New Day in Medicine
Новый День в Медицине
NDM

TIBBIYOTDA YANGI KUN

Ilmiy referativ, marifiy-ma'naviy jurnal

AVICENNA-MED.UZ

ISSN 2181-712X.
EiSSN 2181-2187

2 (76) 2025

ТИББИЁТДА ЯНГИ КУН
НОВЫЙ ДЕНЬ В МЕДИЦИНЕ
NEW DAY IN MEDICINE

Илмий-рефератив, маънавий-маърифий журнал
Научно-реферативный,
духовно-просветительский журнал

УЧРЕДИТЕЛИ:

БУХАРСКИЙ ГОСУДАРСТВЕННЫЙ МЕДИЦИНСКИЙ ИНСТИТУТ
ООО «ТИББИЁТДА ЯНГИ КУН»

Национальный медицинский исследовательский центр хирургии имени А.В. Вишневского является генеральным научно-практическим консультантом редакции

Журнал был включен в список журнальных изданий, рецензируемых Высшей Аттестационной Комиссией Республики Узбекистан (Протокол № 201/03 от 30.12.2013 г.)

2 (76)

2025

февраль

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Received: 20.01.2025, Accepted: 03.02.2025, Published: 10.02.2025

UDC 796.058.2

INDIVIDUALIZATION OF THE TRAINING PROCESS OF ATHLETES TAKING INTO ACCOUNT GENETIC AND PSYCHOPHYSIOLOGICAL FACTORS

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✓ ***Resume***

The aim of the study: to identify the influence of genetic and psychophysiological factors on athletes' endurance. Materials and methods: The study was conducted on 144 male athletes aged 17-20 years (average age 18.5±1.5 years), including 69 football players and 75 track and field athletes. Athletes were classified By types of higher nervous activity (sanguine, choleric, phlegmatic, melancholic), which made it possible to take into account the individual psychophysiological characteristics of the participants. To analyze the reliability of differences between the groups, the t-test for independent samples (Welch's t- test) was used. Research results: Genotype AA (40%): is associated with high anxiety (median 53) and stress (median 26). Carriers have increased emotional reactivity and the frequency of vegetative disorders (47.5%). Genotype AG (43%): provides a balanced psychoemotional state with moderate levels of anxiety (median 43) and stress (median 21). The frequency of vegetative disorders is 25.6%. Genotype GG (17%): demonstrates low levels of anxiety (median 33) and stress (median 15), which ensures high stress resistance and a minimal frequency of vegetative disorders (11.8%). That is why the solution to the issues of optimization of the training process and recovery of athletes, taking into account genetic factors and the type of higher nervous activity, requires an individual approach. It is necessary to develop and implement new personalized programs that include modern methods of psycho-emotional correction, recovery monitoring, and balanced physical activity. Such programs should be carried out on a regular basis, taking into account the specifics of the sport, the level of physical training and individual adaptive capabilities of each athlete.

Key words: higher nervous activity, COMT Val158Met genotype , football players, track and field athletes, adaptation, Cooper test, sports physiology.

ИНДИВИДУАЛИЗАЦИЯ ТРЕНИРОВОЧНОГО ПРОЦЕССА СПОРТСМЕНОВ С УЧЕТОМ ГЕНЕТИЧЕСКИХ И ПСИХОФИЗИОЛОГИЧЕСКИХ ФАКТОРОВ

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✓ ***Резюме***

Цель исследования: выявить влияние генетических и психофизиологических факторов на выносливость спортсменов. Материалы и методы: Исследование проведено на 144 спортсменах мужского пола в возрасте 17-20 лет (средний возраст 18.5±1.5 года), среди которых 69 футболистов и 75 легкоатлетов. Спортсмены были классифицированы по типам высшей нервной деятельности (сангвиники, холерики, флегматики, меланхолики), что позволило учитывать индивидуальные психофизиологические особенности участников. Для анализа достоверности различий между группами применялся t-тест для независимых выборок (Welch's t-test). Результаты исследования: Генотип AA (40%):

ассоциируется с высокой тревожностью (медиана 53) и стрессом (медиана 26). У носителей наблюдается повышенная эмоциональная реактивность и частота вегетативных нарушений (47.5%). Генотип AG (43%): обеспечивает сбалансированное психоэмоциональное состояние с умеренными уровнями тревожности (медиана 43) и стресса (медиана 21). Частота вегетативных расстройств - 25.6%. Генотип GG (17%): демонстрирует низкие уровни тревожности (медиана 33) и стресса (медиана 15), что обеспечивает высокую стрессоустойчивость и минимальную частоту вегетативных нарушений (11.8%). Именно поэтому решение вопросов оптимизации тренировочного процесса и восстановления спортсменов с учетом генетических факторов и типа высшей нервной деятельности требует индивидуального подхода. Необходима разработка и внедрение новых персонализированных программ, включающих современные методы психоэмоциональной коррекции, мониторинга восстановления, а также сбалансированных физических нагрузок. Такие программы должны проводиться на регулярной основе, с учетом специфики вида спорта, уровня физической подготовки и индивидуальных адаптационных возможностей каждого спортсмена.

