Heart rate variability and autonomic activity in young short-track athletes at the age of 14

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Abstract

Objective of the study was to determine the features of heart rate regulation and autonomic regulation for an orthostatic test in 14–year-old short-track athletes in the pre-competition training period.

Methods and structure of the study. The study involved 22 young male short-track athletes, with an average age of 14 years. The experiment was conducted at the stage of preparation for the competition. Temporal (MxDMn, RMSSD, SI) and spectral (TP, HF, LF, VLF) parameters were recorded using the Varicard 2.51 complex and ISCIM-6 software. Further processing and study of the obtained data were carried out using mathematical statistics methods.

Results and conclusions. For fourteen-year-old short-track athletes, the average values of temporal and spectral parameters in the clinostasis position significantly exceed the standard values typical for their peers who do not engage in sports. These values are also significantly higher than those of young athletes of the same age who specialize in other disciplines. The analysis of vegetative reactivity using an orthostatic test showed the presence of an overactive reaction of the body to a change in body position.

Keywords: *heart rate regulation, autonomic reactivity, clinostasis, orthostasis, physical activity, short track, adolescents, adequate physical activity.*

Introduction. In adolescence, systematic training loads are superimposed on the ontogenetic processes of growth and development and, if their volume and intensity do not correspond to the adaptive capabilities of the body, cause tension in the regulatory systems. Work at the limit of functional capabilities often leads to a breakdown of regulation towards decompensation. On the contrary, adequate physical activity increases functional reserves, reduces the tension of regulatory mechanisms, and maintains homeostasis [8].

Structural and functional changes in the heart under the influence of physical activity, as a rule, are of a physiological nature, but often carry signs of maladaptation, a violation of regulatory mechanisms. Overstrain of adaptation mechanisms in youth sports leads to the development of various pathological conditions in the cardiovascular system, not excluding fatal outcomes [10].

In the line of methods for studying the adaptation of the cardiovascular system to training physical activity, the most important place is occupied by variational pulsometry and its mathematical analysis using the method of R.M. Baevsky [1]. The combination of this method with an active orthostatic test allows us to identify the level of autonomic reactivity and detect potential signs of heart rate regulation disorders at an early stage [3, 8]. The severity of adaptive changes depends on the volume and intensity of physical activity, so the analysis of heart rate regulation mechanisms should be carried out taking into account the intensity of physical activity [9].

Objective of the study was to identify the features of heart rate regulation and autonomic regulation in response to an orthostatic test in 14-year-old short track athletes during the pre-competition training period.

Methods and structure of the study. Dynamic studies of HRV were conducted in 22 male short track athletes aged 14 during the pre-competition training period using the Varicard 2.51 device and the ISCIM-6 program.

The following HRV parameters were calculated: the index of the variation range of cardiointervals R-RMxDMn (ms), the index of the stress index (SI, conventional units), the RMSSD index (ms), the total spectrum power (TP, ms), the spectrum power of high-frequency (HF, ms), low-frequency (LF, ms), and very low-frequency (VLF, ms). The recording duration in clinostasis was 5 minutes. To assess the level of vegetative reactivity and identify the reserve capacity of the body, an orthostatic test was carried out for 5 minutes. In order to identify the adaptive potential of the body of short track athletes, a short-term intense load lasting 45 seconds was carried out at the maximum pace for the subject.

Statistical data processing was carried out using the method of variation statistics using Student's t-test. The Biostat software package was used. Average values (M) and the error of the mean (m) were calculated. The critical significance level for testing statistical hypotheses in this study was taken to be $p<0.05$.

Results and conclusions. An analysis of heart rate variability (HRV) indices was conducted in 14-year-old male adolescents involved in short track in the pre-competition period (Table 1).

In the supine position, the predominance of the autonomous regulation circuit (type III) was revealed according to the classification of N.I. Shlyk [8], which, according to a number of authors [3,8], reflects a high level of functional state and should be considered as the potential ability of the body to effectively adapt to competitive physical activity [2]. Under the influence of systematic physical activity in adolescence (13-14 years), there is a change in the lability of the sinus node and the formation of more advanced forms of neurohumoral regulation of the heart due to an increase in the tone of the vagal link of the autonomic nervous system [5]. It should be noted that in some subjects, the HRV indicators are close in magnitude to type IV regulation with a pronounced dominance of the autonomous regulation circuit. In the works [8], the appearance of type IV indicates the state of athletic "form", which occurs during the competitive period. However, in the indicated works, the HRV indicators were obtained in adult athletes of the highest skill level. The obtained data exceed the age standards for athletes of this age group and the corresponding type of vegetative regulation.

