Psychophysiological mechanisms of increasing readiness for competitive activity in equestrian sport: educational perspectives

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Abstract. The research is devoted to psychophysiological regularities of the adaptation of the spatial-temporal functions in the athletes of equestrian sport with the specialization "dressage." Particularly, we evaluate the developmental impact on sensory perception and motor orientation in the spatial-temporal continuum of the special dressage exercise complex. The obtained data confirm the significance of the athletes' space-time characteristics for the effectiveness of sports activities aimed at increasing their preparedness for competitive activity in equestrian sports, because their development leads to an increase in the adaptive capabilities of athletes, helps to optimize the processes in the central nervous system, as well as the vegetative regulation of the functional systems in the body. The development of the horsemen' space-time functions (under control with the help of computer diagnostics of their indicators) can be recommended as an indispensable component of increasing the readiness for competitive activity in equestrian sport.

Keywords: psychophysiological adaptation, regulatory systems, space-time functions, computer diagnostics testing, athletes, horsemen, training process, dressage

1. Introduction

In contemporary conditions, the sport of higher achievements requires the mobilization of all body resources in the range of athletes' individual limiting adaptation possibilities. This is provided by the psychosomatic integration (interaction) of regulatory, sensorimotor, physical, psychoemotional, cognitive, volitional, and space-time properties in a given time range [19]. Sports medicine, relying on the data of psychophysiology and using advanced scientific and methodological support of training activities, should be able prepare an athlete in a given time period to the state of readiness for competitive activity, representing a complex psychophysical condition. It includes: the optimal level of adaptation capabilities and reserves, depending on the balance of the central, neurohormonal, and

autonomic regulation systems; a high level of psycho-physiological resources and their energy supply, corresponding to his/her "peak form," i.e. the maximum performance of an athlete.

A sports career, as E. A. Dergach notes, is an activity aimed at achieving high sports results and associated with the constant development of a person in one or more sports. The formation of an athlete is a long-term, multifaceted process that requires great athlete's psychophysical training efforts and significant social and economic investments [6]. Achievement of high technical results in equestrian sport is possible only with optimal functioning of the body systems of the rider and the horse on the basis of integration of their motor actions [4; 5].

In the most complicated specialization of equestrian sports, dressage (higher school riding), athletes are distinguished by such psycho-physiological phenomena as special abilities, processes, functions, qualities, conditions, and properties. They are manifested in the rider in the features of sensory processes, organization and management of movements in basic parameters (time, space, effort, pace, rhythm), activity, voluntary attention, random memory, functional states and other [15; 17].

To study the "rider-horse" system in the space-time continuum and its reflection in the space-time functions of the central nervous system of sportsmen during equestrian sports, we used psychophysiological tests, implemented in the form of software and computer complex. Computer technologies used in conducting PTs allow one to investigate the equilibrium, mobility, lability, stability of the central nervous system (CNS), i.e. properties important for competitive activity of equestrian athletes, such as orientation in space, temporal parameters of motions [10; 12; 14]. The study of these indicators would establish the physiological mechanisms of the equestrian training process to improve the efficiency of mastering and performing dressage elements and improving horse management, increasing readiness for competitive activity.

Analysis of the published literature showed the relevance of the study of psychophysiological mechanisms, readiness for sports activities: sensorimotor reactions, depending on the spatial and temporal functions of the central nervous system, indicators of regulatory systems that determine the training and competitive activity of riding equestrian athletes.

The *purpose of this research* is to study the space-time functions of the horsemen' CNS in conditions of the training process of riding. *Research objectives*: (a) to assess the development of spatial-temporal properties of the equestrians' CNS, based on the research of sensory-motor reactions of equestrian athletes; (b) to identify the features of changes in individual sensorimotor parameters in women during the training process; (c) to study the influence of physical exercises on the development of neurophysiological spatiotemporal functions in equestrians.

2. Materials and Methods

The study included 22 equestrians (women) aged 24.5 to 39 years. An indispensable condition for participation in the study was the presence in the subjects of competitive experience at different levels of competitions in riding of 4 to 15 years, having sports 1st and 2nd categories, 1st category of the Candidate Master of Sports. Each participant in the study was asked to undergo computer testing according to the tests presented in Table 1.

