

Psychophysiological features of hockey players aged 15-16 years in the annual training macrocycle

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Abstract. *The purpose of the article is to study the dynamics of psychophysiological indicators of elite hockey players aged from 15 to 16 years in an annual training macrocycle. Materials and methods: during July, December and February, elite hockey players aged 15-16 were examined. We studied the speed and accuracy of hand-eye reactions, the level of sensorimotor and voluntary movement coordination, the functional status of the central nervous system (CNS). Mental state was determined by the Luscher *cuđuyk* test. The software and hardware complex NS-Psychotest (Russia) was used in the work. Results: by the end of the competitive period, the interference resistance of hockey players is increased by improving the concentration of excitation processes. Sensorimotor and voluntary coordination of movements changes only with the static form of muscle contractions. The mental status of hockey players 15-16 years old in the dynamics of the annual training macrocycle varies from the conditional norm to stress, which requires individual corrective measures*

Keywords - *sensorimotor integration, sensorimotor movement coordination, voluntary movement coordination, athletes, hockey, puberty*

I. INTRODUCTION

In accordance with the principles of the theory of dynamic systems [1], neurohormonal changes during puberty determine changes in the entire hierarchy of functional systems of the body. Morphological and functional changes are reflected in the physical development of young hockey players [2]. In sports selection, the importance of morphological [3; 4], functional and other indicators [5] increases. 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 lead to regulatory tension in the functional systems of the body [6]. Athlete training often takes place against the background of insufficient recovery of the body [7; 8], which increases the psychophysiological “price” of adaptation. Adverse effects on the functional status of athletes during puberty are exerted by early sports specialization, which contributes to the development of mental stress and an increased risk of injury [9]. In ice hockey, the need to perform motor actions with an object (ice hockey stick) necessitates increasing the effectiveness of sensorimotor integration of movements during sports training. Sensorimotor integration is the convergence of the flow of excitation from the sensorimotor regions of the cortex to neurons of the frontal lobes of the cerebral cortex for further information transfer to the centers of the motor cortex [10]. Sensorimotor integration is characterized by the speed and accuracy of simple and complex visual-motor reactions, and environmental conditions have a great influence on this process [11].

II. MATERIALS AND METHODS

A longitudinal prospective study was carried out on the premises of a specialized school of the Olympic reserve in ice hockey (“Traktor”). Hockey players aged 15-16 years participated in the study (positions: 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.

The study of the psychophysiological characteristics of elite hockey players was carried out using the hardware and software complex NS-Psychotest (Russia, Neurosoft). The functional status of the central nervous system (CNS) was determined by the criteria of T.D. Loskutova [12], sensorimotor integration - in terms of speed and accuracy of various types of visual-motor reactions: simple visual-motor reaction (SVMR), choice reaction (CR), reaction to a moving object (RMO), and reaction under interference (5). The level of sensorimotor coordination of movements was calculated by the ratio of tremorometry parameters [12]. The mental status of hockey players was evaluated using the Luscher color test [12]. Based on the results of the choice of colors, the following indicators were calculated: "Total deviation from the autogenous norm" and "Anxiety".

Comparison of the results between groups was carried out in Statistica 10.0 according to the Mann-Whitney criterion.

III. RESULTS AND DISCUSSION

Table 1 shows the data on the sensorimotor integration indicators. In February, the speed of reaction statistically significantly worsened while the reaction accuracy was constant. The speed of reaction under interference conditions improved (Table 1). The speed of a simple visual-motor reaction remained unchanged.

Table 1. Dynamics of speed and accuracy indicators of visual-motor reactions in hockey players aged 15-16 years

