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Puberty Changes of Haemodynamics in Boys-Athletes.

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ABSTRACT

The article describes the results of haemodynamics studies in hockey players aged 11-15 with regard to the stages of sexual maturation and their comparison characteristics with indicators of the boys from control class who do physical activity in terms of comprehensive secondary school. It has been shown that systematic muscle exercises have dominant effect on functional state of cardiovascular system in athletes in the prepubertal and pubertal periods of the development of their organisms; it is observed invariably high stroke volume of blood and systolic arterial pressure; maximum frequency indices of heart beats, volume of blood per minute and diastolic arterial pressure are observed at the 1- st and 2-nd stages of puberty, and minimum - at the 3-d stage, as distinct from the children of control class, whose parameter data dynamics has opposite direction. It may indicate to stress character of physical overactivity by effect of which the adaptive responses of cardiovascular system predominate over puberty change of its functional activity.

Keywords*:* hockey players aged 11-15, hemodynamics, stages of pubescence.

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INTRODUCTION

In spite of considerable number of works reflecting functional state of hemodynamics of young athletes the changes of its indices are assessed, as a rule, from the standpoint of the trained children [1,2], at the same time the influence of neuroendocrinal change of the period of pubescence, causing increase of sympathetic impulsing on neuromuscular apparatus of heart and blood vessel, is not taken into account [3]. The role of sympathetic regulation in the period of adolescent «jump» is undoubtedly important, enhancement of which is biologically reasonable and necessary for completion of formation of morphological and functional properties of cardiovascular system (CVS). But heightened lability of neural processes, characteristic for puberty [3], reduction of excitability threshold of vegetative nervous system and insufficient involvement of parasympathetic division into compensatory-adaptation body response [4,5] cause adolescent functional disorders of CVS in the form of hypertensive effects, sinus arrhythmia, extrasystole [6]. Irrational physical load can change dynamics of evolutive processes in heart and vessels and cause cardiovascular abnormalities in young athletes as well [7-10]. All this is important in connection with extensive development of athletics for the children and the youth, its initial orientation to preserve good health of rising generation. In literature there are absent data about the longitudinal studies of CVS of young hockey players, and information of their hemodynamics at different stages of sexual maturation (SSM), though indisputable is the fact of influence of level of sexual maturation on physical efficiency and adaptive abilities of the circulatory system of young athletes [11].

All stated above determined the topicality of research, allowed to formulate its objective – the study peculiarities of functional state of CVS of hockey players 11-15 of age at different stages of sexual maturation.

RESEARCH METHODS

In research the boys-athletes (58 boys) who studied in sport specialized classes (SC) of school № 1 in Kazan and played ice hockey with week volume of physical load of 12-14 hours took part in the research. All examinations were conducted in the period of competitions, in parallel to daily practices, at that the children at the age of 11 were at the initial stage of intensive muscle training. For the sake of reliable judgment about specific effect of physical exercises on the level of CVS of the adolescents, the boys from control classes (CC) involved into physical culture in terms of general school (48 boys) were simultaneously studied. The same children aged from 11 to 15 inclusive were continuously observed during 5 years. For the purpose of exclusion of effect of circadian and seasonal rhythms of functional activity of physiological systems [12], and also impact of academic load on the children's organism, examination was conducted at one and the same hours – in the first half of the day, midweek, in the year starting October.

For the study of functional status of CVS, it was used the method of tetrapolar pectoral rheoplethysmography with hardware-software rheographic system «Rheo-Spectrum-2» (LLS «Neurosoft» Ivanovo). Stroke volume of blood (SVB) was calculated by Kubichek formula in modification by Yu. T. Pushkar [13], minute volume of blood (MVB) – as product of SVB per heart rate (HR). General peripheric vascular resistance (GPVR) was calculated by Poiseuille formula [14], measurement of blood pressure (BP) was taken by method of N.S. Korotkov using semi-automatic device «MF–30» (Japan). It was measured systolic, diastolic and medium hemodynamic pressure (SBP, DBP, MHP) [15].

Stages of puberty were determined by method of J. Tanner (1968) depending on the degree of manifestation of secondary sexual characters [16].

Statistical manipulation of the obtained data was carried out by standard methods of variation statistics using software package Microsoft Excel, 2007. For certainty value of differences it was used T-test, based on Student's t-criteria.

THE RESULTS OF RESEARCH AND THEIR DISCUSSION

Taking into consideration that development of CVS in adolescence depends substantially on the level of sexual maturation, the study of its functional status was carried out at each stage of sexual development of young hockey players. At that, it has been established that distribution of the boys according to the stages of sexual maturation in sport and control classes has its peculiarities (table 1).

