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ADAPTATION OF HOCKEY PLAYERS FROM THE PERSPECTIVE OF THE FORMATION OF FUNCTIONAL SYSTEMS

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Annotation. This article presents the results of the correlation analysis of the indicators of hockey players at the stages of long-term training from the perspective of the formation of functional systems. The examined hockey players were divided into 5 groups according to age and stage of long-term training: 11-12 years (n = 36), 13-14 years (n = 34), 15-16 years (n = 34), 17-18 years (n = 37) and 19-21 years (n = 31). Indicators of boys and young men, who do not do sports, are presented as control groups. Indicators of physical development and strength capabilities, indicators of external respiration, central hemodynamics and vegetative regulation of heart rhythm were examined. In order to identify the relationship between the examined indicators in each group, the Spearman rank correlation method was used. It was revealed that the coefficient of efficiency of adaptation (CEA) indicates the degree of maturity of functional systems and characterizes the adaptation changes in these systems. The level of favorable adaptation to physical loads is the expansion of the range of reliable correlations. An increase in the number of "rigid" correlations indicates a maturity of a certain action mechanism of the functional system during muscle activity.

Introduction. The human organism continuously adapts to external and internal environmental factors, which is manifested through the transformation of all systems and organs. In order to support this adaptation, new functional systems (FS) are formed in the organism to provide any functions at any given time, however, as a rule, previously formed ones are used for this process. According to the P.K. Anokhin's theory, FS are a temporary union of various organism systems aimed to achieve a result during the adaptation process [1]. However, the formation of new FS throughout urgent adaptation to the first-time influencing factors is imperfect. Persistent FS are formed in case of repeated or prolonged exposure to such factors [4]. In the human organism, a number of such systems function simultaneously, interact continuously, and their work is aimed at achieving a certain result [1, 5, 6, 7]. In the athlete's organism, in addition to age-related changes, there are also adaptive ones, which can be explained by the adaptation to intense muscle activity. On this premise, the study of mechanisms of formation and structural elements of such systems is important and relevant not only from the standpoint of developmental physiology, but also from the standpoint of sports.

The purpose of this study was to study the adaptation of 11-21 years old hockey players to physical loads at various stages of long-term training through the formation of functional systems.

Methods and organization. The study was carried out on the base of the scientific and research institute of activities in extreme conditions of the FSBEI of HE "Siberian State University of Physical Culture and Sports" located in Omsk. The study involved 172 hockey players aged 11 to 21 years old who train in sports clubs in Omsk, which were divided into 5 groups according to age and stage of long-term training: 11-12 years (n = 36), 13-14 years (n = 34), 15-16 years (n = 34), 17-18 years (n = 37) and 19-21 years (n = 31). The studies were carried out during the preparatory period of the annual training cycle. The comparison groups included adolescents and young men, who do not do sports, of the corresponding age: 11-12 years (n = 45), 13-14 years (n = 42), 15-16 years (n = 42), 17-18 years (n = 41) and 19-21 years (n = 39).

In each age group, a research complex was carried out to assess the level of physical development and strength capabilities (according to generally accepted methods), the functional state of the respiratory system ("Spiro-S 100" by "Altonika"), the functional state of the cardiovascular system (using the generally accepted methods and the ultrasound diagnostic complex "LOGIC 5 General Electric" (USA) by the echocardiography method in M-mode), the heart rhythm vegetative regulation (hardware and software complex "Poly-specter" by "Neurosoft") using indicators of the cardiointervalography and spectral analysis. Physical development was assessed according to anthropometric and strength indicators (body length and mass, rib cage and wrist girth, vital capacity, respiratory minute volume, inspiratory and expiratory reserve volume, minute pulmonary ventilation, hypoxic tests (breathing tests on inhale and exhale), forced vital capacity on inhale and exhale. For all young men, the unity of requirements was maintained while conducting examinations, which were carried out in the morning in compliance with the basic requirements for hygienic conditions and the International Bioethical Requirements and Rules. To participate in the study, all subjects or their legal representatives gave a written informed consent.

Statistical processing of the obtained research results was carried out using the application package "Statistica 6.0".

Results and discussion. To identify the nature and level of relations between the examined indicators in a state of relative rest, we conducted a correlation analysis developed by Spearman. Correlation coefficients, values of which were more than or equal to 0,7, were considered as strong (“rigid). In total, 49 indicators were examined, of which 12 parameters (n=24) were accounted for indicators of physical development and the system of external respiration, 17 parameters were accounted for indicators of the cardiovascular system and 8 indicators of heart rate variability.

As a result of conducted correlation analysis, it was revealed that with age and the stage of long-term training there is a change in the quantity and quality of relations between the examined indicators. The structure of examined correlation matrices serves as an evidence for the ambiguous contribution of functional elements to the support of the adaptation of adolescents and young men to specific training loads.

