Junior ice hockey players' hemodynamics analysis

Фотографии:

Dr.Biol., Professor **M.V. Shaykhelislamova**[1]
Dr.Biol., Professor **F.G. Sitdikov**[1]
PhD, Associate Professor **N.B. Dikopolskaya**[1]
PhD, Associate Professor **G.A. Bilalova**[1]
Dr.Med., Professor **R.G. Biktemirova**[1]
PhD, Dr.Hab., Professor **F.R. Zotova**[2]
Institute of Fundamental Medicine and Biology of Kazan (Volga Region) Federal University, Kazan
Volga State Academy of Physical Culture, Sports and Tourism, Kazan

Keywords: *hemodynamics, 11-15 year-old hockey players, graded cycle ergometry exercise.*

Introduction. Physical loads are a powerful accelerator for the development of the cardiovascular system (CVS) of the growing body, improvement of its neurohumoral regulation [2, 13]. However, despite a great number of research works covering the CVS functionality in junior athletes, its rates variations are generally estimated only from the point of view of children's training level [3, 5]. At the same time, the effects of certain endogenous factors are neglected. Such factors are: age-related morphofunctional reorganization of the CVS, neuroendocrine changes occurring during puberty and causing amplification of sympathetic impulses in the neuromuscular system of the heart and blood vessels, which considerably negates the efficiency of adaptation reactions [6]. The role of sympathetic regulation during pubertal growth spurt is, beyond dispute, crucial, its enhancement is biologically expedient and necessary for the formation of the morpho-functional parameters of the CVS. At the same time, excessive physical loads can exceed the CVS physiological level, which can not only affect the dynamics of evolutive processes in the heart of junior athletes, but also cause cardiovascular system disorders [14]. Of special interest is the study of junior ice hockey players' hemodynamics, since ice hockey, as one of acyclic sport disciplines, imposes heightened requirements to the level of speed-strength and coordination abilities of the body. Game performance is determined by the integrated functioning of the hemodynamic system, vestibular, visual and motor analyzers, the degree of emotional stability of players [8, 9].

Objective of the study was to find the effects of systematic muscular exercise on hemodynamics of 11-15-year-old hockey players.

Methods and structure of the study. Subject to the study were 58 11-15 year-old boys from the special sports classes of School #1 in Kazan city trained in ice hockey groups and having the 5-years-long uninterrupted formal sport records. The 11-year-old subjects were at the beginner stage of intensive physical training process. The Reference Group for the study was composed of the boys (n=48) from general education school who trained in compliance with the standard physical education course. The cardiovascular system functionality was tested in the study by the tetrapolar chest rheoplethysmography using Reo-Spectrum-2 Rheograph (made in Russia). Stroke volume (SV) was determined by the modified method of Kubicek (modified by J.T. Pushkar [10]), cardiac output (CO) was calculated as the product of SV by heart rate (HR). Total peripheral vascular resistance (TPVR) was calculated by the Poiseuille formula [1], blood pressure (BP) was measured by the Korotkov's method using a semi-automatic blood pressure monitor "MF-30" (Japan). We measured systolic, diastolic and mean hemodynamic pressure (SBP, DBP, MHP) [11]. The functional test consisted in the use of a graded physical load performed on a bicycle ergometer "Rhythm" VE-0.5 (Ukraine) at 1.5 W per 1 kg of body mass for 3 minutes.

