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НОВЫЙ ДЕНЬ В МЕДИЦИНЕ
NEW DAY IN MEDICINE

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ООО «ТИББИЁТДА ЯНГИ КУН»

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INFLUENCE OF GENETIC FACTORS ON AUTONOMIC DYSFUNCTION AND INDIVIDUAL CHARACTERISTICS OF REACTION TO PHYSICAL EXERCISES IN FOOTBALL PLAYERS AND TRACK AND FIELD ATHLETES

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✓ ***Resume***

The study of COMT Val158Met polymorphism among athletes involved in football and athletics presented in the article demonstrated a significant influence of genetic factors on stress resistance and the risk of developing autonomic dysfunctions. The results of the studies show that athletes with the AG and GG genotypes have better endurance and adaptation to training loads compared to AA carriers. This is due to the fact that these genotypes are associated with higher dopamine levels, which has a positive effect on athletic performance and reduces the risk of autonomic disorders. Speaking about the predisposition of athletes to autonomic disorders, this study showed significant differences between carriers of different genotypes. Genetic predisposition plays an important role in the regulation of dopamine, which in turn affects physical activity and adaptation to stress. The results emphasize the need for further research in this area to develop personalized approaches to training and prevention of autonomic disorders.

Key words: athletes, football players, track and field athletes, gene, polymorphism, higher nervous activity, COMT Val158Met

ВЛИЯНИЕ ГЕНЕТИЧЕСКИХ ФАКТОРОВ НА ВЕГЕТАТИВНУЮ ДИСФУНКЦИЮ И ИНДИВИДУАЛЬНЫЕ ОСОБЕННОСТИ РЕАКЦИИ НА ФИЗИЧЕСКИЕ НАГРУЗКИ У ФУТБОЛИСТОВ И ЛЕГКОАТЛЕТОВ

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✓ ***Резюме***

Исследование полиморфизма COMT Val158Met среди спортсменов, занимающихся футболом и лёгкой атлетикой, представленное в статье, продемонстрировало значительное влияние генетических факторов на устойчивость к стрессу и риск развития вегетативных дисфункций. Результаты исследований показывают, что у спортсменов с генотипами AG и GG наблюдаются лучшие показатели выносливости и адаптации к тренировочным нагрузкам по сравнению с носителями AA. Что связано с тем, что данные генотипы ассоциируются с более высоким уровнем дофамина, что положительно сказывается на спортивных результатах и снижает риск вегетативных расстройств. Говоря о предрасположенности спортсменов к вегетативным расстройствам, данное исследование показало значительные различия между носителями различных генотипов. Генетическая предрасположенность играет важную роль в регуляции дофамина, что, в свою очередь, влияет на физическую активность и адаптацию к нагрузкам. Полученные результаты подчеркивают необходимость дальнейших исследований в данной области для разработки персонализированных подходов к тренировкам и профилактике вегетативных расстройств.

Ключевые слова: спортсмены, футболисты, легкоатлеты, ген, полиморфизм, высшая нервная деятельность, COMT Val158Met

GENETIK OMILLARNING VEGETATIV DISFUNKTSIYAGA TA'SIRI VA FUTBOLCHILAR VA YENGIL ATLETIKACHILARDA JISMONIY YUKLAMALARGA REAKTSIYANING INDIVIDUAL XUSUSIYATLARI