It was revealed that among hockey players at the initial stage of sports specialization (11-12 years old) the total number of reliable correlations between the examined indicators in a state of relative rest was 464. At the stage of in-depth sports specialization during 1-2 years of study at the age of 13-14 years, the maximum number of reliable correlations between the studied indicators was 893, while during 3-4 years of study their number decreased almost 2 times and among 15-16 years old hockey players it was 457. The stage of improving athletic prowess (17-18 years old) is characterized by a slight increase in the total number of significant correlations up to 527, while at the stage of peak athletic prowess (19-21 years) there is a decrease in correlations to the minimum values and their number is 378 (Fig. 1). According to data presented in Fig. 1, it is obvious that in the comparison groups the total number of significant correlations is relatively less and at 11-12 years it is 326, at 13-14 years – 720, at 15-16 years – 423, at 17-18 years – 508, and at 19-21 years – 361.

Thus, during the process of studying the correlation matrices, we found that the number of relatable correlations changing heterochronously with aging, increasing at the beginning of puberty and during post-puberty. As a result of the analysis of correlations between various systems at different stages of long-term training, the structure of correlations changes. It was revealed that at the stage of initial sports specialization (11-12 years old) the greatest number of interactions with other examined systems was noted among indicators of the respiratory system (133) and indicators of heart rate variability (149). At the stages of in-depth sports specialization (during 3-4 years of study, 15-16 years) and peak athletic prowess (19-21 years), the maximum number of interactions with indicators of physical development (143 and 113, respectively) and the respiratory system (147 and 109, respectively). The analysis of correlations among hockey players at the stage of improving the athletic prowess (17-18 years old) showed that the amount of correlations between heart rate variability and other systems is the largest and it is 294. The stage of in-depth sports specialization, as mentioned above, is noted by the maximum number of correlations, and this number is high in all systems: physical development – 165, heart rate variability – 211, the respiratory system – 248 and 269 of the cardiovascular system.

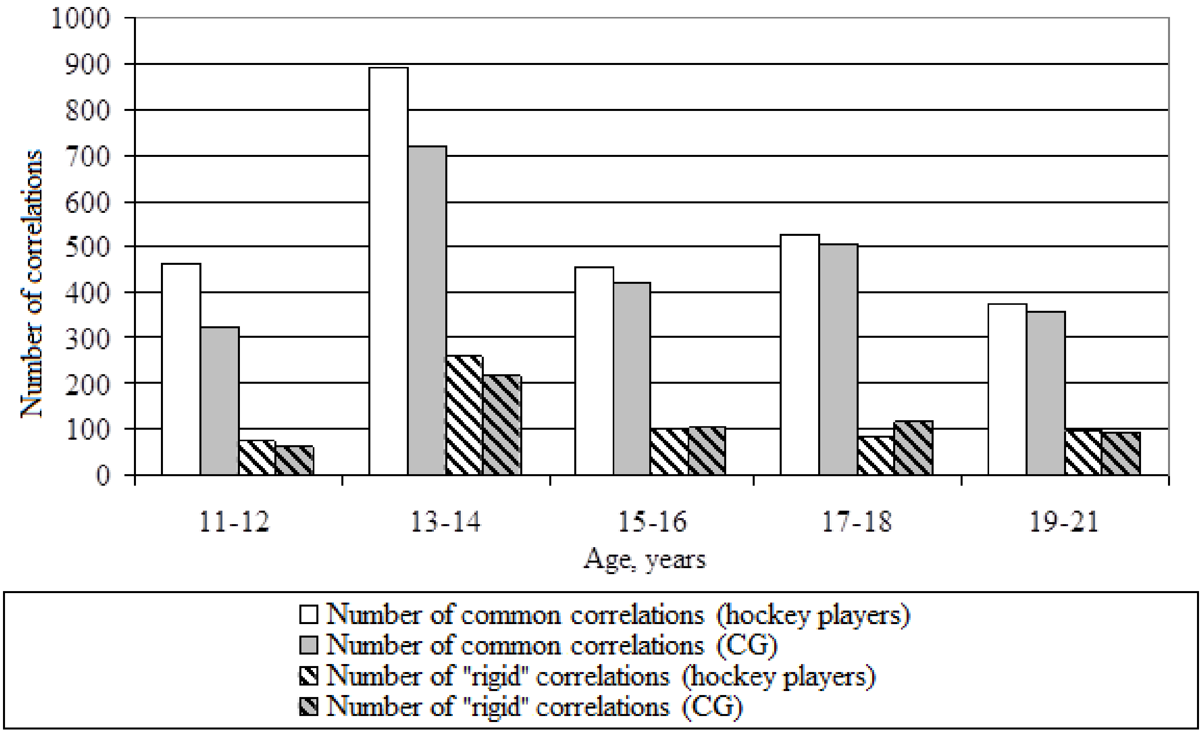

Fig. 1. The number of reliable correlations between the studied indicators in hockey players aged 11-21 years

It is known that an increase in the number of correlations between indicators in the process of adaptation to new conditions may indicate the tension of the activity of regulatory mechanisms, while, however, functional capabilities of the system increase, and it acquires new properties and new capabilities. Despite the fact that the increase in the correlation coefficient between indicators formed in the functional system ("rigidity" of correlations) indicates a decrease in the ability of individual elements of the system to be included in new functional relations, this fact indicates the maturity of this FS and its ability to perform certain tasks more efficiently [2, 4].