Results and discussion. The findings revealed that the dynamics of the CVS parameters in the junior ice hockey players was different from that in the boys of the Reference Group and had its unique features. Thus, HR equaled 84.40±1.90 bpm in the 11-year-old athletes, but it decreased with age to 65.66±1.02 bpm; the most pronounced difference was observed in the age from 14 to 15 years ($p<0.05$), which does not conflict with the regularities of formation of the cardiac chronotropic function in children [2, 6] and agrees with the results of the earlier studies on the direct relationship between the heart-rate fall rate and the level of motor activity [2]. A different picture was observed among the boys of the Reference Group against the background of a gradual decrease in HR from 11 to 13 years (from 82.00±1.99 to 75.80±1.34 bpm); it increased significantly at the age of 14 years - by 7.56 bpm ($p<0.05$), which can be interpreted as a pubertal growth spurt in HR, associated with an increase in sympathetic regulation of cardiac activity [6]. Other research works [7] are devoted to the stabilization or increment of this CVS parameter in 13-15-year-old adolescents with an average level of physical development. It was further found that SV in the 11-12-year-old hockey players slightly changed and was at a relatively high level of 54.90±1.33 and 53.91±1.40 ml, from 12 to 13 and from 14 to 15 years it increased - by 5.41 and 7.42 ml ($p<0.05$), which is consistent with the data of the studies conducted with junior swimmers, skiers, gymnasts, according to which junior athletes' SV increases with improvement of their fitness level [3, 5]. In the non-sporting boys the SV values at all stages of the study were significantly lower than in the sporting ones, the differences ranged from 11.84 to 15.96 ml ($p<0.05$). The same pattern was observed in terms of CO, namely, it increased in the 11-, 12-, 13-year-old hockey players compared with the Reference Group subjects ($p<0.05$).

In the following, it was reasonable to analyse the age-specific changes in the TPVR, as cardiac output and peripheral resistance of the blood vessels are the major factors within the adaptive blood circulatory system [12]. The property that specifies the TPVR dynamics in athletes is its increase with age and improvement of training level, which is most clearly observed at the ages from 12 to 13 and from 13 to 14 years, when the increase equals 202.90 and 327.18 dynes per $s^{-1}cm^{-5}$ ($p<0.05$), at 15 this trend is preserved. In the Reference Group subjects, despite a relatively higher TPVR level at the age of 11 and 12 years ($p<0.05$), a significant decrease is observed at the age of 14 years. An increase of the vascular tone in the 11-15-year-old hockey players may, on the one hand, be associated with the anatomic features of formation of vasculature during the pre- and pubertal periods [6, 7], on the other hand - the detected differences from the Reference Group may indicate that it is the increased physical activity that provokes a progressive increase of the TPVR with age. The emerging problem of increasing vascular tone is alarming, since an arteriolar spasm and growth of peripheral resistance of the blood vessels may be the key factors of pathogenesis of hypertensive conditions in children [4, 11].

Further on it was found that the differences in the TPVR values between the 11-12-year-old sports class and Reference Group boys were quite comparable with the CO values. Thus, the increased CO values in the athletes, which were 1.5 and 1.3 times higher than those in the Reference Group, were accompanied by a relative decrease in the TPVR at this age, that is, compensated by an increase in the capillary blood flow capacity, which indicates the manifestation of the mechanism of self-regulation of hemodynamics [12]. At the same time, the level of this regulation in the junior ice hockey players was insufficient, as evidenced by the BP study results, particularly, unexpectedly high SBP values at the age of 11, 12, 13 and 14, reaching the upper normal level for healthy adolescents [11] - from 129.66±1.85 to 131.24±2.00 mmHg. This was accompanied by an increase in DBP at 11 and 12 years by 8.00 and 7.18 mmHg, which exceeded the values of the Reference Group subjects ($p<0.05$), in whom SBP was lower than in athletes and did not exceed 122.19±1.25 mmHg. Special attention should be paid to MHP as a hemodynamic constant used to estimate the correlation between cardiac output and vascular tone. In the junior athletes, this indicator settled at a relatively high level - from 91.73±1.93 to 98.64±2.25 mmHg, while in the non-sporting boys it was lower and did not exceed 88.06±1.80 mmHg. In other words, an increase in MHP in athletes in combination with higher CO values (at the age of 11-13 years) may indicate a decrease in the capillary blood flow capacity [12].