At the beginning of the testing, a questionnaire was conducted to collect the following data: age, gender, sports experience, rank and type of sport activity. All the subjects were arbitrarily divided into two groups (Monte Carlo method): the main group (MG) included 11 sportswomen, whose training activity included the implementation of special physical training exercises aimed at the development of space-time properties of the CNS. Vitamin complexes (Knikap, Complevit, Vitrum), which contain all the necessary vitamins, as well as minerals in the right dosages and proportions to improve readiness for competitive activity in equestrian sport, were proposed by the sports doctor to improve the functional state of the body of athletes and improve recovery processes. The comparison group (CG) had 11 sportswomen who were engaged in a standard training program (STP). Comparison of the results obtained in the MG and CG made it possible to obtain and analyze objective data on the researched problem.

The training sessions in both groups were held for 6 months, from November 2017 to June 2018. At the end of the study (control stage), repeated computer testing was conducted to identify the effectiveness of using special physical training in the MG in comparison with the STP of the CG to develop the spatial and temporal properties of the central nervous system to increase readiness for the competitive activity of athletes equestrians.

2.1 The initial stage of experimental research.

With the help of a complex of psycho-physiological techniques, spatial-temporal functions of the central nervous system, realized in the behavior of a equestrians, were determined. The data are presented in Table 1.

Table 1. Tests for estimating space-time properties of the athletes in equestrian riding.

Tests	Characteristics of applying the method for diagnosis of CNS functions	Normative indicators for the test methodology
1. "Determining the reaction time to a moving object (RMO)"	RMO is used as a physiological test to determine the level of interaction between the processes of excitation and inhibition in the cerebral cortex, both in a state of relative rest and under the influence of physical exertion. With the help of RMO indicators, one can, to a certain extent, judge the stability of the functioning of the nervous system.	0,12-0,28 sec
2. "Determining the reaction time to a choice"	The reaction time to a choice is one of the variants of a complex sensorimotor reaction, since it is necessary to differentiate the signal (one signal needs to be reacted, and the other one is not).	0,33-0,43 sec
3. "Evaluating the angular velocity of motion"	An important characteristic of the perception processes of time and space of an athlete is the evaluation of speed. This test allows to estimate the angular velocity of the object.	8-28 sec
4. "Evaluating the magnitude of the angles presented"	Along with the ability to assess distance or farness (linear dimensions), an important role in the development of the eye is played by the ability to evaluate the turns. The test is based on a visual assessment of the angles (presented in random order) in degrees.	22-26, degrees
5. "Playing the duration of the time interval"	This test allows to assess the accuracy of time perception and the accuracy of time orientation, i.e. the "sense of time" that is necessary for assessing the psychoemotional state and properties of the nervous system, as well as the significance and degree of participation of the visual or auditory analyzer in perceiving information from a subject.	26-74 (light stimulus, sec) 19-30 (sound stimulus, sec)
6. "Defining the volume angle of rotation"	Orientation in space implies movement in three planes. Therefore, the test for determining the volume angle of rotation is particularly important where rapid movement is required. The estimation of the volume angle of rotation is reduced to a visual estimate of the rotation angle of the three-dimensional object around the axes X, Y, Z in the Cartesian coordinate system.	16-21, degrees

2.2 The training stage of experimental research.

During the study of the space-time properties of athletes in riding, a training tool was developed in the form of a *complex of special physical training* (SPT) exercises for the development of spatial-temporal functions of female equestrians on the basis of riding techniques [8, 9, 15, 16]. The complex of exercises is presented in Table 2.

Table 2. SPT exercises for developing spatial-temporal properties of equestrians in "dressage."

Basic techniques of "dressage"	Content	Recommendations for implementation
Preparatory-developing exercises of the I stage		
"Concession to Schenkel"	Performed at an angle of 35 degrees relative to the direction of the horse' movement.	Running 1-2 (maximum 3) repetitions. Orient the hull of the horse in space relative to the arena.
"Swing"	Performed with the horse moving forward and backward. Equilibration of the rider-horse dyad, finding a balance.	3-4 replays are performed. Uniform diagonal movement backward in 2 measures and forward in 4 measures.
"Traverse"	Performed on harvested lynx or harvested canter. The horse front remains on the line of movement, and its back is shifted inwards. When the traverse is carried out, the constant angle of lead is 35 degrees.	Moving in the arena space with the angle of bending of the horse's body at 35 degrees relative to the line of movement. Running 1-2 (maximum 3-4) repetitions.
Preparatory-developmental-test exercises of the II stage		
"Eight"	Consists of two volts or circles connected to each other in the eight, or circles of the same size corresponding to one being indicated in the ride scheme (test).	2-3 replays are performed daily.
"Serpentine"	Consists of semicircles connected by a straight line. Serpentines with one loop on the long side of the arena are performed at a distance of 5 or 10 meters from the long wall of the arena.	Running 1-2, maximum 3-4 replays daily.
"Pirouette" and "Half-pirouette" on the canter and on the step	It is a 360 degree turn (180 degrees), performed in two tracks, with a radius equal to the length of the horse. Half-pirouettes in a step (180 degrees) are performed on the collected step with preservation of the collection during the entire exercise.	Pirouette (semi-pirouette) at the canter of 6-8 (3-4) tempos. Pirouette (semi-pirouette) in step of 6-8 (3-4) tempos, with a circle diameter of 80 cm or 1 meter.