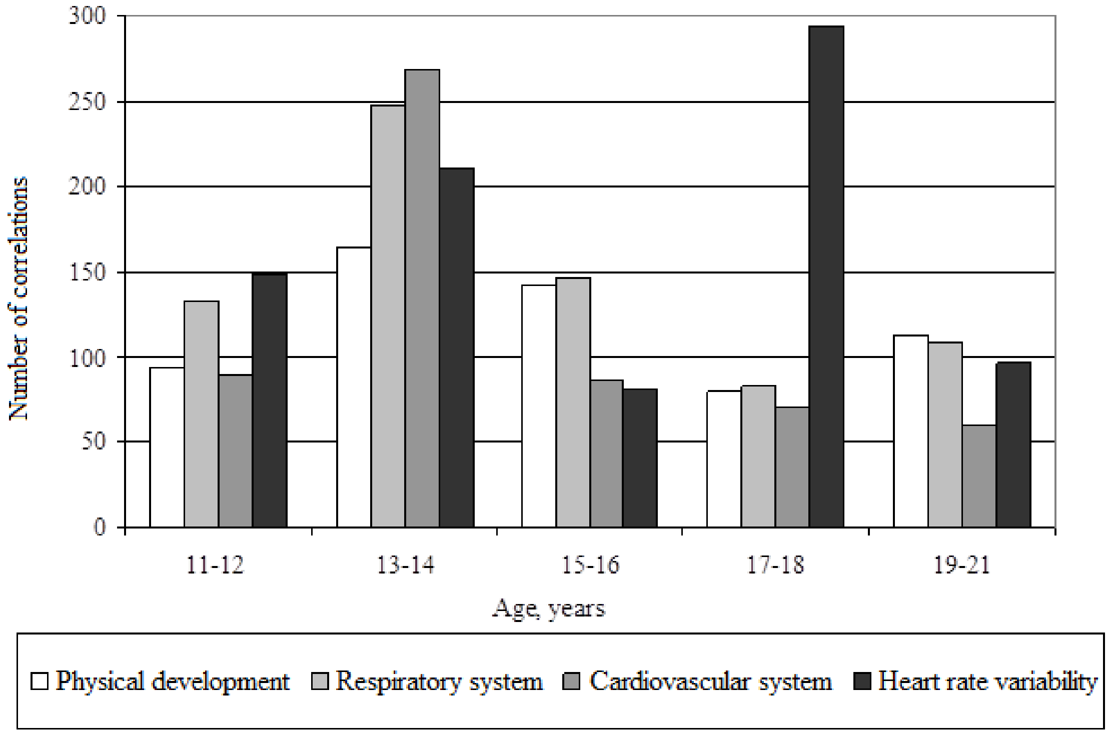

Fig. 2. The number of reliable correlations between the studied indicators in hockey players aged 11-21 years

To assess adaptation, the coefficient of effectiveness of adaptation (CEA) is widely used at present time. This indicator reflects the ratio of the number of "rigid" ($r \geq 0.7$) correlations to the number of common ones. An increase in CEA indicates an increase in the degree of inertia and stress in the functioning of the system [3, 4, 8].

When analyzing the CEA at different stages of long-term training, it was revealed that an increase in this indicator is observed in the groups of 13-14 years old (CEA = 0.29) and in 19-21 years (CEA = 0.25). This may indicate the tension of the adaptation processes of hockey players to training loads. In the control groups, we also noted an increase in CEA in the age periods 13-14 years old, 15-16 years old and 19-21 years old. At the same time, in all age groups, the CEA was significantly higher in relation to the CEA of hockey players.

Conclusion. Therefore, our data indicate that, on the one hand, a large number of intersystem correlations at the stage of in-depth sports specialization (during 1-2 years of study) indicates the search for new possible ways of adaptation by the body; on the other hand, the "rigidity" of the existing correlations increases, which limit the organism in these processes. Meanwhile, at the stage of peak athletic prowess with a small number of common reliable correlations, there is a large number of “rigid” correlations among them, which leads to a decrease in the adaptation’s effectiveness. The lowest CEA values are noted at the stages of initial specialization and improvement of the athletic prowess. At the age of 15-16, the CEA had an intermediate value among other age groups (0,21).

The conducted study allowed us to determine the age periods, as well as the stages of long-term training, which indicate the formation and maturity of FS.

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