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NEUROPSYCHOBIOLOGICAL AND GENETIC CHARACTERISTICS OF PHYSICAL PERFORMANCE IN HIGH-PERFORMANCE SPORTS

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Abstract
The article examines the key aspects of neuropsychobiological and genetic factors that influence physical activity and sports performance at the elite level. It discusses contemporary theories of neurobiological regulation of motor activity, molecular mechanisms of the body's adaptation to physical loads, and genetic markers associated with success in various sports. Examples are provided of how this knowledge can be applied to personalize training processes.

Keywords: Neurobiology, genetics, physical activity, elite sports, molecular mechanisms, neurotransmitters, adaptation, genetic profile, antioxidant systems, stress resistance, motivation, epigenetics.

Introduction
In high-performance sports, the competitive demands on the physical, cognitive and psychological preparation of athletes continue to increase. Traditional training methods are complemented by innovative approaches based on advances in neurobiology and genetics. Scientists pay special attention to the interaction of genetic predispositions and the environment, as well as the influence of neuropsychological factors on the body's adaptation to extreme physical loads.

Physical activity involves many integrative processes that are regulated not only by the structure and function of the musculoskeletal system, but also by the activity of the central nervous system (CNS), the hormonal system, and molecular mechanisms at the cellular level. Understanding these processes allows us to develop personalized strategies for training athletes, increasing the effectiveness of training and reducing the risk of injury.

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The central nervous system (CNS) plays a key role in regulating physical activity. Higher motor centers, including the prefrontal cortex and the motor cortex, are involved in controlling complex motor actions, which is especially important for technically demanding sports such as gymnastics or fencing.

High-performance sports require athletes to possess exceptional physical capabilities, which are influenced by a complex interplay of neuropsychobiological and genetic factors. Recent studies highlight the significance of allelic-genotype variants of sports-related genes and their correlation with psychophenotypic and neuromediator indicators, providing deeper insights into the determinants of athletic performance. These findings emphasize the importance of understanding the genetic predispositions and neuropsychological traits that contribute to the development of elite athletes, offering opportunities for more personalized and effective training methodologies. Such research underscores the growing role of genetics and neuroscience in optimizing physical performance in competitive sports (Sh., UN, and A.G., 2023).

Particular attention is paid to studying the mechanisms of neuroplasticity that ensure the brain's adaptation to new motor tasks. Research shows that regular training helps strengthen synaptic connections in the motor cortex and basal ganglia, which improves motor coordination and reaction speed (Tanaka et al., 2021).

The dopaminergic system has a significant impact on the level of motivation of athletes. Dopamine is responsible for the feeling of satisfaction and reward, which stimulates further performance of training tasks. At the same time, serotonin is involved in mood regulation, reducing the level of anxiety and fatigue during prolonged physical exertion (Cools et al., 2020).

The HPA axis is actively involved in the process of adaptation to physical exercise. Stress hormones such as cortisol help the body mobilize resources for intense exercise, but their prolonged elevation can lead to overtraining (Wunsch et al., 2019).

Genetic predisposition to certain sports is explained by the presence of polymorphisms in a number of genes that affect physiological and biochemical processes. For example, the ACTN3 gene, widely known as the "sprinter gene," is associated with high muscle fiber contraction speed. People with certain

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ACTN3 alleles have an advantage in speed-strength sports (MacArthur & North, 2007).

The PPARA gene, which regulates fatty acid oxidation in muscle, plays an important role in endurance sports such as marathon running and cycling. Research also points to the importance of polymorphisms in genes associated with recovery, such as the SOD2 gene, which affects the body's antioxidant defenses (Eynon et al., 2013).

Along with genetics, epigenetic factors such as DNA methylation and histone modification play an important role in regulating gene expression. These mechanisms allow the body to adapt to environmental changes, including training loads (Seaborne et al., 2018).

The mTOR and AMPK signaling pathways play a central role in the regulation of energy metabolism and protein synthesis in skeletal muscle. mTOR is responsible for activating anabolic processes, which is important for muscle recovery and growth after exercise, while AMPK is activated during energy deficit and stimulates catabolic processes (Egan & Zierath, 2013).

Exercise causes an increase in reactive oxygen species (ROS), which can lead to oxidative stress. Antioxidant enzymes such as superoxide dismutase (SOD) and glutathione peroxidase protect cells from damage and promote recovery after intense exercise (Radak et al., 2015).

High-performance sport requires high resilience to stress. This is achieved through the development of cognitive skills such as attention, concentration, and the ability to cope with negative emotions. Modern methods, including meditation and cognitive behavioral therapy, have been successfully used to improve the psychological preparation of athletes (Walker et al., 2020).

Samuel Marquardt's (2010) psychobiological theory emphasizes the importance of motivation in overcoming fatigue and achieving goals. Self-regulatory mechanisms, including goal awareness and emotion management, help athletes maintain high levels of motivation throughout their careers.

Neuropsychobiological and genetic characteristics of physical activity in high-performance sports are one of the most complex and multifaceted areas of scientific research. Studying these aspects allows us to better understand the nature of physical activity and sports achievements, identify key mechanisms regulating the body's adaptation to extreme loads, and develop innovative methods of training, recovery, and injury prevention.

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Conclusions:

1. **The role of the central nervous system and neuropsychobiological factors:**

The central nervous system plays a key role in regulating motor activity, as well as in developing resistance to stress and psycho-emotional stress. Neuroplasticity of the brain allows athletes to adapt to new motor tasks, which is critically important for improving their technical preparedness.

Neurotransmitters such as dopamine and serotonin provide a balance between motivation, concentration and fatigue. Their activity is directly related to cognitive and physical resilience, which confirms the need to take psychobiological factors into account when preparing athletes.

2. **Genetic markers of athletic talent:**

An athlete's genetic profile determines his predisposition to certain sports. The ACTN3 gene is associated with the development of speed-strength abilities, while the ACE polymorphism affects endurance.

Epigenetic changes induced by training and the environment allow regulation of the expression of genes responsible for adaptation to loads. This opens up new perspectives for the individualization of training programs.

3. **Molecular mechanisms of adaptation and recovery:**

The mTOR and AMPK signaling pathways play a key role in regulating energy metabolism and recovery processes in skeletal muscles. Their activation depends on the type of load and intensity of training, which allows for targeted action on anabolic and catabolic processes.

The body's antioxidant systems, including superoxide dismutase and catalase, protect cells from oxidative stress. Their activation helps improve recovery processes after physical exertion.

4. **Practical significance of the research:**

The use of a personalized approach in sports training, based on the genetic profile and neuropsychobiological characteristics, allows to increase the effectiveness of training programs, reduce the risk of injury and improve sports results.

The use of modern monitoring technologies, such as heart rate variability analysis, molecular tests and neuropsychological assessment methods, makes it

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possible to promptly adjust the training process depending on the athlete's condition.

Neuropsychobiological and genetic research therefore represents a powerful tool for improving sports practice. This knowledge allows not only to identify potential champions, but also to provide them with optimal conditions for achieving high results. In the future, further development of this field will open up new horizons in studying the limits of human capabilities and developing innovative approaches in high-performance sports.

Continuing scientific research in this area can contribute to the creation of more effective and safe methods of training athletes based on a deep understanding of the biological and psychobiological mechanisms underlying human physical capabilities.

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