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INDIVIDUAL FEATURES OF THE PHYSICAL PERFORMANCE OF SPORTSMEN WITH DIFFERENT TYPICAL PROPERTIES OF THE NERVOUS SYSTEM

The article presents the research findings of individual characteristics of the physical performance of football players with different typological properties of the nervous system. It is found that sportsmen with a high level of individual typological properties of the nervous system achieve a high level of physical performance in the test with a gradual increase in running speed by involving anaerobic capabilities, and with a low gradation of typological properties, aerobic ones of the cardiorespiratory system. The opportunities of using individual-typological properties of the nervous system of physical performance for a comprehensive assessment of the success of football players' game activities are substantiated.

Key words: physical performance, typological properties of the nervous system, cardiorespiratory system, sportsmen.

Formulation of the problem. Analysis of recent research and publications. The World Football Championship in Qatar witnessed the growth of complex tactical and technical methods and the personal responsibility of sportsmen for the decisions made, the price of a mistake increased [1]. The requirements for the system of preparation, control and correction of the training process, selection and competition among players have increased. Under such conditions, it becomes necessary to search for such characteristics or properties of the sportsman's body, which will be

decisive in the selection and will characterize the effectiveness of game activity [2]. According to our research findings and data from the literature, such stable characteristics can be attributed to innate highly genetically determined individual typological properties of the central nervous system (CNS): strength (SNP), functional mobility (FMNP) and balance (BNP) of nervous processes [3, 4, 5]. At the same time, several convincing data were obtained regarding some regularities of physical performance and related features of the functional state of the cardiorespiratory system (CRS) of sportsmen [6, 7]. The problem of physiological mechanisms of interaction between genetically determined typological properties of the central nervous system, physical performance, and features of the central nervous system of sportsmen under conditions of extreme physical exertion remains the most interesting and less researched for experimental physiology.

A differentiated approach to improving the training process is widely used at the stage of higher skill in modern sports [8, 9]. The problem of organizing the training process considering the differentiated approach in sports is sufficiently covered [10, 11]. The main direction of implementing a differentiated approach to improving sports skills is the use of many rational options for individual training [3, 8, 12]. At the world level and in Ukraine, there is a methodology for building and managing the training process, which is based on considering the individual characteristics of the state of health, physical capabilities, motor qualities, performance of technical and tactical tasks, game efficiency, mental and constitutional features, dominance of vision, legs, brain asymmetry, competitive style, etc. [13, 14]. It is important to note that the criteria for differentiating the training process can be age characteristics, the level of physical, technical, and functional preparation, game role, somatotype of the sportsman and others [15, 16, 17]. The listed criteria for differentiating the training process are characterized by pedagogical, morphological, and psychological factors. Specialists in the theory and physiology of sports understand that the focus of the training process is the improvement of morpho-functional characteristics [12, 13, 16], cardiovascular and respiratory systems [6, 7], nervous systems [3, 4, 5] and mechanisms providing muscle activity [9, 14]. However, insufficient attention has been paid to the stable biological properties of load differentiation.

The issues related to the dynamics of the development of bioenergetic and motor qualities of football players at various stages of improving skills have been considered in the works of several authors [15, 16]. The studies have shown that the leading component reflecting the level of physical fitness of football players is the aerobic component of endurance. The factor of anaerobic glycolytic stability is the second most important factor, the third one is the reliability of the technique. According to experts, the sports skills of football players largely depend on physical capacity, speed strength, and speed abilities [18, 19]. Many authors indicate the dependence of game activity on the level of physical, technical, and tactical preparedness of players [20, 21].

It should be noted that the individual typological properties of the nervous system are characterized by a stable biological nature [3, 4, 5]. The uniqueness of each approach will be determined by the individual typological properties of the nervous system, which are the most informative regarding the organization of differentiation, management, and prediction of game activity. We assume that the individual typological properties of the nervous system in sportsmen can influence physical performance. The differences in these indicators can be the basis for solving the problems of a differentiated approach to the management of the training process and increasing the physical performance of sportsmen. Most scientific works have no significant information about the characteristics and features of physical performance in highly qualified sportsmen with different individual-typological properties of the nervous system. The theoretical and practical possibility of using the typological properties of the nervous system to monitor the physical performance of sportsmen has not been clarified [10, 18]. This indicates the existence of a contradiction between the need to implement a differentiated approach to improving physical performance considering the individual and typological features of the nervous system [22, 23, 24, 25].

