of the functional reserve of the cardiovascular system. It was significantly higher and amounted to 270,81, 205.66 and 221.10 % in the group of boys with high, low and average MA respectively.

Table 1. *Indices of heart pumping function in groups of boys with low (I), average (II) and high (III) motor activity*

Conditions of measuring indices	Indices	Groups of subjects		
		I	II	III
Initial state, Watt	HR	76,67±1,79	72,45±1,90	66,24±1,83+^
	SV	67,20±1,64	72,87±1,81*	83,81±2,54+^
	MV	5,12±0,15	5,26±0,17	5,55±0,23
0,5	HR	95,14±1,71	91,26±2,56	85,08±2,28+
	SV	91,54±2,69	96,16±3,86	108,16±3,97+^
	MV	8,67±0,26	9,17±0,45	9,23±0,59
1,0	HR	117,11±1,71	110,84±2,32*	100,59±1,72+^
	SV	88,49±2,82	95,76±4,09	118,57±3,36+^
	MV	9,70±0,31	10,65±0,53	11,93±0,48+
1,5	HR	127,60±1,75	125,84±2,78	115,40±1,88+^
	SV	82,73±2,53	92,80±3,96*	130,39±4,08+^
	MV	10,53±0,35	11,63±0,62	15,03±0,55+^

Note. * - statistically significant differences between the indices of I and II groups of boys;
+ - statistically significant differences between the indices of I and III groups of boys;
^ - statistically significant differences between the indices of II and III groups of boys.

The cardiac output during motor activity increases due to the inclusion of one or more compensatory mechanisms: the increase of heart rate or the value of SV, and in some cases, both of the parameters of the cardiovascular system. However, their contribution to the increase of MV is different. Thus, for example, the stroke output increases not more than twice relative to the initial level, whereas HR can increase by three or more times during maximum load [4]. The lower HR is at rest, the higher cardiac chronotropic abilities are. The increase of the stroke output, which depends on the basal-reserve volume of the blood is the key optimizing factor of MV in persons with high MA.

When the power of load increases from 0.5 to 1.0 Watt, the phenomenon of blood economization in terms of the index of cardiac output is not realized, as the values of minute volume in the test groups were approximately the same. However, in the group of high MA the boys had certain reserves in heart

work: they had a lower chronotropic response to load, and during progressive load further increase of HR can contribute to a significant growth of MV.

Cardiac output was raised using different ways. In the group of boys with high MA the increase of the cardiac output took the path of increasing both HR, and SV. This can be considered as one of the mechanisms of endurance development [2]. This mechanism is believed to be the most effective. In our studies the increase of inotropism in the myocardium leads to an increase of SV by the full use of the basal-reserve volume of the blood and formation of an extra reserve volume of the blood [2]. Its bigger amount provokes the situation when more significant maximization of SV will contribute to the increase of MV. As a result, the hemodynamic effect of increased SV exceeds the effect of heart rate. In the groups of boys with low and average MA the increase of MV occurred as a result of the heart chronotropic response. Besides, the chronotropic effect of increased heart rate exceeded the inotropic one, associated with the immutability of SV, which we observed in these groups starting from the 1.0 and 1.5 W loads (Tab. 1).

The 1.5 W load performed on a bicycle ergometer provoked a further increase of heart rate in the groups under study. This index significantly increased in the groups of boys with low and average MA, reaching 127,60 ± 1,75 and 125,84 ± 2,78 bpm respectively. The increase of MV in these groups was mainly due to the chronotropic effect, when the acceleration of heart work indicates tolerance of the applied load.

At the last level of load SV in the groups of boys with low and average MA tended to decrease compared with the previous load, which adversely affected the index of cardiac output, which was lower for an accurate amount in these groups compared with the group with high MA. This is probably due to the fact that the high chronotropic response of heart to the 1.5 W physical load results in a significant shortening of diastole and thereby the problems with filling of the heart ventricles begin. The mechanism of the significant increase of SV in case of progressive load in the group of boys with high MA, apparently, can be explained by the fact that they have bigger left ventricular diastolic and systolic volumes than the boys of other groups [6]. Therefore, at exercise both of the volumes decrease significantly, which predetermines the increased stroke volume. Moreover, stroke output grows due to reduced end-systolic volume of blood, since the cardiovascular system is stable and theconstant return of blood to the heart is observed [7].

Conclusions. The adduced data on the response of the heart pumping function to the veloergometric stress test in the groups of boys with different motor activity indicate to different contribution to the cardiac output of MV and HR indicators. The cardiac inotropy was higher in the groups of boys with high MA. It can be taken as the most efficient way of manifestation of urgent adaptation of MV to load. In the group of boys with low and average MA the minute volume increased

owing to heart rate. The chronotropic mechanism of increase of the cardiac output in the quoted groups is remarkable when the loading was over 1,0 watt.

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