Parameter	Period			p
	July M±m; σ (n=36)	December M±m; σ (n=19)	February M±m; σ (n=34)	
SVMR (reaction time), ms	198.59±2.37 16.04	197.37±4.07 17.76	203.03±2.96 17.25	p ₁ =0.718 p ₂ =0.280 p ₃ =0.246
SVMR, c.u.	0.95±0.01	0.96±0.01 0.04	0.96±0.005 0.03	p ₁ =0.386 p ₂ =0.255 p ₃ =0.961
CR (reaction time), ms	305.13±9.81 39.26	300.42±3.87 16.86	319.94±6.39 36.70	p ₁ =0.987 p ₂ =0.122 p ₃ =0.018
CR, c.u.	0.90±0.02 0.06	0.90±0.01 0.05	0.91±0.01 0.06	p ₁ =0.842 p ₂ =0.403 p ₃ =0.235
Interference resistance (reaction time), ms	326.11±3.94 26.46	319.84±4.48 19.53	310.73±3.58 20.55	p ₁ =0.382 p ₂ =0.016 p ₃ =0.199
Interference resistance, c.u.	0.92±0.02 0.15	0.91±0.05 0.22	0.95±0.01 0.05	p ₁ =0.198 p ₂ =0.110 p ₃ =0.992
RMO, ms	-2.40±1.15 7.35	0.69±1.61 7.00	-0.89±0.85 4.89	p ₁ =0.185 p ₂ =0.427 p ₃ =0.494
RMO (number of accurate reactions), %	55.44±1.74 11.12	53.89±2.17 9.48	50.36±2.94 16.88	p ₁ =0.730 p ₂ =0.203 p ₃ =0.587
RMO (number of advanced reactions), %	30.49±1.73 11.07	27.21±3.00 13.10	32.24±3.34 19.18	p ₁ =0.477 p ₂ =0.752 p ₃ =0.536
RMO (number of delayed reactions), %	14.07±1.37 8.80	18.89±2.58 11.24	17.42±2.48 14.24	p ₁ =0.133 p ₂ =0.626 p ₃ =0.329

Regardless of the form of muscle contractions, the level of sensorimotor coordination of the spatio-temporal parameters of movements of the leading upper limb in hockey players aged 15-16 corresponds to the average level (Table 2). In the dynamics of the training macrocycle, this indicator improves in December with a static form of muscle contractions and then remains at a consistently high level, while with a dynamic form - throughout the entire observation period it remains invariably average.

A similar situation is observed in the dynamics of changes in voluntary coordination of movements: there is an improvement in the static form of muscle contractions and a constant level in the dynamic form (Table 2).

The functional status of the central nervous system of elite hockey players, determined by the criteria of T.D. Loskutova, remains unchanged. A similar picture was recorded in terms of the criteria for the functional status of cortical centers (Table 3).

Table 2. Dynamics of indicators of sensorimotor coordination and regulation of movements in hockey players aged 15-16 years

Parameter	Period			p
	July M±m; σ (n=36)	December M±m; σ (n=19)	February M±m; σ (n=34)	
Sensorimotor coordination (static form), %	20.13±2.12 14.22	5.70±0.77 4.47	6.73±1.14 6.57	p ₁ =0.000 p ₂ =0.000 p ₃ =0.817
Sensorimotor coordination (dynamic form), %	13.10±1.13 7.59	13.11±1.12 6.52	12.20±0.87 5.00	p ₁ =0.859 p ₂ =0.948 p ₃ =0.707
Voluntary coordination (static form), %	-1.13±1.09 7.29	2.09±0.78 4.53	1.20±1.23 7.08	p ₁ =0.026 p ₂ =0.253 p ₃ =0.267
Voluntary coordination (dynamic form), %	-1.66±0.73 4.89	-1.49±1.09 6.37	0.05±1.02 5.88	p ₁ =0.793 p ₂ =0.302 p ₃ =0.377
Movement regulation, %	-1.60±4.24 27.84	2.42±2.75 16.01	-1.50±2.93 16.82	p ₁ =0.110 p ₂ =0.384 p ₃ =0.383

Note: p₁ - statistical significance of the differences between the indicators "July" - "December"; P₂ - statistical significance of the differences between the indicators "July" - "February"; p₃ - statistical significance of the differences between the indicators "December" - "February"

Table 3. Dynamics of indicators of the functional status of the central nervous system in hockey players aged 15-16 years

Parameter	Period			p
	July M±m; σ (n=36)	December M±m; σ (n=19)	February M±m; σ (n=34)	
Functional level of the system (SVMR), s ⁻²	4.40±0.18 1.23	4.62±0.27 1.16	4.53±0.20 1.19	p ₁ =0.240 p ₂ =0.227 p ₃ =0.905
Response stability (SVMR), s ⁻¹	1.89±0.11 0.76	2.14±0.17 0.73	2.06±0.12 0.69	p ₁ =0.245 p ₂ =0.279 p ₃ =0.776
Level of functional abilities (SVMR), s ⁻²	3.44±0.16 1.10	3.71±0.24 1.05	3.62±0.18 1.03	p ₁ =0.272 p ₂ =0.362 p ₃ =0.920
Functional level of the system (interference), s ⁻²	3.42±0.31 2.05	3.42±0.43 1.87	3.45±0.33 1.88	p ₁ =0.516 p ₂ =0.517 p ₃ =0.947
Response stability (interference), s ⁻¹	1.62±0.16 1.09	1.48±0.22 0.96	1.51±0.18 1.01	p ₁ =0.529 p ₂ =0.331 p ₃ =0.789
Level of functional abilities (interference), s ⁻²	2.52±0.23 1.56	2.41±0.32 1.40	2.45±0.25 1.44	p ₁ =0.579 p ₂ =0.365 p ₃ =0.819
Excitation concentration, %	38.79±0.84 5.62	38.20±0.9 4.09	35.67±1.48 8.66	p ₁ =0.755 p ₂ =0.006 p ₃ =0.041