Ключевые слова: высшая нервная деятельность, генотип COMT Val158Met, футболисты, легкоатлеты, адаптация, тест Купера, спортивная физиология.

GENETIK VA PSYCHOPHISIOLOGIST OMILLARNI INOBATGA OLGAN HOLDA SPORTCHILARNING MASHGULOT ZHARAYONINI INDIVIDUALLASHTIRISH

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✓ ***Resume***

Tadqiqot maqsadi: sportchilarning chidamliliga geneticist va psychophysiology omillarning ta'sirini aniklash. Materiallar va usullar: Tadqiqot 17-20 yoshli (ўrtacha yosh 18.5±1.5) 144 nafar erkak sportchida ўkazildi, ularning 69 nafari soccer va 75 nafari engil athleticachi edi. Sportchilar oliy asab faoliyati turlari (sanguiniklar, cholericlar, phlegmaticlar, melancholiclar) byyicha tasniflandi, bu ishtirokchilarning individual psychophysiologist hususiyatlarini hisobga olish imkonini berdi. Guruҳlar ўrtasidagi farklar ishonchliligini taҳlil qilish uchun mustakil tanlovlar uchun t -test (Welch's t-test) қўllanildi. Tadqiqot natizhalari: AA genotype (40%): yukori havotirlik (median 53) va stress (median 26) bilan boglik. Tashuvchilarda yukori ҳissiy ta'sirchanlik va vegetative buzilishlar frequency (47.5%) kuzatiladi. AG genotype (43%): ўrtacha darazadagi havotirlik (median 43) va stress (median 21) bilan muvozanatli psychoemotional holatni taminlaydi. Vegetative frequency - 25.6%. GG genotype (17%): havotirlik (median 33) va stressning (median 15) pasta darajalarini kursatadi, bu yukori stressga chidamlilikni va vegetative buzilislarning minimum frequency blue (11.8%) taminlaydi. Shu sababli, geneticist omillar va oliy asab faoliyati turini hisobga olgan holda sportchilarning mashgulot zharayonini optimalallashtirish va tiklanishini taminlash masalalarini ҳal kilish individual yondashuvni talab etadi. Psychoemotional correction zamonaviy usullarini, tiklanish monitoringini, shuningdek, muvozanatlashtirilgan zhismoniy yuklamalarni uz ichiga olgan yangi individuallashtirilgan dasturlarni ishlab chikish va zhoriy etish zarur. Bundai dasturlar sport touring ўziga hos hususiyatlari, zhismoniy tayyorgarlik darazhasi va har bir sportchining individual adaptation imkoniyatlarini ҳisobga olgan holda muntazam ravishda ўtkasilishi lozim.

Kalit suzlar: oliy asab faoliyati, COMT Val158Met genotype, footballchilar, engil athleticikachilar, adaptation , Cooper testi, sports physiology

Relevance

When analyzing the literature devoted to the study of the influence of genetic factors and types of higher nervous activity (HNA) on the adaptive capabilities and psycho-emotional state of athletes, it was found that the main reasons for the decrease in physical performance and resistance to stress are the lack of a personalized approach in training and recovery programs, insufficient consideration of genetic characteristics, such as the COMT Val158Met genotype, as well as the influence of emotional reactivity associated with the type of HNA.

The key factors preventing optimal adaptation of athletes are the lack of systemic monitoring of the psycho-emotional state, the low level of use of objective methods for assessing heart rate variability (HRV) and insufficient attention to the correction of stress resistance, especially in choleric and melancholic people. Irrational organization of training loads, ignoring the predisposition of athletes to emotional exhaustion and burnout, as well as insufficient use of psychological support methods significantly reduce the effectiveness of sports training. These factors emphasize the need to develop new approaches to organizing the training process, including taking into account genetic and psychophysiological characteristics, the use of modern diagnostic and monitoring methods, and the introduction of comprehensive psychological support programs for athletes prone to increased anxiety and stress.