2.3 The control stage.

At the control stage, final testing of athletes participating in pedagogical experiment was conducted. To assess the adaptive abilities of the body of athletes, the state of regulatory influences of the central nervous system and autonomic NS on the cardiovascular system of the body and functional reserves and to study the stability of the central nervous system in changing space-time conditions, the Varicard 2.51 hardware and software complex [20] was used; computer program.

At the final stage of the pedagogical experiment, we had the final testing of the athletes participating in our study. To assess the adaptive capabilities of the athlete's body, the state of regulatory influences of the central nervous system and the autonomic nervous system on the cardiovascular system of the body, functional reserves, and the study of the CNS stability in changing spatio-temporal conditions, the hardware-software complex "Varicard 2.51" [20] and the computer program "Researcher of temporal and spatial properties of human version 2.1" [10; 11; 12; 13; 14] were used.

Methods of Mathematical Statistics were used to analyze the data obtained, with the help of the applied statistical programs SPSS for Windows (version 17.0). Also, the use of the one-sample λ-Kolmogorov-Smirnov test to the obtained experimental data revealed the distribution of the investigated variables within the normality limits, which allowed further use of the t-Student parametric criterion for dependent and independent samples.

3. Results

An important role in achieving training goals is played by the principles of individualization, optimization, and awareness. To fulfill the goals and objectives of the training process set out in cooperation with the trainer, the athlete must participate in his strategic and tactical planning. In other words, the athlete takes into account individual psycho-physiological characteristics and is aware of requirements for evaluating the stages of training in the optimal range of development of their psychophysical functions, providing readiness for competitive activity [2, 3, 16]. Achievement of high sports results in equestrian sport has *significant features*, since it is carried out in a communicative "triangle", an athlete-coach-horse, in which the subject-subject interaction of the athlete-coach is supplemented by the subject-object interactions of the athlete and the horse. Effectiveness is achieved through the disclosure, training, and harmonious development of the horse's physical capabilities and the level of contact reached between the rider and the horse. In the equestrian sport, it is especially important, because the dyad "rider-horse" always stands and is judged in competitions, in which there are no restrictions on age, sex, weight, etc. [4, 5]. In this regard, equestrian sport is the most complex sport and is included in the program of the Summer Olympics and Games of the Spartakiad of Russia [16].

M. E. Agafonova notes that for a successful performance at equestrian competitions, which are held in three programs (manege riding, field trials, overcoming of obstacles), it is necessary to have a high level of not only functional (technical) preparedness, both for the rider and the horse, but also a sufficient level of psychological, physical, and biological readiness for competitive activities [1]. Since the movement and interaction of the rider-horse tandem is carried out in the space-time coordinates of the arena, the *level of development of the space-time functions of the athlete can* have an impact on the performance in a competition, which was the subject of our study.

In a comparative aspect, the results of the study of the space-time functions of the MG and CS riders at the *ascertaining stage* of the study are presented in Table 3.

Table 3. Sensory-motor indicators that determine the spatial and temporal functions of the central nervous system of equestrian athletes (women) in the MG and CG, compared with the normative indicators at the initial stage of the experimental study.

Spatial-temporal functions of the athlete	MG				CG			
	Average	Standard deviation	Standard Error of Mean	Comparison with the norm	Average	Standard deviation	Standard Error of Mean	Comparison with the norm
The reaction time to a moving object (RMO), sec.	0,280	0,011	0,001	Average	0,275	0,023	0,01	Average
Response time to a choice, sec.	0,467	0,02	0,01	Low	0,478	0,036	0,01	Low
Estimating the angular velocity of the object, %	7,5	4,6	1,39	Low	7,6	4,7	1,42	Low
Estimating the magnitude of the angles, %	22,3	5,8	1,75	Average	22,7	5,6	1,69	Average
Reproducing a time interval filled with a light stimulus, %	29,8	17,2	5,19	Average	29,4	17,5	5,28	Average
Playing the time interval filled with sound stimulus, %	18,0	10,4	3,14	Low	16,0	10,7	3,23	Low
Determining the volume angle of rotation, %	15,3	11,03	3,33	Low	13,4	11,5	3,47	Low

In this work, an experimental study of the spatial and temporal functions of the central nervous system was carried out, determining psycho-physiological readiness for competitive activities of

athletes-horsewomen of the MG and CG at the initial stage of an experimental study, the results of which are presented in Table 3.