Note: p₁ - statistical significance of the differences between the indicators "July" - "December"; P₂ - statistical significance of the differences between the indicators "July"

- "February"; p3 - statistical significance of the differences between the indicators "December" - "February"

The variability of the distribution of the histograms of the speed of SVMR and reactions under interference, which is the mathematical basis for calculating the Loskutova's criteria, remains unchanged throughout the observation period (Table 3). At the same time, by the end of the competitive period, hockey players have a statistically significant improvement in the concentration of excitation in the nerve centers of the cerebral cortex, which is due to an improvement in the speed of reactions under interference (Table 3).

The current emotional status of hockey players aged 15-16 years, determined by the mathematical processing of the Luscher color test, also does not change during the preparatory and competitive periods and reflects a slight tension of the players (Table 4). However, when analyzing the intragroup distribution of indicators of the emotional status, cases of mental stress were found (Figure 1a). The state of stress was considered an indicator of the total deviation from the autogenous norm of more than 20 cu, which indicates the presence of an increased and pronounced level of neuropsychic tension.

Table 4 – Dynamics of the emotional status of hockey players

Parameter	Period			p
	July M±m; σ	December M±m; σ	February M±m; σ	
Anxiety, c.u.	2.62±0.38 2.59	2.06±0.38 2.25	2.53±0.84 3.25	p ₁ =0.287 p ₂ =0.225 p ₃ =0.852
Total deviation from the autogenous norm, c.u.	14.81±1.01 6.90	13.09±0.92 5.44	14.27±2.14 8.28	p ₁ =0.325 p ₂ =0.251 p ₃ =0.786

Note: p1 - statistical significance of the differences between the indicators "July" - "December"; p2 - statistical significance of the differences between the indicators "July" - "February"; p3 - statistical significance of the differences between the indicators "December" - "February"

In early July, stress is manifested in 42% of hockey players; in 32% of cases, the "anxiety" was increased by more than 4 points (Figure 1b). In December-February, the number of players with stress decreases to 23-27% in terms of the total autogenous norm and up to 20-21% in terms of anxiety.

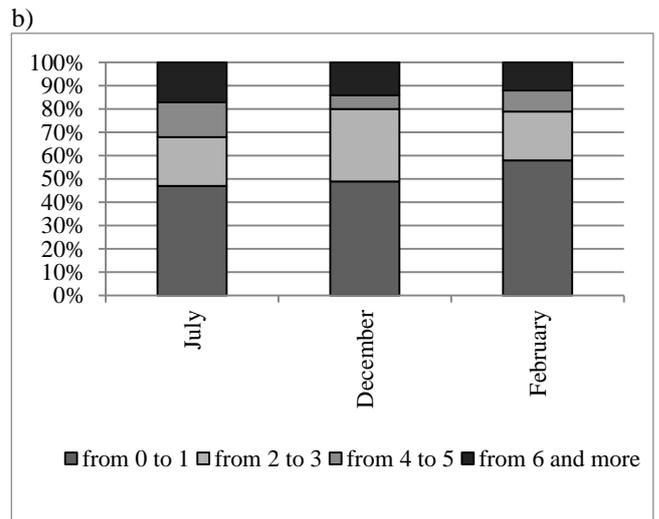
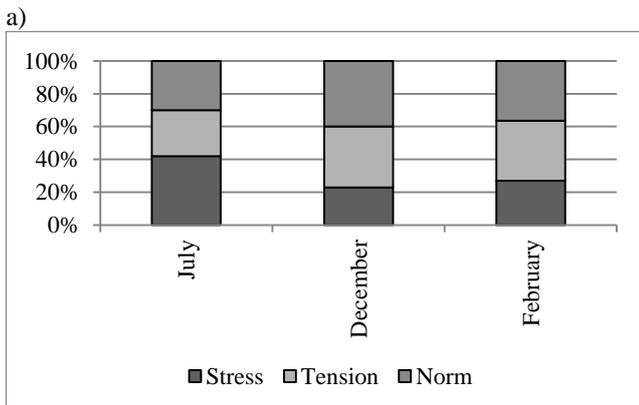