These problems determined the relevance of this work. There is a need to confirm or refute the physiological role of genetically determined individual typological properties of the nervous system in the formation of physical performance of sportsmen.

The purpose of the study is to establish the individual characteristics of the physical performance of football players with different typological properties of the nervous system during the test with gradually increasing running speed.

Research materials and methods. Individual highly genetically determined typological properties of the central nervous system were studied, physical capacity was determined, and functional capabilities of the central nervous system were assessed in 31 players of the professional team of the Premier League of the Ukrainian Football Championship. The research was conducted using the instrumental base of the Mykhailo Bosy Physiology Research Institute of Cherkasy Bohdan Khmelnytsky National University in the track and field arena of Cherkasy.

The neurodynamic functions of the players were studied using the Diagnost-1M computer device. Genetically determined individual typological properties, the functional mobility of nervous processes were determined [3]. The experimental task for determining the individual typological properties of FMNP consisted of information processing in the feedback mode. It was necessary to differentiate positive and brake signals (geometric shapes). When the “square” shape appeared on the screen, the subject pressed the right button, “circle” - the left button, “triangle” – ignored the signal. In the case of a correct answer, the exposure of the next signal was shortened by 20 ms. The result was the time needed to process 120 signals. The faster the subject performed the task involving the differentiation of 120 signals, the higher the FMNP was.

The physical performance and reactivity of cardio-respiratory system were studied under the conditions of a field test using shuttle running and walking. Under such conditions, the highest level of special physical performance is achieved, the necessary, specific muscle groups are involved, and the reactive capabilities of CRS reach stabilization (steady state) [19]. To determine physical performance, we gave preference to the field test, since, according to the research protocol, the load on the sportsman increases due to an increase in running speed, and not a change in the angle of elevation of the track surface, while working on a treadmill [17].

The reactive capabilities of the CRS of football players were determined by the functional indicators of breathing, hemodynamics, and blood lactate under conditions of physical exertion. Sportsmen performed a shuttle test with a stepwise increase in running speed. During testing, football players walked and ran between two chips that were 20 meters apart. The speed of walking and running was determined by a sound signal with a gradually increasing rhythm. The test was stopped when the sportsman did not have time to run to the chip twice. The duration of the test was 15-20 minutes and depended on the individual capabilities of the subject. Preparation for the test lasted up to 5-7 minutes.

The research program consisted of the following stages: indicators were recorded for - 1 min. at rest, sitting, 2 min. - standing, 3-4 min. – shuttle walking at a speed of $5 \text{ km} \cdot \text{h}^{-1}$, 5-20 min. – continuous shuttle run with a gradually increasing speed (the speed increased by $0.5 \text{ km} \cdot \text{h}^{-1}$ every minute), the initial speed was $10 \text{ km} \cdot \text{h}^{-1}$ and further until “failure”. Recovery occurred at a walking speed of $5 \text{ km} \cdot \text{h}^{-1}$ to a heart rate of 120 bpm^{-1} . The individual level of physical capacity and functional reactivity was determined by the indicators of ergometers, gas analysis, heart rate and lactate measurements. The cardiorespiratory capabilities of the sportsmen were studied using a portable gas analyzer “Oxycon Mobile” by Jaeger (Germany), which provided telemetric data registration.

An array of data on the activity of the respiratory system and blood circulation was formed for each sportsman with 10-second averaging during the time of the research. During the test and after its completion, functional indicators were recorded: test time (min.), minute respiratory volume ($V_E \text{ l} \cdot \text{min}^{-1}$) and respiratory rate (RR, $\text{breath} \cdot \text{min}^{-1}$), oxygen consumption (VO_2 , $\text{ml} \cdot \text{min}^{-1}$, $\text{ml} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$), volume of released carbon dioxide (VCO_2 , $\text{ml} \cdot \text{min}^{-1}$, $\text{ml} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$), respiratory quotient

(RQ), heart rate (HR, $\text{beats} \cdot \text{min}^{-1}$), stroke volume (SV, $\text{ml} \cdot \text{min}^{-1}$), cardiac output (CO, $\text{l} \cdot \text{min}^{-1}$), lactate (HLA) on the 1st and 3rd min. of recovery.