The results given in Table 3 indicate slight differences in the initial indices characterizing the space-time functions in the compared groups of the MG and CG athletes, indicating the homogeneity of the comparison groups, which is a prerequisite for revealing the effects of training influences on the MG athletes' special physical training.

After training sessions for 6 months according to the specially developed program (MG) and the standard training program (CG), repeated examination of the indicators characterizing the spatiotemporal functions of the trainees was carried out. The comparison of the spatial-temporal functions of the properties of the MG and CG riders at the control stage of the study is presented in Table 4.

Table 4. Sensory-motor indicators that determine spatial-temporal functions of the athletes (women) in the MG and CG in comparison with the normative indicators at the control stage of the experimental study.

Spatial-temporal functions of the athlete	MG				CG				Comparison of average, t
	Average	Standard deviation	Standard Error of Mean	Comparison with the norm	Average	Standard deviation	Standard Error of Mean	Comparison with the norm	
The reaction time to a moving object (RMO), sec.	0,116	0,031	0,01	High	0,243	0,033	0,01	Average	3,25**
Response time to a choice, sec.	0,308	0,036	0,01	Average	0,464	0,04	0,01	Low	3,41**
Estimating the angular velocity of the object, %	30,5	2,6	0,78	High	8,6	3,1	0,93	Average	3,58**
Estimating the magnitude of the angles, %	31,3	3,7	1,12	High	25,4	4,6	1,39	Average	3,72**
Reproducing a time interval filled with a light stimulus, %	47,8	10,1	3,05	Average	33,4	13,5	4,07	Average	2,29*
Playing the time interval filled with sound stimulus, %	28,5	7,4	2,23	Average	18,4	9,1	2,74	Low	3,28**
Determining the volume angle of rotation, %	24,1	7,3	2,20	High	16,6	10,2	3,08	Average	3,23**

Significance level: * - $p \leq 0,05$, ** - $p < 0,01$.

The results of Table 4 show a significant increase after using the developed training program for the accuracy of determining the spatial parameters in the MG if compared to the CG by 4-10%. And in comparison with the initial level (the initial stage), the accuracy of test performance (by individual indicators) increased after training in the MG by 10-20%, and it was only 1-4% in the CG. These data testify to the effectiveness of the development of spatial-temporal functions of athletes, ensuring the effectiveness of competitive activities of the athletes.

To diagnose the dynamics of the adaptive capabilities of the body of athletes and the state of vegetative regulation of the body functions in MG and CG groups, we diagnosed the variability of the heart rhythm. The results are shown in Figures 1 (MG) and 2 (CG).

The optimal state of the regulatory systems in the MG (Fig. 1), after training the spatial-temporal functions according to the program developed by the authors, demonstrates the balance of the sympathetic and parasympathetic parts of the autonomic nervous system (ANS). It can be concluded

that long-term adaptation, expressed in vegetative balance and vestibular stability in equestrian sport, is caused by the use of exercises that form the *spatial-temporal properties of the athletes* and is an indicator of the level of adaptive capabilities of the organism. The CG athletes (Fig. 2) have a disalance in vegetative regulation; at the same time, one observes a marked increase in activity of the vasomotor center regulating the vascular tone and weakening the activity of the sympathetic cardiovascular center, which is manifested in the lowered, in comparison with the MG, indices of the equestrians' spatial-temporal functions.

General assessment of the state of regulatory systems

Characteristics of the system of regulating the average rhythm	Private diagnostic findings	Score in points	Deviation from mode
B. Vegetative homeostasis	The balance of the sympathetic and parasympathetic parts of the autonomic nervous system	0	0.05
G. Vasomotor (vascular) center	Normal activity of the subcortical cardiovascular center	0	-0.35
D. Sympathetic cardiovascular center	Normal activity of the subcortical cardiovascular center	0	1.09
The activity index of the PARS + (IRSA +) regulatory systems: 1 (-0 + 0)			**NTI:1**

Figure 1. Status of the equestrians' regulatory systems at the end of the study in the MG.

