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STATOKINETIC STABILITY OF FOOTBALL PLAYERS AND ITS RELATIONSHIP WITH INDIVIDUAL-TYPOLOGICAL PROPERTIES OF THE NERVOUS SYSTEM

The article presents the results of the study of statokinetic stability and individual typological properties of the nervous system of highly qualified football players. Statokinetic stability was determined on the "MPFI stabilograph-1" stabilograph and the StabiliS software package according to the quality factor of the balance regulation function (KFR), the trajectory length of the pressure center oscillation (Length), the average speed of the pressure center movement (AvgSpeed), the average range of the pressure center oscillation (Range), the average frequency of the spectrum of the pressure center oscillation in the mediolateral and anteroposterior planes (wAvgFMA, Hz). Individual typological properties of the nervous system, namely, the strength of nervous processes (SNP), were determined on the "Diagnost-1M" device.

The relationship between SNP and the trajectory length of the pressure center oscillation (Length) of the stabilogram was established. The rank correlation coefficient Rx between the SNP and Length indicators in football players was 0.36 ($p=0.027$). The results of the stabilogram of football players according to the characteristics of KFR, Length, AvgSpeed, Range and wAvgFMA showed that football players with an above-average level of SNP demonstrated a higher level of statokinetic stability than individuals with a below-average level of the studied typological property ($p<0.036$).

Therefore, the most adequate characteristics of the effective implementation of statokinetic stability of football players are its connection with the individual-typological properties of the nervous system, namely the SNP. It is possible that the individual-typological features of the organization of the nervous system and the SNP determine the strategy of football players' game activity.

Keywords: *individual typological properties, statokinetic stability, strength of nervous processes, football players.*

Introduction. Knowledge about the state of statokinetic stability of their body is necessary to solve the problems of special training of football players, increase its efficiency, optimize the load [1; 2]. The vertical position of the football player's body is stable due to the high position of the center of gravity from the support and constant movement in space. Under any conditions that destabilize the balance of the statokinetic neural network system, mechanisms that correct the stability of the body are included. Research of the regulation mechanisms of statokinetic stability is an urgent task of physiology and treatment of various disorders of the central nervous system and

musculoskeletal system [3; 4]. This problem is also relevant for the diagnosis of functional states of a person in various types of work, military and sports activities [5; 6; 7; 8; 9]. A high level of postural stability is also necessary for performing everyday safe actions and for reducing the risk of falling [10]. For many sports, balance is one of the leading coordination abilities. Therefore, monitoring the ability to maintain balance is critically important both for a comprehensive analysis of the level of sportsmen training and for the team recruitment and selection [11]. As noted by a number of authors, statokinetic stability depends on the state of visual and vestibular function [12; 13], auditory sensory system [14], endurance and muscle coordination [15]. It is known that the visual system solves the problem of stabilizing statokinetic stability by several mechanisms. First, the visual system participates in assessing the magnitude, speed and direction of body movement in space [10]. Second, it can indirectly affect the quality of regulation of statokinetic stability through the nonspecific influence of the visual analyzer on the tonic contraction of postural muscles or through the vestibular system [5].

The results of recent studies indicate that statokinetic stability of football players is of great importance for ensuring effective game activity [16]. It has been established that the level of development of individual components of statokinetic stability depends on the nature of motor activity, type of sport, sportsman's qualification and heredity [7]. The criteria for a differentiated approach to assessing statokinetic stability can be differences in physical, technical or functional preparedness of football players, game role, and personal characteristics [17; 18]. It is also known that statokinetic stability can be influenced by individual typological properties of the nervous system [19]. The interaction of neurodynamic characteristics and statokinetic functions has not been studied for a long time for some reason despite the understanding of the natural origin of genetically determined individual typological properties of the CNS, their relative constancy, reliability and ease of registration. The results of the study can be considered, on the one hand, as a variant of modulation of central functions on statokinetic function, and on the other, as a means of integral influences of the properties of the main nervous processes on the activity of the postural activity system in the context of intersystem interaction of the organism, which is an urgent task of physiology and medicine. We assume that such criteria are met by the individual-typological properties of the nervous system: functional mobility, strength and balance of nervous processes.