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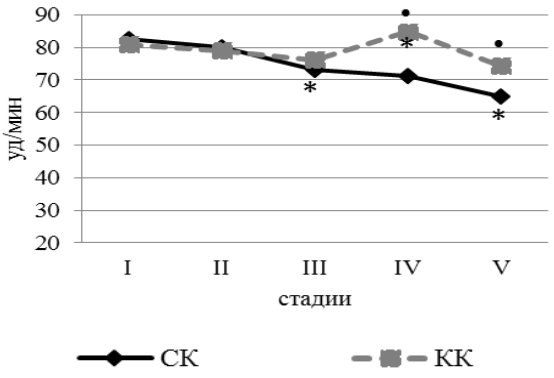
Table 1: Puberty stages distribution of the boys aged 11-15 in sport and control classes (%)

Age	Puberty stages									
	SC					CC				
	I	II	III	IV	V	I	II	III	IV	V
11	100					70	30			
12	20	80					70	30		
13		30	70					80	20	
14		10	50	40				10	90	
15			10	70	20				30	70

Note: SC – sport class, CC – control class

So, among the children aged 11, not going in for athletics, 30% of them are already at puberty stage II, whereas in the group of hockey players all the children belong only to puberty stage I. The number of the boys aged 13 being referred to puberty stage III from control class increases by 50% in comparison with the boys aged 12, and 20% of them refer already to stage IV, whereas in the group of athletes 30% of adolescents are going through puberty stage II, and the rest are at the third stage of sexual maturation. At the age of 15, 70% of the boys from control class enter puberty stage V, and stage IV is still dominating in the athletes, moreover, 10% of the boys are still at puberty stage III. That is, it is observed relative slowing down of puberty process (development of secondary sexual characters) in the young hockey players aged 11-15, probably, as the result of effect of strenuous physical exercises, in particular, secretion of quantity of glucocorticoid [17,18], capable to slow down orthergasia of gonads and, thus, to effect on the processes of sex differentiation [19].

The study of hemodynamics depending on the level of sexual maturation of the boys has detected a clear connection with a concrete stage of sexual maturation, and strongly pronounced dominance of the processes of adaptation over puberty (figures 1, 2, 3, 4). So, maximum values of series of hemodynamic indices are observed in the boys from sport class at puberty stages I and II, when cardiac rhythm equals 82,55±1,82 and 80,20±1,65 beats/minute, and its certain reduction goes on at puberty stages III and V, accounting for 7,20 and 6,10 beats/minute ($p<0,05$) correspondingly. Maximum indices of blood minute volume (BMV) in athletes are also registered at puberty stages I and II – 4,93±0,10 and 4,90±0,12 l, it is noteworthy that by puberty stage III they reduce to 1,03 l ($p<0,05$), and further stabilize between 4,17±0,10 and 4,47±0,19 l. At that blood stroke volume has constant and relatively high indices at all puberty stages (between 54,90±1,33 and 65,50±1,66 ml), by puberty stage V it is observed its greater increment by 8,70 ml ($p<0,05$). Puberty stages I and II in the hockey players are characterized by substantial increasing of systolic blood pressure and diastolic blood pressure, that are equal to 131,00±2,00, 132,00±2,20 mm Hg and 73,00±1,60, 72,20±1,36 mm Hg, diastolic blood pressure reduces by puberty stage III ($p<0,05$), and systolic blood pressure reduces to little degree only by stage V, when its index does not exceed 126,60±1,50 mm Hg. Dynamics of peripheral resistance in the young hockey players is characterized by constant values at puberty stages I-III, not exceeding 1431,40±79,36 dynes $s^{-1}cm^{-5}$, by increasing by puberty stages IV by 311,42 dynes $s^{-1}cm^{-5}$ ($p<0,05$), the raised level of this level is preserved at puberty stage V.



Beats/minute **stages**
SC **CC**

Figure 1: Change in frequency indices of cardiac beats in boys from sport and control classes at different stages of pubescence

* - differences are significant in comparison with previous stage of pubescence by $p<0,05$;

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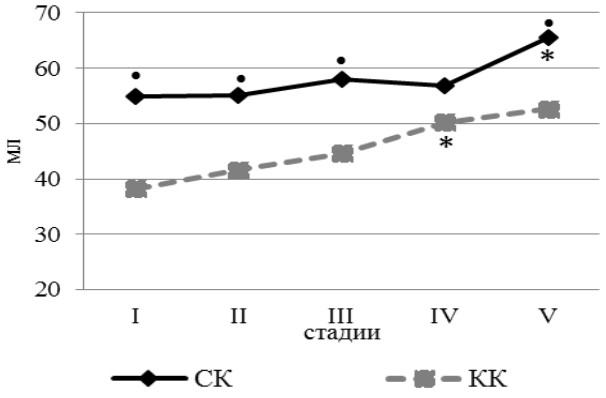
• - differences are significant between SC and CC by p<0,05.