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✓ ***Rezyume***

Maqolada keltirilgan futbol va yengil atletika sportchilari o'rtasida COMT Val158Met polimorfizmini o'rganish genetik omillarning stressga chidamliligi va vegetativ disfunktsiyalarni rivojlanish xavfiga sezilarli ta'sirini ko'rsatdi. Tadqiqot natijalari shuni ko'rsatadiki, AG va GG genotiplari bo'lgan sportchilar AA tashuvchilariga qaraganda chidamlilik va mashg'ulot yuklamalariga moslashishning yaxshi ko'rsatkichlariga ega. Buning sababi shundaki, bu genotiplar dopaminning yuqori darajasi bilan bog'liq bo'lib, bu sport ko'rsatkichlariga ijobiy ta'sir ko'rsatadi va vegetativ kasalliklar xavfini kamaytiradi. Sportchilarning vegetativ kasalliklarga moyilligi haqida gapirganda, ushbu tadqiqot turli genotiplarning tashuvchilari o'rtasida sezilarli farqlarni ko'rsatdi. Genetik moyillik dopaminni tartibga solishda muhim rol o'ynaydi, bu esa o'z navbatida jismoniy faollik va stressga moslashishga ta'sir qiladi. Olingan natijalar vegetativ kasalliklarni o'rgatish va oldini olish uchun shaxsiylashtirilgan yondashuvlarni ishlab chiqish uchun ushbu sohada keyingi tadqiqotlar zarurligini ta'kidlaydi.

Kalit so'zlar: sportchilar, futbolchilar, yengil atletikachilar, gen, polimorfizm, oliy nerv faoliyati, COMT Val158Met

Relevance

The COMT (catechol - O - methyltransferase) gene is responsible for the metabolism of catecholamines, including dopamine [13]. The Val158Met (rs4680) polymorphism of the COMT gene determines different levels of activity of this enzyme, which in turn affects the level of neurotransmitters in the brain and the characteristics of nervous activity. In particular, the Val (G) allele is associated with higher enzyme activity and faster dopamine metabolism, while the Met (A) allele is associated with low COMT activity and higher dopamine levels in synapses [14].

The COMT Val158Met gene polymorphism is one of the most studied genetic variations affecting dopamine metabolism, which is important for various aspects of the psychophysiological state, including vegetative disorders. The results obtained will allow us to create an individual training program for athletes taking into account their genetic characteristics, namely the COMT Val158Met gene polymorphism. A study of the distribution of polymorphisms of this gene among football players and track and field athletes showed a significant influence of genetic factors on the type of higher nervous activity and individual characteristics of the reaction to physical activity.

To assess the influence of the COMT Val158Met gene polymorphism on the individual predisposition of athletes to the development of autonomic disorders.

Materials and methods

Genetic analysis of COMT Val158Met gene polymorphisms was carried out using a statistical program such as SPSS, which is widely used to process genetic and biomedical data. The assessment of the correspondence of the distribution of genotypes to expected frequencies was carried out according to the Hardy-Weinberg law. The p-value criterion was taken as the level of significance for the studies conducted. To analyze the relationship between genetic changes in the COMT Val158Met gene and autonomic dysfunction in Pathway Studio 10 used filters from the ResNet 11 database to select only those genes and interactions that could be associated with the corresponding genetic polymorphism. The program's algorithm allows you to determine the type of Genetic Change , when changes in genes or their polymorphisms correlate with certain diseases or conditions of the body.

Results and discussions

A study of the COMT Val158Met gene polymorphism among 100 athletes (football players and track and field athletes) showed that the AA genotype was found in 40% of the subjects, AG in 43%, and GG in 17% (Fig. 1). This distribution indicates genetic diversity, which can affect adaptation to physical activity and athletic performance [3]. The calculations showed that the distribution of the AA, AG, and GG genotypes in the athlete sample complies with the Hardy-Weinberg law. This indicates that this population does not have significant factors that disrupt genetic equilibrium, such as selection, migration, or genetic drift [2,16,20].

