

Typological features of heart rate variability in hockey players aged 15-16 years in the annual training macrocycle

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Abstract. *The purpose of the study is to identify typological features of the dynamics of heart rate variability in elite hockey players in the annual training macrocycle. Materials and methods: during July, December and February, 15-16-year-old elite hockey players were examined. Heart rate variability was evaluated by standard methods. The reactivity coefficient of the parasympathetic nervous system in the transition period of the orthostatic test was calculated, as well as the type of heart rate regulation was determined. Results: typological features of heart rate regulation in elite hockey players aged 15-16 years are revealed. In the competitive period, there is an increase in the autonomy of regulatory processes due to the strengthening of the role of the bulbar center of cardiovascular activity, which begins earlier in hockey players with types III and IV. Restructuring of heart rate regulation in hockey players with types I and II is carried out for longer periods, in the middle of the competitive period it is reflected in the reactivity of the parasympathetic system in response to orthostasis.*

Keywords - *heart rate variability, type of heart rate regulation, athletes, hockey, puberty.*

I. INTRODUCTION

The neurohumoral system gives the right to use the parameters of biological signals to judge about a particular organ and the body as a whole. Heart rate variability (HRV) is a generally accepted method for assessing the mechanisms of regulation of the visceral systems of the human body [1; 2; 3; 4; 5; 6; 7].

In recent decades, in the literature on assessing HRV indicators and their dynamics, much attention has been paid

to the typological approach. The typological approach of N. Shlyk (2009-2019) distinguishes four types of heart rate regulation: with moderately (type I) and significantly expressed (type II) centralization and with moderately (type III) and significantly expressed (type IV) autonomization.

Morphofunctional changes are reflected in the physical development of young hockey players [8]; in sports selection, the importance of morphological [9; 10], functional and other indicators increases [11]. Hyperfunction of hypothalamic structures and the pituitary gland, an increase in stress hormones and androgens against the background of increased secretory activity of the thyroid gland leads to regulatory tension in the functional systems of the body [12].

Therefore, the purpose of this study is to determine the typological HRV features in elite hockey players aged 15-16 years in the dynamics of the annual training macrocycle.

II. MATERIALS AND METHODS

The study was conducted on the premises of the ice hockey sports school of the Olympic reserve (Traktor, Russia). From 2009 to 2017, Traktor is regularly included in the TOP-5 hockey schools in Russia. Hockey players aged 15-16 years participated in the study (forwards, defenders). The study was divided into three stages: July - the beginning of the preparatory period (n = 36), December - the middle of the competitive period (n = 19), February - the end of the competitive period in which preparation for the Final of the Russian Championship was organized (n=34). The experiment observed the principles of the Helsinki Declaration.

Baseline ECG recording was carried out for 5 minutes in the supine position (relative rest). International standards for electrocardiographic studies were observed to assess HRV in a short-term ECG recording [13]. ECG was recorded using the VNS-MICRO equipment (Neurosoft, Russia). Processing of the research results was carried out using the PolySpectrum HRV analysis program (Neurosoft, Russia). HRV analysis was carried out using recognized methods [13; 14; 15]. In addition to the research methods recommended by the standard [16], we used the method of variational pulsometry: the regulatory processes adequacy index (RPAI); vegetative rhythm index (VRI); stress index (SI). According to the literature, variational pulsometry indicators are highly informative for HRV assessment [16]. In addition to the HRV study, the reactivity of the parasympathetic nervous system was assessed [14]. The coefficient 30:15 was calculated in the transition period of the active orthostatic test.

An express method was used to determine the type of regulation (N. Shlyk) [17] in the modification of R. Baevsky [16].

For statistical processing of the research results, the Spearman correlation analysis was used in the Statistica 10.0 software.