The obtained statistical material was processed using the Microsoft Excel 2019 computer program [16].

Research results and their discussion. The physical performance of football players during the shuttle test with a stepwise increase in running speed was assessed according to the indicators: the duration of the load - T, (min), the power of work - W, in watts (W, $\text{W} \cdot \text{kg}^{-1}$) and the average running speed - V ($\text{km} \cdot \text{h}^{-1}$). The results of the physical capacity of football players performing shuttle test with a gradual increase in running speed, are presented in Table 1.

Table 1

Physical performance of football players (n=31) according to the results of the shuttle test with a gradual increase in running speed

Statistical indicators	Indicators of physical performance			
	Load duration	Power		Speed
	T, min.	W, watts	W, $\text{W} \cdot \text{kg}^{-1}$	V, $\text{km} \cdot \text{h}^{-1}$
Min	7.49	184	2.0	12
Max	9.54	266	3.0	15
M	9.06	218	2.8	13.9
m	0.24	3.81	0.02	0.13
CV	3.5	8.5	4.7	4.9

It was found that the average running time of sportsmen in the test with gradually increasing speed was 9.06 ± 0.24 min., and the power of work was 218.0 ± 3.81 W. The average running speed that sportsmen developed during the test was 13.9 ± 0.13 km/h. The given results indicate a high level of physical performance of the examined sportsmen.

At rest and during the shuttle test with a stepwise increase in running speed, the functional reactivity of the CRS of football players was studied according to the indicators: HR, Q, SV, V_E , $\text{VO}_{2,\text{max}}$ and HLA, the results of which are presented in Table 2.

Table 2

Indicators of the cardiorespiratory system of football players (n=31) in a state of relative rest before performing the shuttle test with gradually increasing running speed

Statistical indicators	Functional indicators						
	HR $\text{beats} \cdot \text{min}^{-1}$	Q $\text{l} \cdot \text{min}^{-1}$	SV ml	V_E $\text{l} \cdot \text{min}^{-1}$	$\text{VO}_{2,\text{max}}$ $\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$	VCO_2 $\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$	HLA, $\text{mmol} \cdot \text{l}^{-1}$
Min	176.6	20	98	127.6	47	48	6.8
Max	209.3	32	171	184.6	69	68	14.5
M	188.4	28	152	153.9	59.0	60.0	10.7
m	1.69	0.52	3.32	3.3	1.13	1.18	0.64
CV	4.3	8.9	10.7	10.5	9.4	9.3	13.3

The maximum absorption of oxygen is known to be an important indicator that determines the aerobic capabilities of a sportsman and is most closely related to the physical performance of football players. The value of VO_2 characterizes the largest amount of oxygen that a sportsman can utilize during breathing. We showed that during an official match, football players maintained most of the game activity in the mode of aerobic metabolism [24]. Therefore, the value of VO_2 characterizes not only the power of aerobic metabolism and the functional reactivity of CRS, but is also the most

important indicator that determines the ability of a football player to perform game tasks [26]. The value of VO_2 can be an indicator that distinguishes teams by the level of preparedness and characterizes the physical capacity and functional reactivity of the team and an individual football player. It is believed that teams and athletes who achieve better results have higher VO_2 values [27]. Moreover, the VO_2 value is a sensitive criterion of physical performance under conditions of training loads that are aimed at increasing endurance, and is also related to the total amount of work that the player performs on the field during the game. In our research, it was found that under the condition of performing the shuttle test with a stepwise increase in running speed, football players absorbed VO_2 in the range of $47\text{--}69 \text{ ml}^{-1} \cdot \text{min}^{-1} \cdot \text{kg}$ with an average value of $59.0 \pm 1.13 \text{ ml}^{-1} \cdot \text{min}^{-1} \cdot \text{kg}$, which corresponded to the work power of $218.0 \pm 3.81 \text{ W}$, and the shuttle running speed of $13.9 \pm 0.14 \text{ km} \cdot \text{h}^{-1}$.