The discrepancy between the cardiac output and peripheral circulation in the junior ice hockey players became especially apparent after physical exercise; however, it should be noted that their CVS response varied depending on age. Thus, it was at the age of 11, 12 and 13, when the chronotropic effect was the most pronounced, the inotropic cardiac manifestations were weakened, and the HR shift was 20.33; 25.03 and 24.45% ($p<0.05$) at each age, respectively. At the same time, practically no increase was noted in SV, while the CO increase equaling 20.08, 21.57 and 24.38% ($p<0.05$) was provided at the expense of HR. The absence of a SV shift in the boys at the stage of urgent adaptation to increased physical loads may be associated with a considerable pre-load tension of the cardiac inotropic function, when the athletes' cardiac output significantly exceeds its values in the children of the Reference Group. These data may indicate the manifestation of the homeostatic mechanism of regulation of hemodynamics – "law of initial values" by Widler, according to which initially high activity of the functional state slightly changes under the influence of external impulses [11]. Meanwhile, the CO increase in response to the graded exercise is accompanied by a simultaneous increase in the TPVR ($p<0.05$) - from 15.18 to 27.80%; being most pronounced at the age of 12 years. Herewith, a significant increase is also observed in DBP, which altogether may indicate a discrepancy between the increasing circulating blood volume of the capillary flow outcome, which is confirmed by a mathematically significant increase in MHP (11, 12 years) ($p<0.05$). The 14-15-year-old athletes were found to have a more balanced ratio of the cardiac chrono- and inotropic reaction, increasing role of the latter in providing CO. For instance, in the 14-year-old hockey players, the increase in HR was 20.78% ($p<0.05$), at the age of 15 - 11.24% ($p<0.05$), and SV - 21.80% ($p<0.05$) and 16.10% respectively. At the same time, SBP increased by 24.30% ($p<0.05$) and 20.33% ($p<0.05$), along with a relative stabilization of DBP. However, the detected decrease in the TPVR by 133.15 and 188.98 dyne s^{-1} cm^{-5} is insufficient against the background of a sharp increase in CO by 38.25 and 40.05% ($p<0.05$), which leads to a significant increase in MHP ($p<0.05$). Hence, CO increases without an adequate decrease in the peripheral resistance of the blood vessels, consequently, muscular work is performed under significant load on the arterial bed. It is not improbable that cardiac output that increases in this case is a compensatory adaptive reaction of the heart aimed to overcome the vascular resistance [6]. Dissociation between cardiac output and vascular bed capacity may indicate the earliest changes in the regulation of the circulatory system in children, which may testify to a tendency to hypertensive reactions [4, 11].

Conclusion. The age of 11-15 years is a critical and vulnerable period in the development of CVS of sporting boys, which necessitates strict medical supervision and correction of athletic training regime.

References

1. Akulova F.D. Instrumentalnye metody issledovaniya serdechno-sosudistoy sistemy [Instrumental methods of cardiovascular research]. Moscow: Meditsina publ., 1996, 416 p.
2. Arshavskiy I.A. Funktsionalnye osobennosti serdtsa pri fizicheskikh nagruzkakh v vozrastnom aspekte [Heart functionality during exercise in age aspect]. Stavropol: Dep. Education RSFSR publ., 1977, 234 p.
3. Vagapova A.M. Vliyanie sposobov plavaniya na pokazateli nasosnoy funktsii yunykh plovtsov. Avtoref. dis. kand. biol. nauk [Influence of swimming techniques on pumping function indices in junior swimmers. PhD diss. abstract]. Kazan, 2009, 22 p.
4. Delyagin V.M., Novikova T.A., Olimpieva S.P. Dokazatelny analiz rezultatov sutochnogo monitorirovaniya arterialnogo davleniya u detey i podrostkov [Evidence analysis of results of daily blood pressure monitoring in children and adolescents]. *Sistemnye gipertenzii*, 2011, vol. 8, no. 2, p. 60.
5. Elistratov D.E. Osobennosti adaptatsii serdtsa yunoshey k fizicheskoy nagruzke v zavisimosti ot tipa krovoobrascheniya i urovnya dvigatelnoy aktivnosti. Avtoref. dis. kand. biol. nauk [Peculiarities of young men's heart adaptation to physical activity depending on circulation type and level of motor activity. PhD diss. abstract]. Kazan, 2013, 22 p.