III. RESULTS AND DISCUSSION

When analyzing the dynamics of individual changes in the distribution of regulation types in hockey players during the preparatory and competitive periods, several subgroups were distinguished: 1) with the predominance of autonomic regulatory mechanisms — “stable types - autonomization”; 2) with the predominance of central regulatory mechanisms - “stable types - centralization”; 3) transitive types “centralization ↔ autonomy”. The number of hockey players with stable types during the preparatory and competitive periods is 71%, of which the majority are characterized by the predominance of the most favorable autonomic regulatory mechanisms (III and IV) - 52%, and the minority - by the unfavorable types with centralization of regulatory processes (I and II) - 21%. According to the literature, only moderate autonomy of heart rate regulation in children and adolescents can be regarded as favorable in terms of successful adaptation to physical activity, and a significant increase in the tone of the parasympathetic nervous system (type IV) should be regarded as a predictor of overtraining [17]. Due to the fact that, according to the results of preventive medical examination (September and February), in hockey players with type IV heart rate regulation, pathologies in the cardiovascular system were not found, a significant predominance of autonomic regulatory mechanisms in the players was regarded as good physical fitness. “Transitive” types were found in 27% of players. In this case, the predominance of autonomic mechanisms by the end of the competitive period was considered as a favorable outcome, an unfavorable one was characterized by the predominance of central regulatory mechanisms. The number of “transitive types” was 13% to the total sample.

The combination of specific physical activity and sports selection leads to the predominance of players with type III regulation, as the most adaptive to physical and psychological stress [17]. Among students who are not involved in sports, adolescents with type III regulation account for no more than 33% [17]. The number of hockey players with type IV

regulation by the end of the competitive training period was doubled and was at the level of non-athlete students, the total number of which was 18% [17]. Due to the fact that hockey players of type IV had no contraindications for playing sports, significantly expressed autonomy at the time of medical examination was regarded as an indirect indicator of high aerobic abilities and overall physical health.

The total number of hockey players with a predominance of central regulatory mechanisms is less than for non-athlete students - 45% [17]. Despite the fact that according to the literature non-athlete students with type II regulation represent 25% of adolescents [17], hockey players aged 15-16 years with significant centralization of heart rate regulation and reduced adaptability to physical loads should be under the special supervision of a sports doctor. Moreover, different individual dynamics in all transitive regulation types reflects a change in the reactivity of the parasympathetic system. In the dynamics of both “favorable” and “unfavorable” types, different variants of changing the reactivity index of the parasympathetic system develop, depending on the initial individual type.

Correlation matrices and schemes for elite hockey players aged 15-16 years with various types of regulation were analyzed. The general group was divided into two subgroups - with the predominance of central regulatory mechanisms (types I and II) and with the predominance of autonomic regulatory mechanisms (types III and IV). In July, hockey players with types I and II showed strong correlation between the total power of regulation (TP) and the indices of the vasomotor center (LF waves) and, especially, suprasegmental structures of the ANS (VLF waves); for players with III and IV types, high and medium correlations are found with all spectral waves of the cardiac rhythmogram (Table 1). Regardless of the type of regulation, in December, hockey players experienced a decrease in the contribution of suprasegmental structures (VLF waves) to the total power of regulation (Table 1).

Table 1 - Correlation matrix of relationships between the indicators of spectral characteristics and the total power of regulation (TP) depending on the type of regulation

| HRV indicators | Regulation | | | | | |
|----------------|--|-------------|-------------|--|-------------|-------------|
| | with the predominance of central regulatory mechanisms | | | with the predominance of autonomic regulatory mechanisms | | |
| | July | December | February | July | December | February |
| VLF | 0.93 *** | 0.56 *** | 0.83 *** | 0.69 *** | 0.47 | 0.59 *** |
| LF | 0.70 *** | 0.75 *** | 0.80 *** | 0.92 *** | 0.80 *** | 0.72 *** |
| HF | 0.29 | 0.87 *** | 0.82 *** | 0.91 *** | 0.84 *** | 0.79 *** |

Note: TP - total power of regulation; HF - power of high frequency waves (0.15-0.40 Hz); LF - power of low-frequency waves (0.04-0.15 Hz); VLF - power of very low frequency waves (≤ 0.04 Hz); *** - $p \leq 0.001$

By the end of the competitive period, in players with type I and II, the relationships between cardiac rhythmogram components (VLF, LF and HF waves) equalize with the total power of regulation, while hockey players with type III and IV retain strong correlations between TP and the power of the vagus and vasomotor center. The latter can be regarded as a shift in the leading regulation level to the level of the bulbar

center of the central nervous system and an increase in the efficiency of the ANS.