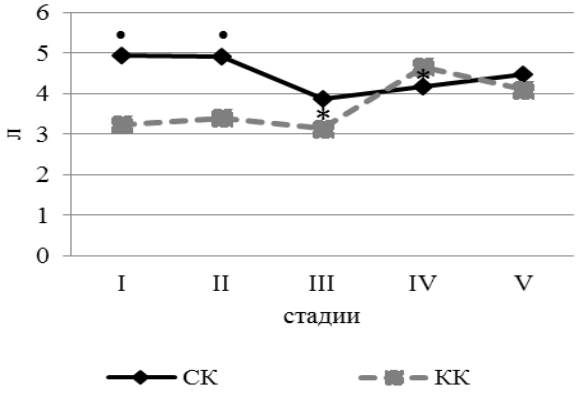


ml **stages**
SC **CC**

Figure 2: Changes in indices of blood stroke volume in boys from sport and control classes at different stages of pubescence

* - differences are significant in comparison with previous stage of pubescence by p<0,05;

• - differences are significant between SC and CC by p<0,05.



l **stages**
SC **CC**

Figure 3: Changes in indices of blood minute volume in boys from sport and control classes at different stages of pubescence

* - differences are significant in comparison with previous stage of pubescence by p<0,05;

• - differences are significant between SC and CC by p<0,05.

It is noteworthy that maximum hemodynamic indices have directly opposed character in boys from control class and, in contrast with athletes, their maximum values are registered at puberty stages III and IV. Thus, against frequency reduction of heart contraction in the process of pubescence (between 80,99±1,72 and 74,35±1,38 beats/minute) by puberty stage IV its values increase by 8,66 beats/minute in comparison with puberty stage III (p<0,05). Analogous dynamics is detected in relation to blood stroke volume and blood minute output, that increase by 5,57 ml and 1,52 l correspondingly, by puberty stage IV, at that blood stroke volume is increasing still by puberty stage V (p<0,05). Changes in blood pressure in the boys from control class are less significant, at the same time it is observed the tendency to increasing systolic blood pressure between II and III stage of sexual maturation (by 5,26 mm Hg), and diastolic blood pressure from III to IV PS (by 3,40 mm Hg). At the same time almost at all stages of pubescence the indices of systolic blood pressure, somatotropic hormone and diastolic blood pressure (between I and II puberty stages) in the boys from control class is significantly lower, than in the hockey players. And general peripheric vascular resistance has different dynamics – as distinguished from the athletes, it is observed its lowering in the children from control class in the process of pubescence, and it is strong pronounced between puberty stages IV and V accounts for 267,42 dynes $s^{-1}cm^{-5}$. According to many researches [3,5], just stages III and IV of sexual maturation (the stage of activation of gonads and the stage of maximum steroidogenesis [20]) are critical in the development of CVS of adolescents (puberty «jump» of cardiac rate, increase in blood stroke volume, blood minute volume and

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vascular tone), which is explanable from the point of view of physiological hyperfunctioning of hypophysis, medullary and cortical layers of atrabiliary capsules [20], and connected with it steep increase in production of adrenaline, noradrenaline and cortisol, amplifying sympathetic regulation of the functions of myocardium and hemodynamics [3].