6. Kalyuzhnaya R.A. Fiziologiya i patologiya serdechno-sosudistoy sistemy detey i podrostkov [Physiology and pathology of cardiovascular system of children and adolescents]. Moscow: Meditsina publ., 1973, 325 p.
7. Krylova A.V., Pobezhimova, O.K. Adaptivnye vozmozhnosti serdechno-sosudistoy sistemy podrostkov na raznykh etapakh pubertata [Adaptive capabilities of cardiovascular system of adolescents at different stages of puberty]. *Mater. V Vseros. shkoly-konf. s mezhdunad. uchastiem «Fiziologiya krovoobrashcheniya»* [Proc. V Rus. school-conf. with intern. participation "Physiology of blood circulation"]. Moscow: MAX Press publ., 2012, p. 87.
8. Mavliev F.A., Zotova F.R., Samsykin A.S. Osobennosti kardiogemodinamiki yunykh hokkeistov 10-11 let [Features of cardiohaemodynamics of junior hockey players aged 10-11 years]. *Uchenye zapiski un-ta im. P.F. Lesgafta*, 2012, no. 11 (93), pp. 81-86.
9. Pletnev A.A. Osobennosti funktsionalnogo sostoyaniya kardiorespiratornoy sistemy i statokineticheskoy ustoychivosti khokkeistov-lyubiteley. Avtoref. dis. kand. biol. nauk [Features of cardiorespiratory system functionality and statokinetic stability of amateur hockey players. PhD diss. abstract]. Chelyabinsk, 2010, 24 p.
10. Pushkar J.T., Tsvetkova A.A., Heimets G.I. Avtomatizirovannoe opredelenie minutnogo objema krovi metodom reografii [Rheography for automated assessment of minute volume]. *Byul. Vsesoyuz. kardiol. nauch. tsentra AMN SSSR*, 1980, no. 1, pp. 45-48.
11. Spivak E.M., Pechnikova N.V. Osobennosti vegetativnoy regulyatsii serdechno-sosudistoy sistemy pri pervichnoy arterialnoy gipertenzii u podrostkov [Features of autonomic regulation of cardiovascular system in primary arterial hypertension in adolescents]. *Yaroslavskiy pedagogicheskiy vestnik*, 2012, vol. 3, no. 3, pp. 155-157.
12. Yakovlev G.M., Karlov V.A. Tipy krovoobrascheniya zdorovogo cheloveka: Neyrogumoralnaya regulyatsiya minutnogo objema krovoobrascheniya v usloviyakh pokoya [Types of blood circulation in healthy person: Neurohumoral regulation of cardiac output at rest]. *Fiziologiya cheloveka [Human Physiology],* 1992, vol. 18, no. 6, pp. 86-88.
13. Kolt G.S. A focus on children and adolescents in sport. *J. Sci. Med. Sport*, 2011, P. 14.
14. Matheson G.O., Klugl M., Dvorak J., Engebretsen L. Responsibility of sport and exercise medicine in preventing and managing chronic disease: applying our knowledge and skill is overdue. *Br. J. Sports Med.*, 2011., no. 45, P. 1272.

Corresponding author: bettydn@mail.ru

Abstract

The study was designed to analyse the age-specific haemodynamics in junior (11-15 years old) ice hockey players. Subject to the study were 58 boys from the special sports classes of School #1 in Kazan city trained in ice hockey groups and having the 5-years-long uninterrupted formal sport records. The 11 year-old subjects were at the beginner stage of intensive physical training process. The Reference Group for the study was composed of the boys (n=48) from general education school training in compliance with the standard physical education course. The cardiovascular system functionality was tested in the study by the tetrapolar chest rheoplethysmography using Reo-Spectrum-2 Rheograph (made in Russia).

The study data was found to indicate that a systemic physical training may be of high effect on the junior athletes' age-specific cardiovascular system functionality. It was found that the 11-14 years old subjects' systolic blood pressure (SBP) notably grows with the falling heart rates (HR) and the growing stroke volumes (SV) associated with the growing peripheral resistance of the blood vessels with age – versus the Reference Group subjects whose test rates were significantly lower. Fast adaptation of the 11-13 year-old athletes' cardiovascular system (CVS) to graded exercise is associated with spastic responses of the vessels without any positive changes in the stroke volumes (SV).