The analysis of the results of Table 2 showed that the high values of VO_2 in football players were consistent with other high indicators of the cardiorespiratory system - HR (188.0 ± 1.69 , $\text{beats} \cdot \text{min}^{-1}$), Q - (28.0 ± 0.52 , $\text{l} \cdot \text{min}^{-1}$), SV - ($153.9 \pm 3.32 \text{ mL}$) and V_E - ($154 \pm 3.32 \text{ l} \cdot \text{min}^{-1}$), which were registered during shuttle running. According to experts, qualified football players must have a high level of aerobic capacity [26, 27]. The level of monitoring of special capacity (MSC) in football players of the Premier League is $61.27 \text{ ml}^{-1} \cdot \text{min}^{-1} \cdot \text{kg}$ on average, in football players of leading foreign teams - $67.05 \text{ ml}^{-1} \cdot \text{min}^{-1} \cdot \text{kg}$ that corresponds to the level of MSC in sportsmen specializing in cycling, academic rowing, cross-country skiing, and middle- and long-distance running [13, 14, 16].

In previous works [24, 25], we found that football players performed up to 30% of work in the anaerobic mode of energy supply per game, therefore it was extremely important to investigate the state of physical performance and functional reactivity of the sportsmen's central CRS according to the VCO_2 and HLa indicators. It is necessary to consider the fact that the value of VO_2 indicates the functional capabilities of aerobic systems, while VCO_2 and HLa characterize the performance and functional capabilities of anaerobic metabolism. Therefore, we analyzed the results of the study of VCO_2 and HLa during the shuttle test. We found that the examined football players were characterized by high values of VCO_2 , - $48\text{--}68 \text{ ml}^{-1} \cdot \text{min}^{-1} \cdot \text{kg}$. The average value of this indicator was $60.0 \pm 1.18 \text{ ml}^{-1} \cdot \text{min}^{-1} \cdot \text{kg}$. The lactate index at the 3rd minute of recovery after performing the test with a gradual increase in running speed in the subjects varied between - $6.8\text{--}14.5 \text{ mmol}^{-1} \cdot \text{l}$, and the average value was $10.7 \pm 0.67 \text{ mmol}^{-1} \cdot \text{l}$.

To establish the connection between the physical performance of football players and the characteristics of individual and typological properties of the central nervous system, we investigated and found the average level of FMNP. The FRNP for the examined football players was $62.6 \pm 0.56 \text{ s}$. The highest indicator of FMNP was 55 s, and the lowest was 68 s. Using the method of sigma deviations, the examined sportsmen were divided into three groups according to the FMNP indicator: below average ($<M - 0.5\sigma$), average ($M - 0.5\sigma - M + 0.5\sigma$) and above average ($>M + 0.5\sigma$) level of FMNP. It was found that among highly qualified football players, 30.2% of the examinees were assigned to the group with a higher-than-average indicator of FMNP and performed the task of processing 120 signals in 55-58 seconds. 42.0% of all examined sportsmen were included in the group with a medium level of FMNP. The FMNP indicator for this group ranged from 59 to 63 s, and the average indicator was $60.4 \pm 0.3 \text{ s}$. While 27.8% of people performed the test task of differentiating 120 signals in 64-68 s and were assigned to the group with a lower-than-average gradation of FMNP. We should note that typological properties are genetically determined properties of the central nervous system. They do not change in the process of training and competitive activities of professional football players [18]. However, at the same time, neurodynamic properties together with bioenergetic properties and indicators of physical, technical, and tactical preparedness have an impact on the success of football players of a high level of qualification [3, 4, 5]. To establish the connection between the physical performance of football players and the characteristics of individual and typological properties of the central nervous system, we performed calculations and compared individual quantitative and qualitative indicators of the reactivity of CRS under the condition of performing a shuttle run with a gradual increase in its speed in groups of sportsmen with different

gradations of FMNP. The results of the study of physical performance at the level of maximum oxygen consumption in groups with different levels of functional mobility of nervous processes are presented in Table 3.

In the groups of football players with different gradations of FMNP, physical performance was determined and analyzed according to the indicators of the duration of the test - T, (min), work power - W in watts (W, W.kg⁻¹) and the average running speed - V, (km·h⁻¹).