The analysis of the literature shows that most scientific works lack thorough information about the nature and features of statokinetic stability depending on the typological characteristics of football players. There are no works in which individual typological properties of the nervous system act as a criterion for differentiating statokinetic stability. That is why knowledge about the relationship between statokinetic stability of football players and typological properties of the main nervous processes is of not only theoretical but also practical interest. This provides an opportunity to deepen the understanding of the features of the formation of individual typological properties of the nervous system, and on the other hand, provides grounds to predict the statokinetic stability of football players. A number of questions remain unanswered regarding the statokinetic stability of highly qualified football players and its relationship with individual typological properties of the nervous system in the process of game activity. The mechanisms of the features of the relationship between the statokinetic stability of football players and the typological properties of the nervous system are also unknown.

In general, the analysis of scientific works on the problem indicates the existence of an objective contradiction between the need to implement a differentiated approach to organizing the training process of football players and the insufficient scientific elaboration of the issue, considering the peculiarities of the individual typological properties of the nervous system of football players.

Therefore, the aim of the work was to establish or refute the relationship between the indicators of statokinetic stability of highly qualified football players and the individual typological properties of the nervous system.

Research methods. We studied the statokinetic stability and individual typological properties of the nervous system of 39 Premier League football players. Using the "MPFI

stabilograph-1" stabilograph platform and the StabiliS software package, we determined the statokinetic stability indicators of football players based on the quality coefficients of the balance regulation function (KFR, %), the trajectory length of pressure center oscillation (Length, mm), the average speed of the pressure center movement (AvgSpeed m/s), the average range of the pressure center oscillation (Range, mm), the average frequency of the spectrum of the pressure center oscillation in the mediolateral and anteroposterior planes (wAvgFMA, Hz).

Individual typological properties of the nervous system, and the strength of nervous processes (SNP) were determined according to the method of Makarenko M.V. et al. on the "Diagnost-1M" device [20; 21]. Experiments were performed on the IBM RS AT 386 computer system. The subject had to differentiate exciting and inhibitory stimuli, which were addressed to the left and right hands, as quickly as possible within 5 minutes. The SNP was assessed according to the results of the processed information amount. The more signals the subject processed in 5 minutes, the higher the level of SNP. The experimental material was processed by the method of variational statistics using the Statgraphics, Microsoft Excel programs.

Research results. As a result of the research, it was found that the indicators of statokinetic stability of football players had a significant relationship with SNP. Thus, the rank correlation coefficient Rx between the indicators of SNP and the level of the trajectory length of the pressure center oscillation (Length) in highly qualified football players was 0.36 ($p = 0.027$). This indicates that the higher the SNP of the subject, the higher the level of statokinetic stability and, conversely, football players with low indicators of the studied typological property of nervous processes were characterized by a greater length of the trajectory of the pressure center oscillation.

To verify or refute the existence of a connection between the results of the SNP study in football players, we determined its average level, which was 618.2±13.5 signals. The highest SNP indicator was 738 signals, and the lowest was 530 signals. Using the sigmal deviation method, football players were divided into three groups according to the SNP indicator: with below-average (<M-0.5σ), average (M-0.5σ – M+0.5σ) and above-average (>M+0.5σ) SNP levels.

According to the results of the distribution of the subjects by the level of SNP, it was found that the majority of football players were characterized by an average level of strength of nervous processes (587 - 675 signals). Among highly qualified football players, there were 42% of such individuals (Fig. 1).

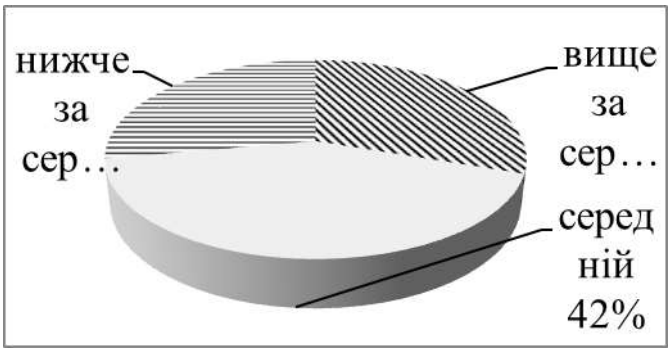

Figure 1. Distribution of football players by the level of nervous processes strength
below average - 28%, above average – 30%, average – 42%

The number of sportsmen with below- (530-586 signals), and above-average (676 -738 signals) SNP indicators was significantly less. Among highly skilled football players, 30.2% of the subjects were classified as above-average SNP and performed signal processing tasks more than 676 signals in 5 min., while 27.8% of individuals performed test tasks and differentiated less than 586 signals and were classified as below-average SNP.