According to our results, in short track athletes in the prone position, the time values of the MxDMn, RMSSD and SI indicators are 474±35.36 ms, 143±12.54 ms and 50±4.92 conventional units, spectral TP, HF, LF, VLF: 18293±2752 ms, 13135±1915 ms, 3582±688 ms and 1086±385 ms, respectively. At the same time, in the work of Shlyk N.I. [8] In 14-year-old athletes with type III regulation, the HRV indices are significantly lower and equal to: 345±13.7 ms, 78±5.5 ms, 49±4.8 ms for MxDMn, RMSSD, SI and 4553±352 ms, 2542±348 ms, 1124±118 ms, 382±73 ms for TR, HF, LF, VLF, respectively. In addition, the HRV indices we obtained in 14-year-old short track speed skaters are significantly higher compared to the indices in young volleyball players [2], 14-year-old sambo wrestlers [6], 15-year-old skiers [8], 15-year-old rowers [7]. Without excluding the situation in which the level of the functional state of young short track athletes is really high, we conducted an additional individual analysis of the indicators, which allows us to identify the probability of a pre-nosological condition. The results showed that in individual subjects, the value of the HRV indicators in clinostasis and during the transition to orthostasis indicates the presence of the IV pathological type of vegetative regulation. Thus, in athlete B-v, the TR indicator is 21166 ms, HF – 13135 ms, RMSSD – 161 ms, MxDMn – 521 ms, which indicates a violation of the heart rhythm [8]. The authors associate the spread of MxDMn values \u200b\u200bbeyond 530 ms with a shift in the pacemaker or the development of grade I SA block. During the transition to orthostasis, subject B-ko recorded a twofold increase in the MxDMn indicator, which corresponds to the pathological phenomenon of bradycardia.

According to the concept of R. M. Baevsky [1], the functional reserve is defined as the ability to adapt to

Table 1. Heart rate variability indices in clinostasis and orthostasis in short track athletes (M±m)

Stage, at rest	Heart rate variability indices							
	Heart rate, beats, min.	MxDMn, ms	RMSSD, ms	SI, conv. units	TP, ms	HF, ms	LF, ms	VLF, ms
Clinostasis	69± 4,28	474± 35,36	143± 12,54	50± 4,92	18293± 2752	13135± 1915	3582± 688	1386± 315
Orthostasis	118± 8,80	403± 29,02	107± 9,33	65± 5,21	8754± 1309	6034± 1156	2373± 604	589± 104
P	p<0,05	p>0,05	p<0,05	p<0,05	p<0,05	p<0,05	p>0,05	p<0,05

Table 2. Heart rate variability indices in clinostasis and orthostasis after anaerobic load (M±m)

Stage, after FN 45 seconds	Heart rate variability indices							
	Heart rate, beats, min.	MxDMn, ms	RMSSD, ms	SI, conv. units	TP, ms	HF, ms	LF, ms	VLF, ms
Clinostasis	72±5,29	532±38,02	174±17,61	49±5,66	23644± 3875	18043± 2538	5586± 1164	1222± 469
Orthostasis	108±7,51	287±24,50	99±7,82	167±14,53	7298± 1062	5023± 1203	1557± 780	373± 195
P	p<0,05	p<0,05	p<0,05	p<0,05	p<0,05	p<0,05	p<0,05	p<0,05

Note: FN – physical activity.

the effects of external conditions without disrupting homeostasis and disrupting the regulatory mechanisms. One of the informative tests for identifying hidden reserves of the cardiovascular system of the body is the orthostatic test [1, 2, 4]. If the regulatory mechanisms do not have sufficient functional potential, the transition to orthostasis is a stressful effect to which the body reacts with hyperreactivity, or a paradoxical reaction [8]. After performing the orthostatic test, an increase in tension in the regulatory systems was detected, which manifested itself as hyperreactivity with a decrease in the TR indicator by 109%, HF – by 118% and VLF – by 135%.

The obtained results of the active orthostatic test confirm the assumption about the unfavorable state of the functional-adaptive reserves of the heart in young short track athletes aged 14 years. The dynamics of the HRV indices during the test physical load testifies to the decrease of the adaptation reserves. Taking into account the peculiarities of the sport in our work, the young athletes performed anaerobic glycolytic work lasting 45 seconds (Table 2).

The analysis of the HRV results showed that after muscular work the transition to orthostasis is accompanied by a sudden increase in the autonomic reactivity of sympathetic genesis, which is expressed in a 3.4-fold increase ($p<0.05$) in the stress index (SI) with simultaneous suppression of vagal reactivity with a decrease in the TR index by 3.2 times ($p<0.05$), HF and LF by 3.6 times ($p<0.05$), VLF by 3.3 times ($p<0.05$) (Table 2).

In some athletes, during the transition to orthostasis, reactivity proceeded according to a paradoxical type, while instead of decreasing, the indicator increased (MxDMn, RMSSD, HF, TP) and, conversely, instead of increasing, a decrease was recorded (SI).

Conclusions. HRV analysis allows us to assess the state of the autonomic regulation of the heart rate. In young 14-year-old short track athletes, a moderate dominance of the autonomous regulation mechanism was revealed in the pre-competition period.

The indicators of load orthostatic testing revealed different levels of autonomic reactivity from moderate to hyperreactive and paradoxical, which is associated with different levels of functional fitness of young short track athletes.

Using HRV analysis, it is possible to monitor the functional state of the cardiovascular system of young athletes involved in short track at various stages of the training process.

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