Table 3

Physical performance of sportsmen (n=31) at the level of maximum oxygen consumption during the test with gradually increasing running speed in groups with different functional mobility of nervous processes

Investigated indicators	Levels of functional mobility of the nervous processes, s		
	High (57.1 ± 0.4)	Medium (60.4 ± 0.3)	Low (65.6 ± 0.7)
T, min.	9.26 ± 0.18*	8.96 ± 0.23	7.96 ± 0.27
W, watts	224.3 ± 3.8*#	213.5 ± 3.5	214.3 ± 3.6
W, W·kg ⁻¹ .	2.8 ± 0.04*	2.7 ± 0.05	2.5 ± 0.07
V, km·h ⁻¹ .	15.7 ± 0.1*#	14.4 ± 0.3	13.5 ± 0.1

Note. Statistical significance of differences at the level of P<0.05 between groups B and H - *, between B and C - #.

The presented results characterize the relationship between the physical performance of football players and the properties of the main nervous processes. A higher level of FMNP corresponded to higher values of physical capacity. And, on the contrary, sportsmen with a low level of FMNP were characterized by low physical performance. For example, football players with a higher-than-average level of FMNP during reaching the maximum oxygen consumption on average performed physical work with a power of 224.3 ± 3.8 W, which is statistically significantly more than that of people with a low level of the studied typological property - 214.3 ± 3.6 W (p=0.047).

Football players with an average level of FMNP occupied an intermediate position. On average, they developed a power of 213.5 ± 3.5 W during the test that was statistically significantly less than that of persons with a high degree of the studied typological property (p=0.043). Football players with a high level of FMNP were also characterized by a statistically higher relative physical capacity, calculated considering the sportsman's body weight - 2.8 ± 0.04 W.kg⁻¹ that is statistically more than in the group of football players with a low gradation of the studied typological property - 2, 5 ± 0.07 W.kg⁻¹ (p=0.037). The duration of the load for persons with a high level of FMNP was on average - 9.26 ± 0.18 min., while in subjects with a low level of the investigated typological property, this indicator was statistically lower - 7.96 ± 0.27 min. (p=0.027). The indicators of running speed in the groups of sportsmen with a high level of FMNP were equal to 15.7 ± 0.1 km·h⁻¹, which was statistically significantly higher than that of the subjects with a medium of 14.4 ± 0.3 km·h⁻¹ (p=0.031) and a low level of the studied typological property - 13.5 ± 0.1 km·h⁻¹ (p=0.029).

Therefore, the physical performance of football players if they perform shuttle running at the level of maximum oxygen consumption, depends on the FMNP. Football players with high and medium levels of FMNP were characterized by higher physical performance than individuals with low levels of the studied typological property.

Since we have found that football players spend the main time of the game in the mode of aerobic metabolism, it is interesting to find out the peculiarities of physical performance at the level of AT in groups with different levels of FMNP [21]. Football players with different gradations of PMNP during the test with a gradual increase in running speed at the level of AT were determined and analyzed for

physical performance. The results of the physical performance of the sportsmen in groups with different levels of FMNP under the condition of AT are presented in Table 4.

The results indicate no connection between physical capacity – duration of running T , (min.), work power W , in watts (W , $W \cdot kg^{-1}$) and average running speed V , ($km \cdot h^{-1}$) of football players and properties basic nervous processes. The values of physical capacity were the same regardless of the level of FMNP. No statistically significant differences were found between the indicators of duration of work, power of work and average running speed in the groups of examinees with different gradations of FMNP ($P > 0.05$).

Table 4

Physical performance at the anaerobic threshold level in sportsmen ($n=31$) with different levels of functional mobility of nervous processes

Investigated indicators	Levels of functional mobility of nervous processes, s		
	High (57.1±0.4)	Medium (60.4±0.3)	Low (65.6±0.7)
T , min.	7.37±0.33	7.45±0.21	7.36±0.36
W , watts	190.6±4.7	187.5±5.4	185.9±6.2
W , $W \cdot kg^{-1}$	2.50±0.02	2.50±0.04	2.47±0.08
V , $km \cdot h$	12.20±0.02	12.40±0.04	12.19±0.06

Therefore, the physical performance of football players if they perform shuttle running at the level of the anaerobic threshold of oxygen consumption, is not related to the level of FMNP. Football players with high, medium, and low levels of FMNP were characterized by the same physical capacity.