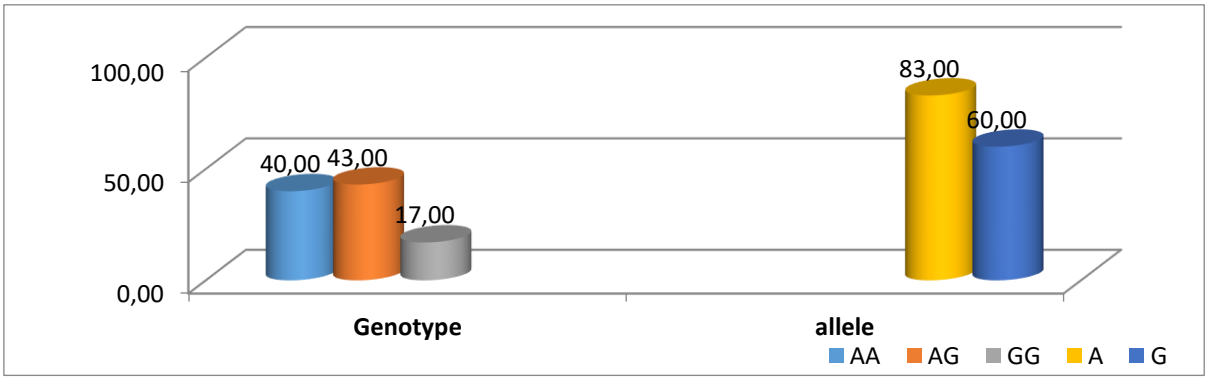

Figure 1.

Distribution frequency of genotypes and alleles of the COMT Val158Met gene among athletes

Conducted by the Pathway program Studio 10 using ResNet 11 database filters, the analysis allowed us to select several genes for which the program found links to autonomic disorders via the COMT Val158Met polymorphism. Examples of such genes include:

- MAOA (monoamine oxidase A): is involved in the metabolism of dopamine and other neurotransmitters, and its interaction with COMT can affect dopamine levels in various parts of the brain, which is associated with symptoms of autonomic dysfunction [1];

SLC6A3 (dopamine transporter): alters dopamine metabolism, and its interaction with COMT may influence the body's stress responses [11];

BDNF (brain-derived neurotrophic factor): modulates cognitive functions and stress responses associated with the autonomic nervous system [32].

Highlighted using Pathway Studio 10 and ResNet 11 databases, key molecular interactions are directly linked to the COMT Val158Met polymorphism and its impact on autonomic dysfunction. The findings provide insights into the molecular mechanisms underlying genetic influences on autonomic nervous system function.

To analyze the effect of COMT Val158Met polymorphisms on body parameters such as weight, height, body mass index (BMI) and other anthropometric parameters, it is necessary to take into account the interaction of genetic and environmental factors. High levels of dopamine, characteristic of the AA genotype, contribute to more muscle mass and corresponding weight gain [10]. Increased levels of dopamine and its slower metabolism affect metabolism, which can lead to better adaptation to strength training and an increase in body mass during training with heavy weights [14]. Athletes with the AG genotype, possessing universal adaptive abilities, can vary in weight and muscle parameters depending on the training program and type of sport, which is ensured by a balanced level of dopamine [10]. This is associated with increased stress resistance, but may also influence the tendency to lower weight and muscle mass due to less pronounced adaptation to strength training. Athletes with the GG genotype often have higher endurance and aerobic performance, which is explained by a genetic predisposition to more efficient oxidative metabolism [4].

Given that BMI is dependent on weight and height, the influence of COMT polymorphisms also extends to this indicator. Carriers of the AA genotype often demonstrate a higher BMI due to a tendency to gain muscle mass. Athletes with the AG genotype may exhibit average BMI values, depending on the type of athletic training, and carriers of the GG genotype usually have a lower BMI due to a lower percentage of fat mass [5].

Based on the above, we can talk about practical recommendations for weight control in athletes. Athletes with the AA genotype may benefit from including more strength training in their program to maximize their predisposition to gain muscle mass. Carriers of the AG genotype are recommended to have a flexible approach to training, alternating strength and aerobic loads, which will help improve adaptive performance and maintain optimal weight. Athletes with the GG genotype can focus on developing aerobic endurance and metabolic adaptation, as they are less prone to gaining excess weight, but can develop high endurance and cardiovascular strength.