In groups of football players with different gradations of SNP separately and for the team as a whole, statokinetic stability indicators were determined and analyzed using a stabilograph based

on KFR, Length, AvgSpeed, Range and wAvgFMA. Table 1 presents the results of statokinetic stability in football players with different levels of SNP.

Table 1.

Statokinetic stability in football players with different levels of nervous process strength

Levels of the SNP property	Statokinetic stability indicators				
	Length, mm	AvgSpeed, m/s	KFR, %	Range, mm	wAvgFMA, Hz
Above-average	412. 1 ±26.7	7.9 ±0.44	81.3 ±1.62	17.4 ±1.46	0.281 ±0.01
Average	445.8 ±25.6	8.3 ±0.43	79.5 ±1.85	19.3 ±1.45	0.291 ±0.02
Below-average	456.7 ±28.6	8.6 ±0.45	75.4 ±1.34	23.4 ±1.65	0.318 ±0.01

Note: * statistically significant differences between groups of subjects with high, medium and low levels of SNP at the $p<0.05$ level.

Table 1 shows that the presented results of the state of statokinetic stability in highly qualified football players in connection with the level of SNP characterize the qualitative aspect of the relationship between the studied indicators. Higher levels of SNP corresponded to higher values of statokinetic stability. Conversely, sportsmen with low levels of SNP were characterized by low statokinetic stability. Thus, football players with above-average levels of SNP (676-738 signals) were also characterized by a high level of statokinetic stability. In this group of subjects, the indicators of Length, AvgSpeed, Range and wAvgFMA in the mediolateral and anteroposterior planes were statistically significantly lower, and the KFR indicator was higher than in individuals with below-average levels of SNP ($p = 0.013 - 0.043$). Football players with an average level of SNP occupied an intermediate position in terms of statokinetic stability indicators.

Since football players with high and average SNP were also characterized by a higher level of statokinetic stability than individuals with a below-average gradation of the typological property of the nervous system, it would not be entirely correct to draw a conclusion about the features of the provision. However, we obtained advantages in all indicators of statokinetic stability in subjects with higher SNP. The results presented in Table 1 confirm the validity of such a generalization. In individuals with high SNP, the indicators of statokinetic stability were higher than in subjects with a low gradation of the typological property under study.

Thus, the results of the correlation and comparative analysis show that the statokinetic stability of highly qualified football players depends on the individual typological properties of the nervous system. Individual typological properties of the nervous system, SNP determine the participation of various mechanisms of statokinetic stability of football players. It was found that football players with a high and average level of SNP were characterized by high statokinetic stability than individuals with a low studied typological property of the nervous system.

Discussion of the results. The conducted studies have shown that in highly skilled football players, there is a connection between statokinetic stability and individual-typological properties of the nervous system. If the necessary physical, anthropometric, functional and other characteristics were available, individuals with the high SNP achieved better results in statokinetic stability than those whose indicators of individual-typological properties of the nervous system were lower.

The main generalization of the results of our work is that the obtained indicators of statokinetic stability and characteristics of the nervous system of the subjects are in a corresponding dependence on biological determinants, which is reflected in the high indicators of statokinetic stability and neurodynamic properties of football players [18; 22]. The existence of a connection between the individual typological properties of the higher divisions of the nervous system and indicators of statokinetic stability formed the basis of the idea we formulated about a dynamic

multi-circuit neurodynamic system with hierarchically organized mechanisms for the regulation of neurometabolic processes and motor properties [23]. Based on the results of our study, we can generalize that the typological properties of the main nervous processes (SNP) have a genetic influence on the statokinetic stability of football players, which creates the necessary functional conditions for effective playing activity. Considering our data and theoretical analysis of scientific sources [24], there are good reasons to generalize that football players with above-average and average levels of SNP were characterized by higher statokinetic stability than individuals with below-average levels that ensures their achievement of high results in game activity in comparison with representatives with low typological properties of the nervous system.