General assessment of the state of regulatory systems

Characteristics of the system of heart rate regulation	Private diagnostic findings	Score in points	Deviation from mode
B. Vegetative homeostasis	Moderate predominance of the sympathetic nervous system	1	2.44
G. Vasomotor (vascular) center	Increased activity of vasomotor center regulating vascular tone	2	1.23
D. Sympathetic cardiovascular center	The marked weakening of the activity of the sympathetic cardiovascular center	-2	-0.14
Activity indicator of regular PARS+ (IRSA+) systems: 7(-2+5)			**NTI:5**

Figure 2. Status of the equestrians' regulatory systems at the end of the study in the CG.

4. Discussion

In sports it is impossible to demonstrate high results without controlling the athlete' body movements in space from one position to another while maintaining the optimal functional state of the CNS in order to realize potential capabilities [11, 13]. Therefore, the research on spatial-temporal functions of athletes is in demand and necessary for studying the reserve capabilities of adaptation of the CNS, ANS, and the organism as a whole, as well as the formation of cerebral motor programs that predict motor changes and give the necessary programmed characteristics to further movements [3, 7, 14, 22].

As a result of the psychophysiological study of the test "Determining the reaction time to a moving object (RMO)," it is established that the use of SPT exercises helps stabilize the processes of excitation and inhibition in the cerebral cortex of equestrians in the MG. Meanwhile, the time of delayed and advanced reactions decreases, the speed of motor response to moving stimuli when performing the RMO test increases in the MG, if compared to the CG. This contributes to maintaining a balance in the rider-horse dyad.

With the help of the test "Determining the reaction time to a choice", it is established that the speed increases and the response time to the received signal in the MG decreases if compared to the CG. Training the complex sensorimotor reaction contributes to the competitive readiness of athletes and their achievement of better results in competitive activities, if compared to the CG athletes. The analysis of the data obtained during the test "Evaluating the angular velocity of motion" makes it possible to establish that the number of errors admitted decreases when the angular velocity of the

object is known; also, the memorization of the object's speed, its recognition, and repetition are significantly improved.

In the study of MG athletes, due to test "Evaluating the magnitude of the angles", it is found that their ability to remotely memorize the magnitude of angles in a random order is improved, the eye is developed, and the ability to evaluate the turns is improved. The size of the errors admitted at the angles estimation decreases in contrast to the CG athletes. This testifies to the improvement of technical training of female athletes of the main group under the influence of special physical training.

The indicator "duration of the time interval" in contemporary Adaptology is used as a marker of human adaptive capacity. Since high psychoemotional reactivity is a maladaptive state, in which excessive excitability of the nervous system disrupts the real time estimate and speeds up the "internal clock." Based on the results of the test "Playing the duration of the time interval," which evaluates the accuracy of time perception, i.e. the "sense of time," the recognition of the "filled" and "unfilled" time interval and its reproduction, it is established that the MG athletes more accurately reproduce the time intervals of different duration and do it with the least error (in comparison with the CG). This confirms a balance between the processes of excitation and inhibition in the CNS, which contributes to the most technical performance of equestrian exercises "Menka" and "Swing." The CG athletes reproduce the time intervals with a large error and the least accuracy, which indicates a certain decrease in the functional state of the CNS and the adaptive reserves of horsemen.

The data obtained on one of the most significant and informative tests for equestrian sport, "Defining the volume angle of rotation," in which the orientation in space is determined in three planes. The development of this function is required for the rapid movement of the rider. The study found that the MG athletes move better in different directions and more efficiently assess their movement in space in comparison with the CG.

The studied indicators of physiological adaptation are important for the training process and allows to better understand and reveal the mechanisms of the complex sensorimotor reaction of athletes of different qualifications and training [3, 21]. In the future, the results obtained will make it possible to apply the physiological substantiation of the training process both in equestrian sport and in other complexly coordinated sports activities.

5. Conclusion

Preparation of equestrians requires interaction of all links of sensory perception. It is very important to navigate in space (to determine time, space, effort, pace, rhythm), clearly perform the necessary motor actions in the management of the horse, while observing control in various spatial positions. The interaction of the vestibular apparatus and sensory systems determines the success of the motor activity of these athletes when performing tasks in the competitive program in various spatial-temporal conditions. The justified selection of SPT exercises for training the athletes is very important, because it allows to optimize the complex psychomotor interactions of sensory, motor, and cognitive functions. Consequently, the equestrians perform better difficultly coordinated actions in dressage. As shown by the study, the training process based on the SPT exercises for the development of space-time orientation allows improving the indices of psychophysiological tests, which creates the basis for effective performance of competitive exercises in sports dressage.

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