A comparative analysis of allele frequencies among boys and girls was not conducted, since the sample was not divided into groups by gender. However, it should be noted that genetic data may reveal sex differences in the frequency of alleles A and G, which may be due to differences in hormonal background, training process and physiological characteristics between boys and girls [17]. It is expected that the frequency of allele A may be higher among girls, which is associated with lower activity of the COMT enzyme and higher levels of dopamine, while in boys the frequency of allele G may be higher, which is associated with greater stress resistance and faster metabolism of dopamine.

An assessment of the predisposition to autonomic disorders in the distribution of genotypes among athletes (AA – 40.0%, AG – 43.0%, GG – 17.0%) indicates a significant diversity in COMT activity, which determines individual characteristics of the physiological response to physical activity and stress. The AA genotype (homozygous for Met) is associated with high sensitivity to stressful situations due to high dopamine levels, which can cause difficulties in stress management and lead to an increased risk of developing autonomic dysfunctions [6]. On the other hand, the GG genotype (homozygous for Val) can demonstrate a more stable response to stress, but this type of athletes may experience difficulties with motivation and emotional responsiveness due to low dopamine levels [3]. Athletes with the AG genotype may have a more balanced state, since the dopamine level in their body will be higher compared to AA carriers. This may contribute to better adaptation to physical activity and a lower predisposition to the development of autonomic disorders [13]. GG carriers, having the lowest COMT activity, may demonstrate better results in recovery from stressful loads, which also reduces the risk of autonomic dysfunction [18].

The level of stress experienced by athletes also depends on their genetic predisposition. Carriers of the AA genotype may be more sensitive to stressful situations, which may lead to a higher incidence of autonomic disorders [21]. It is important to consider that stress loads may be particularly high in competitive conditions, and genetic predisposition may play a key role in the body's response. Increased dopamine levels in athletes with the AA genotype may lead to increased emotional reactivity and sensitivity to stress. They may have difficulty managing stress and be more susceptible to developing anxiety or burnout, especially under high competitive pressure. Additional stress management methods are needed, including cognitive behavioral therapy and relaxation techniques [9].

AG carriers have a more balanced stress response, as the level of COMT activity allows maintaining an optimal level of dopamine. They can successfully adapt to various stressors and have better recovery abilities after intense physical and emotional stress. However, regular monitoring of the psychoemotional state and the inclusion of recovery procedures are important aspects of training [8]. Athletes with the GG genotype have high stress resistance due to low dopamine levels in the prefrontal cortex. This reduces emotional reactivity and promotes better adaptation to competitive stress. However, low dopamine levels can lead to decreased motivation, which requires additional stimuli to maintain interest and concentration during training [19].

High levels of dopamine in the prefrontal cortex can improve cognitive functions such as attention and working memory. However, excessive accumulation of dopamine can lead to excessive concentration, which sometimes interferes with switching attention. Athletes with the AA polymorphism of the COMT Val158Met gene may benefit from training aimed at developing flexibility of thinking and cognitive skills, which will allow them to better adapt to changing competitive conditions [15]. AG carriers exhibit a balance between improved cognitive functions and the ability to switch attention. This creates optimal conditions for performing complex cognitive tasks in sports, such as planning tactical actions in football or assessing distance in track and field. The heterozygous genotype promotes better cognitive plasticity, which is an advantage in sports that require rapid adaptation [7]. Athletes with the GG genotype, despite lower dopamine levels, can demonstrate stable but less flexible attention and cognitive functions. This may be useful in situations that require sustained concentration on one task, but may reduce efficiency in situations that require rapid switching and

decision making. For such athletes, the use of cognitive training aimed at improving flexibility of thinking and multitasking is recommended [12].

As a comparison of the conducted studies and existing works on the manifestation of AA, AG and GG genotypes in extreme conditions, we would like to consider the manifestation of COMT Val158Met genotypes in extreme conditions that are artificially created to study the adaptation mechanisms of athletes. Experimental conditions include modeling high physical and psycho-emotional loads, such as performing exercises to failure, simulating competitive stress or hypoxic training. An important aspect of the discussion is the assessment of the risk of vegetative dysfunctions depending on genetic characteristics.