The correlation scheme of relationships between power indicators of different waves and integrative indicators of vegetative balance differs significantly depending on the type of regulation. In July, hockey players with type I and II formed a “triangle” of direct, in most cases strong, correlations between indicators of variational pulsometry - RPAI, VRI and SI. There are no direct correlations between indicators of different spectrum waves. In December, the “triangle” of direct correlations between the indicators of RPAI, VRI and SI disappears. However, new connections are formed between the power indicators of the parasympathetic and sympathetic neurons of the bulbar center, as well as between the power indicators of influence from the vasomotor center and the reactivity of the parasympathetic system - 30: 15. In February, hockey players with a predominance of central regulatory mechanisms restored only two direct connections of the “July Triangle” - RPAI↔SI and SI↔RPAI. The relationship between the power of LF and HF waves remains, but the relationship between the power of LF waves and 30: 15 disappears. In addition, new direct connections are formed between all indicators of variational pulsometry and the vagosympathetic interaction index - LF / HF.

Similarly to the correlation pattern of hockey players with a predominance of central types of regulation, in July, hockey players with type III and IV formed a “triangle” of direct correlations between the indicators of variational pulsometry. However, all these correlations are strong. Already in July, a direct strong correlation was formed between the activity of the sympathetic and parasympathetic centers of the medulla oblongata. A strong correlation of LF wave power is formed only with the stress index. Medium strength correlations are also formed between VLF and SI, HF and LF / HF.

In December, of all July feedbacks, only the relationship between the power of LF waves and SI is preserved, but a new one also appears - between the power of HF waves and SI, which reflects active adjustment in the regulation system of the cardiovascular system. In December, in hockey players with types I and II, there were no correlations with the power of suprasedgmental structures of vegetative regulation, which can be regarded as the beginning of a shift in the leading role in heart rate regulation to the bulbar center of the central nervous system. In February, all July feedbacks of the LF wave power with the indicators of variational pulsometry and of the HF wave power with the vasomotor interaction index LF / HF return and strengthen. In addition, there are new correlations between the power of HF waves and indicators of variational pulsometry - SI and VRI. A typical feature of the intrasystem integration of the ANS regulatory systems at the end of the competitive period is an increase in the priority of influences from the CNS bulbar center, which should positively affect the functional status of the cardiovascular system. Unlike hockey players with a predominance of central regulatory mechanisms, in July, in players with types III and IV, all the relationships between the LF wave power and the variational pulsometry indicators as well as between the VLF wave power and the stress index became stronger. There was no average force feedback between the power of HF waves and vasomotor interaction index. In addition, already in July, correlations were formed between the HF

wave power and RPAI, VRI and SI. In December, hockey players with types III and IV retained all feedback, and there was a strong feedback between the HF wave power and the vagosympathetic interaction index, which can be regarded as an acceleration of shifting the leading role in heart rate regulation to the central nervous system segmental divisions. In December, all December connections were preserved, but unlike the correlation scheme of hockey players with types I and II, the correlations between the LF wave power and RPAI, SI and VRI weakened. Such a change in the scheme of intrasystem integration, apparently, reflects an increase in the autonomy of regulatory processes with a shift in the leading role to the vagus nuclei. Thus, unlike hockey players with a predominance of central regulatory mechanisms, players with types III and IV already have an increase in the role of segregated structures of the ANS in heart rate regulation by the beginning of the competitive period and the transition to the leading role to the vagus nuclei by the end of the competitive period.

IV. CONCLUSION

Typological features of hockey players aged 15-16 years were revealed depending on the type of regulation. In the competitive period, there is an increase in the autonomy of regulatory processes due to an increase in the role of the bulbar center of cardiovascular activity. However, there are differences: for hockey players with types III and IV, such a restructuring begins earlier and, at the end of the competitive period, the leading role in regulation belongs to the centers of the vagus. In the case of a predominance of central regulatory mechanisms, such a change is individualized, carried out over longer periods, and is reflected in the reactivity of the parasympathetic system in response to orthostasis in the middle of the competitive period. Thus, in the training of hockey players with the centralization of regulatory processes, more attention should be paid to measures for preventing the failure of adaptation processes. Apparently, typological features exist not only in heart rate regulation but also in the performance of the somatic system. Under active regulatory changes in the performance of the ANS in hockey players with type I and II, apparently, there must be psychophysiological features of such players that allow them to withstand competition for a place in the team.

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