Thus, the obtained results make it possible to generalize that the physical performance of football players under the condition of gradually increasing load at the level of VO_{2max} is dependent on the individual typological properties of the nervous system [24, 25, 28]. Football players with a high and medium level of FMNP were characterized by higher values of physical performance. In case of performing physical load at the level of AT, a clear dependence of physical capacity on individual and typological properties of the nervous system was not found in highly qualified sportsmen.

The presented results characterize the peculiarities of the relationship between the physical performance of highly qualified football players and the individual-typological properties of the main nervous processes.

Conclusions

1. Genetically determined typological properties of the nervous system, under the condition of gradually increasing physical load, determine the level of physical performance and functional capabilities of CRS of football players.
2. During the shuttle run at the VO_{2max} level, the dependence of physical performance on the FMNP was found. Statistically significant higher values of T , min.; W , watts, and $W \cdot kg^{-1}$ and V , $km \cdot h^{-1}$ of physical capacity corresponded to a high level of FMNP than in groups of persons with a low investigated typological property ($p=0.033-0.045$).
3. During the performance of the test with a gradual increase in running speed at the AT level, we obtained results that indicate the absence of a connection between the physical performance indicators (T , min.; W , watts, and $W \cdot kg^{-1}$ and V , $km \cdot h^{-1}$) of football players with typological properties of the main nervous processes ($P > 0.05$).
4. The possibilities of using individual-typological properties of the central nervous system and physical capacity for a comprehensive evaluation of the success of football players' game activities are substantiated.

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Lyzohub V.S., Pustovalov V.O., Kozhemiako T.V., Bezakopylna S.V., Khomenko S.M., Shpaniuk V.V. Individual Features of Physical Performance of Sportsmen with Different Typological Properties of the Nervous System

Abstract and problem. The individual-typological properties of the nervous system are known to be characterized by a stable biological nature and are the most informative regarding the organization of differentiation, management and forecasting of game activities. It was hypothesized that the individual typological properties of the nervous system in sportsmen can influence physical performance. The differences in these indicators can be the basis for solving the tasks of a differentiated approach to the management of the training process and increasing the physical performance of sportsmen.

Purpose. To determine individual features of the physical performance of football players with different typological properties of the nervous system during the test with gradually increasing running speed.

Research methods. An individual typological property of the central nervous system, the functional mobility of nervous processes, was determined in highly qualified football players using the “Diagnost-1M” neurodynamic complex. Physical performance was studied under the condition of performing the test with stepwise increasing running speed, and the functional indicators of the cardiorespiratory system were studied with the gas analyzer “Oxycon Mobile” of the Jaeger company.

Main research results. The dependence of physical performance on the FMNP was determined under the condition of running a shuttle run at the $VO_{2\max}$ level. Statistically significant higher values of T , min.; W , watts and $W \cdot kg^{-1}$; V , $km \cdot h^{-1}$ of physical capacity corresponded to a high level of FMNP than in groups of the persons with a low studied typological property ($p=0.033-0.045$). During the performance of the test with a gradual increase in running speed at the AT level, we obtained results that indicate the lack of a connection between the indicators of physical performance (T , min.; W , watts and $W \cdot kg^{-1}$; V , $km \cdot h^{-1}$) of football players with typological properties of the main nervous processes. Between indicators W , W , $W \cdot kg^{-1}$; V , $km \cdot h^{-1}$, no statistically significant differences were found in the groups of subjects with different gradations of FMNP ($P>0.05$).

Scientific novelty of research results. It was determined that sportsmen with a high level of FMNP achieved a high level of physical performance in the test with a gradual increase in running speed by involving anaerobic, and with a low gradation of the typological property - aerobic capabilities of CRS. The possibilities of using individual-typological properties of the central nervous system and physical capacity for a comprehensive evaluation of the success of football players' game activities were substantiated.

Conclusions. The limit physical load at the level of maximum oxygen consumption in elite sportsmen recognizes the level of physical performance and the participation of CRS in accordance with the individual typological properties of the sportsmen's CNS. Genetically determined typological properties of the nervous system, under the condition of gradually increasing physical load, determine the level of physical performance and functional capabilities of the central nervous system of football players.

Key words: physical performance, typological properties of the nervous system, cardiorespiratory system, sportsmen.

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