In conditions of exercise to complete muscle failure, athletes with the AA genotype (Met/Met) exhibit a higher sensitivity to pain and emotional stress. Increased dopamine levels and low COMT enzyme activity can lead to rapid activation of the sympathetic nervous system, which is expressed in increased heart rate, increased blood pressure, and accelerated breathing. Signs of increased sweating and heart rhythm instability are often observed, indicating the risk of developing autonomic dysfunctions such as tachycardia and autonomic crises [14]. With a decrease in oxygen levels in the air, athletes with the AA genotype may exhibit more pronounced symptoms of hypoxia, such as dizziness, weakness, and difficulty breathing. Low COMT activity leads to the accumulation of dopamine, which, under hypoxic conditions, can disrupt the normal regulation of breathing and cardiac activity. This is associated with a higher sensitivity to physiological stress and the likelihood of developing hyperventilation or arrhythmia [6]. Under competitive stress, athletes with the AA genotype may experience increased anxiety, difficulty concentrating, and signs of excessive sympathetic nervous system activation. This is expressed in increased sweating, trembling, and a feeling of shortness of breath. In such situations, athletes may be prone to panic attacks or autonomic crises, especially with insufficient psychological preparation [3].

Athletes with the AG (Val/Met) genotype demonstrate intermediate responses to high-intensity exercise. Moderate COMT activity promotes more balanced dopamine levels, which allows for effective regulation of the autonomic nervous system. This is manifested in a moderate increase in heart rate and blood pressure, as well as a greater ability to recover after exercise. Autonomic dysfunctions are less common under such conditions, but chronic overloads may result in regulation disorders, such as increased fatigue or autonomic instability [9].
Under conditions of reduced oxygen levels, athletes with the AG genotype exhibit less pronounced hypoxic symptoms compared to AA carriers. Their ability to adapt to hypoxia is explained by moderate COMT activity, which ensures a balance between dopaminergic activity and sympathetic regulation. However, prolonged exposure to hypoxic conditions may result in episodes of dizziness and weakness [8]. Under competitive stress, athletes with the AG genotype demonstrate more stable performance compared to AA carriers, but may show signs of increased tension in situations of high responsibility or uncertainty. Such athletes are characterized by good adaptation to competitive stress, provided that psychoregulatory methods such as breathing exercises and visualization are used [19].

Carriers of the GG genotype (Val/Val) exhibit high resistance to physical exertion, which is associated with rapid dopamine metabolism due to high activity of the COMT enzyme. This helps to reduce emotional and pain sensitivity, which allows such athletes to withstand high loads without significant autonomic disorders. However, with extremely high loads, signs of fatigue are possible, such as a general decrease in tone and slow recovery [15]. Under hypoxic conditions, athletes with the GG genotype demonstrate the greatest resistance to oxygen deficiency, which is associated with lower dopamine levels and lower emotional reactivity. Their autonomic nervous system quickly adapts to changing conditions, which minimizes the risk of developing hypoxic symptoms such as dizziness or nausea. However, under conditions of prolonged hypoxia, a decrease in cognitive functions such as attention and memory may be observed [7]. In competitive conditions, GG carriers exhibit the lowest emotional reactivity, which reduces the risk of autonomic dysfunctions such as tachycardia or hyperventilation. However, low dopamine levels can lead to insufficient motivation and decreased fighting spirit, which requires additional stimuli to maintain psychological readiness for competition [12].

Conclusion

Thus, the analysis of the influence of COMT Val158Met polymorphisms on body parameters confirms the need to take into account the genetic profile when developing training and dietary programs

for athletes. The introduction of such approaches into sports practice will improve the effectiveness of sports training and reduce the risk of overtraining.

Vegetative dysfunctions can manifest themselves in the form of increased fatigue, sleep disorders, decreased performance, as well as unstable blood pressure and heart rate. Prevention of these disorders in athletes with different COMT genotypes requires a comprehensive approach that includes not only adequate physical activity, but also measures aimed at supporting the nervous system and controlling stress levels.

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