Actually, the improvement of coordination mechanisms in the structures of the brain, central and peripheral apparatus, the change in lability, coordination and rhythm acquisition opens up opportunities for increasing statokinetic stability through physical education and sports [25]. Considering that the typological properties of the nervous system, SNP, and statokinetic stability are genetically determined, attention should also be paid to the fact that the high level of the studied properties in highly qualified sportsmen may be the result of natural selection. It is likely that in the process of long-term sports improvement, there is a selection of football players with high indicators of statokinetic stability and SNP and the elimination of those who have low properties. Therefore, in groups of highly qualified football players, there were significantly more representatives with a high level of development of the typological properties of the nervous system and with more pronounced characteristics of statokinetic stability.

Our study is based on the understanding that the individual-typological properties of nervous processes, namely SNP, are highly genetically determined properties, and the characteristics of the statokinetic function are stable and reliable psychophysiological properties [26]. They can change under the influence of phenotypic environmental factors, sports and training, therefore, studying their interaction in highly qualified athletes makes it possible, on the one hand, to consider it as a variant of modulation of central functions, and on the other hand, as a means of integral influences of the properties of basic nervous processes, SNP on statokinetic stability within the framework of intersystem interaction of the organism. Based on the results of our research and analysis of the literature, we proposed a hypothesis according to which the formation of statokinetic stability in football athletes is influenced by gene-regulatory mechanisms that are determined and adjusted by the individual typological properties of the nervous system (SNS), and are also modulated by afferent impulses from the proprioceptors of working muscles during training and competitive loads.

Therefore, the individual typological properties of the HNA, the strength of nervous processes constitute the neurodynamic basis of the statokinetic stability of football players. Statokinetic stability in football players depends on the level of development of highly genetically determined properties of the main nervous processes.

The results can be the basis for selection into sports sections and used to optimize the training process and prevent adverse changes in the body.

Conclusions:

1. The features of statokinetic stability of football players with different levels of nervous process strength were studied. A relationship between the strength of nervous processes and statokinetic stability indicators was revealed for highly qualified football players. The rank correlation coefficient R_{xy} between SNP indicators and the trajectory length of the pressure center oscillation (Length) in highly qualified football players was 0.36 ($p=0.027$).
2. It was found that football players with high and average levels of SNP were characterized by higher indicators of statokinetic stability than individuals with low levels of the studied typological property.
3. The results of statokinetic stability in football players according to its characteristics revealed that football players with a higher level of SNP demonstrated a higher level of statokinetic stability than individuals with a low level of the studied typological property.

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Статокінетична стабільність футболістів та її зв'язок з індивідуально-типологічними властивостями нервової системи

У статті представлені результати дослідження статокінетичної стійкості та індивідуально-типологічних властивостей нервової системи висококваліфікованих футболістів. Статокінетичну стійкість визначали на стабілографі «МПФИ стабилограф-1» і пакету програмного забезпечення StabiliS за показниками коефіцієнту якості функції регулювання рівноваги (KFR), довжини траєкторії коливання центру тиску (Length), середньої швидкості переміщення центру тиску (AvgSpeed), середнього розмаху коливання центру тиску (Range) середньої частоти спектру коливання центру тиску у медіолатеральній та антеріопостеріорній площині (wAvgFMA, гц). Індивідуально-типологічні властивості нервової системи, а саме силу нервових процесів (СНП) встановлювали на приладі «Діагност-1М».

Встановили зв'язок СНП та довжини траєкторії коливання центру тиску (Length) стабілограми. Коефіцієнт рангової кореляції Rxy між показниками СНП та Length у футболістів дорівнював 0,36 (p=0,027). Результати стабілограми футболістів за характеристиками KFR, Length, AvgSpeed, Range та wAvgFMA показали, що футболісти з вище за середній рівень СНП демонстрували вищий рівень статокінетичної стійкості, ніж особи з нижче за середній рівень досліджуваної типологічної властивості (p<0,036).

Отже, найбільш адекватними характеристиками ефективної реалізації статокінетичної стійкості футболістів є її зв'язок з індивідуально-типологічними властивостями нервової системи, а саме СНП. Можливо, що індивідуально-типологічні особливості організації нервової системи та СНП визначають стратегію ігрової активності футболістів.

Ключові слова: *індивідуально-типологічні властивості, статокінетична стійкість, сила нервових процесів, футболісти.*

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