Figure 1 - Dynamics of the intragroup distribution of indicators of the total autogenous norm and anxiety in hockey players aged 15-16 years
Note: a) total deviation from the autogenous norm; b) anxiety

Due to the fact that the speed of reaction is determined by the inherited level of excitability of the nervous system and the mobility of nervous processes, the high speed of reaction in hockey players aged 15-16 years is the result of sports selection at the initial stages of sports training. At the age of 15-16, by the end of the competitive period, elite hockey players experience an improvement in sensorimotor integration under interference, while the speed of reaction in choice reactions decreases. The redistribution in the speed of various reactions against the background of a consistently high speed of simple visual-motor reaction (SVMR) and reaction to a moving object (RMO) may be evidence of an increase in the interference resistance of players in the competitive training period. The physiological meaning of this process lies, apparently, in the primary need of the body to maintain and even lower the threshold of excitation of the cortical nerve centers under the action of stressful stimuli, and secondly to improve the sensorimotor integration in the choice reactions. Thus, the reliability of the hockey player's motion control system is achieved against the background of ongoing neurohormonal changes of the pubertal period. At the end of the competitive period, dynamic stereotypes of technical and tactical game schemes have already been formed in the central nervous system, the body only needs to provide a high level of excitability for their implementation in game conditions. By the time of optimal preparedness (February), the functional mobility of neurons, apparently, is becoming less significant for a competitive result.

Improving the sensorimotor and voluntary coordination of movements only with the static form of muscle contractions, apparently, is due to the incompleteness of the formation of the movement control system in hockey players during puberty. As we revealed earlier, in the period of 15-16 years, another increase in muscle mass occurs, which should be accompanied by changes in the central mechanisms of intramuscular and intermuscular regulation of movements. The regulation of static movements (posture retention) compared with dynamic movements occurs with the participation of a smaller number of nerve centers of the higher parts of the brain and requires less functional mobility of the inter- and motor neurons of the motor centers. The relative simplicity of organizing the motor stereotype of static

movements predetermines faster changes in the functional systems for organizing complex coordination movements with a static form of muscle contractions than with a dynamic one. This fact will determine the improvement of movement coordination in the hockey player's stances (the beginning of the movement, power techniques, face-offs). Sensorimotor and voluntary coordination of movements with the dynamic form of muscle contractions is still imperfect. During the dynamic work, the movement control system takes a longer time than during the isometric type of muscle contractions, which is apparently due to a combination of changes: an increase in the number of myofilaments in myofibrils, changes in the proportions of individual parts of the musculoskeletal system under the influence of growth hormone. During this period of ontogenesis, the changes in functional systems of movements with a predominantly dynamic form of muscle contraction associated with the morphological changes of the neuromuscular apparatus can have a significant effect on the biomechanical structure of the actions of an athlete, especially in a state of fatigue.

The improvement in the concentration of excitation in the nerve centers of the cerebral cortex by the end of the competitive period is apparently due to an improvement in the speed of reactions under interference. The functional status of the cortical nervous system of hockey players at this age does not change until the end of the competitive period, but it is necessary to note the presence of mental stress in 42% of players at the beginning of the preparatory period, apparently due to the stressful influence of the selection factor in the team. In the period of preparation for important competitions, the mental status of the team players varies from a conditional norm to a state of stress, but the development of mental tension during this period can have adaptive mobilization value, maintaining a high level of excitability and, in general, improving stress resistance of hockey players.

IV. CONCLUSION

At the age of 15-16, by the end of the competitive period, elite hockey players experience an improvement in interference resistance with a simultaneous deterioration of the speed of reaction in choice reactions as a result of the improvement of concentration of excitation in the centers of the cortex of the cerebral hemispheres. Sensorimotor and voluntary coordination of movements with the dynamic form of muscle contractions is still imperfect. During this period, only the level of sensorimotor and voluntary coordination of movements with the static form of muscle contractions improves, which is due to the biomechanical features of complex coordination movements. The functional status of the cortical nervous system of hockey players at this age does not change until the end of the competitive period, but the mental status of the players varies from the conditional norm to the state of stress. The process of sports selection into the team at the beginning of the preparatory period of the annual

training macrocycle has the maximum stressful effect on the mental status of players. In teams of hockey players aged 15-16 years, 1/3 of the players have an unfavorable mental status, which requires special corrective work.

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