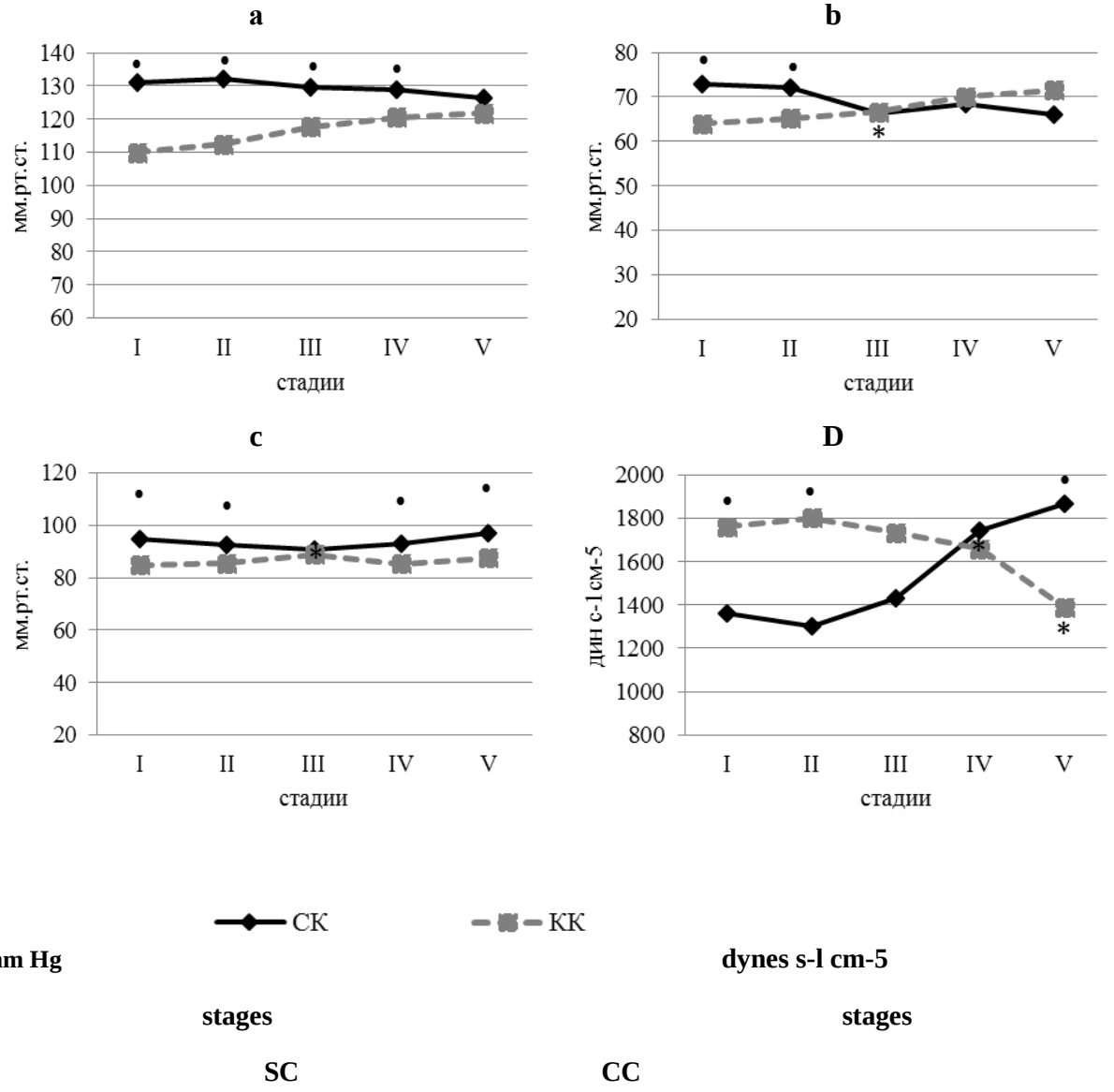

Figure 4: Change in indices of functional status of cardio-vascular system of the boys from sport and control classes at different stages of pubescence

a – systolic blood pressure; **b** – diastolic blood pressure; **c** – somatotrophic hormone; **d** – general peripheric vascular resistance.

* - differences are significant in comparison with the previous stage of pubescence by p<0,05;

• - differences are significant between SC and CC by p<0,05.

Contradiction, being observed in the group of young hockey players, whose puberty changes in CVS are against common regular occurrences (maximum values of cardiac rate, blood minute volume and diastolic blood pressure at puberty stages I and II and their decreasing by puberty stage III, stabilization with significant figures of systolic blood pressure, diastolic blood pressure and somatotropic hormone, beginning with puberty stage I and increased level of peripheral vascular resistance), shows that physical loads in regime of forced athletic trainings have pronounced stress character and adaptive responses of cardiovascular system, prevail over its evolutive processes connected with puberty. It is proved by the obtained data about long and

significant stress in hypophysial-suprarenal system in the young hockey players, accompanied by considerable increase in the level of excretion of free cortisol, between puberty stages I and IV [21]. It is not ruled out, that just glucocorticoids possessing the ability to potentiate and cardiotonic and vasoconstrictive activity of catecholamines [22,23] condition hemodynamic effects in the young hockey players in tension state of adaptation (increasing stroke volume of blood and blood pressure, tonicizing peripheric vessel).

SUMMARY

According to the stated above one can conclude that the status of cardiovascular system of the young hockey players depends on the stage of pubescence – it is observed maximum values of heart rate, systolic blood pressure and diastolic blood pressure at puberty stages I and II and their significant decrease by puberty stage III. As distinct from the boys from control class whose changes in haemodynamics have directly opposite character, and the indices of systolic blood pressure, diastolic blood pressure and somatotropic hormone are significantly lower than in the hockey players.

CONCLUSION

So, the conducted longitudinal study has shown that systematic muscle training is a dominating factor in the development of cardiovascular system of adolescents in the period of puberty. It has been detected stress character of physical overload, by effect of which the adaptive responses of hemodynamics prevail over puberty shifts of its functional activity.

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