Based on the literature sources of the analyzed reviews, it can be concluded that the COMT Val158Met genotypes have a significant impact on the adaptive abilities and psycho-emotional state of athletes. The GG genotype demonstrates high stress resistance and better recovery rates, while the AA genotype is associated with increased anxiety and low stress resistance. The AG genotype provides a balanced state that promotes universal adaptation to stress. Among athletes with different types of higher nervous activity, the greatest resistance to stress is observed in sanguine people, while melancholic people demonstrate increased emotional reactivity and low stress resistance.

The aim of the study: to identify the influence of genetic and psychophysiological factors on athletes' endurance.

Materials and methods

The study was conducted on 144 male athletes aged 17-20 years (average age 18.5±1.5 years), including 69 football players and 75 track and field athletes. Athletes were classified By types of higher nervous activity (sanguine, choleric, phlegmatic, melancholic), which made it possible to take into account the individual psychophysiological characteristics of the participants. To analyze the reliability of differences between the groups, the t-test for independent samples (Welch's t- test) was used.

Results and discussion

According to our analysis, sanguine people more often have the AG genotype (45.2%), which ensures resistance to stress, while melancholic people have a predominant AA genotype (45.5%), which explains their predisposition to high levels of anxiety and stress. In terms of frequency, the AG genotype is the most common among athletes (43%), followed by AA (40%), and the GG genotype has the lowest frequency (17%) (Fig. 1). These data emphasize the need for an individualized approach to the development of training and recovery programs based on the genetic and psychophysiological characteristics of athletes.

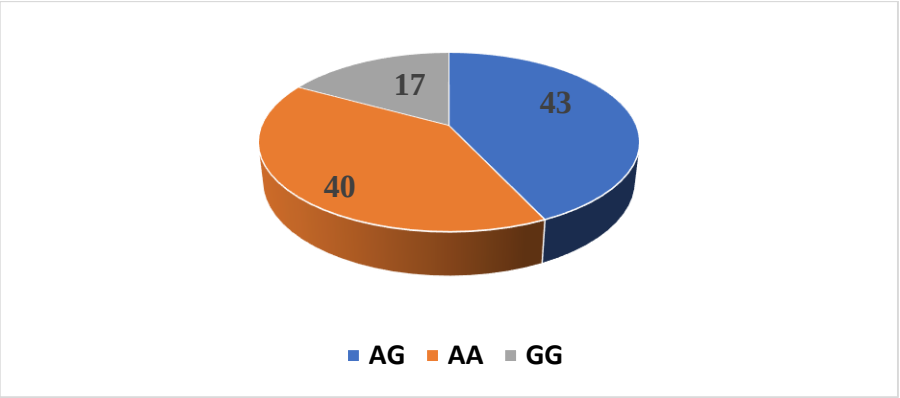

Figure 1. Prevalence of genotypes among athletes

According to the review, one of the urgent and unresolved problems remains the study of the influence of genetic factors and types of higher nervous activity on the adaptive capabilities and recovery of athletes. Organizational problems include insufficient integration of genetic research into the practice of sports medicine and the lack of specialists with knowledge of the role of COMT Val158Met genotypes and their impact on stress resistance, psychoemotional state and physical performance. At the same time, individualized programs that take into account genetic characteristics and the type of higher nervous activity are of great importance for increasing the effectiveness of the training process and recovery of athletes. Such programs allow you to optimize physical activity, increase stress resistance and endurance, minimize the risk of emotional burnout and overfatigue. With their help, it is possible not only to improve athletic performance, but also to prevent complications associated with intense physical activity and emotional exhaustion.

The second stage involved analyzing the results of the Cooper test, which measures the maximum distance an athlete can cover in 12 minutes, reflecting the level of aerobic endurance. This indicator allows us to assess the body's ability to maintain active skeletal muscle function through efficient oxygen consumption. VO2max (maximum oxygen consumption) determines the maximum amount of oxygen that the body can use per unit of time during intense exercise. This indicator serves as a key criterion for assessing cardiorespiratory endurance and the adaptive capabilities of the cardiovascular system.

Similar results are confirmed by a number of foreign studies: Yadav et al. (2018): it is noted that sanguine people demonstrate the best aerobic and anaerobic performance, due to their emotional stability and rapid recovery. Amirkalali et al . (2017): choleric people are characterized by high energy, but require additional recovery measures due to their emotional lability. Alexeeva et al. (2019): melancholics demonstrate increased anxiety and low stress tolerance, which significantly reduces their physical performance and cardiorespiratory adaptation. Smith et al. (2020): point out the importance of taking into account the type of HNA when developing personalized training programs, which can reduce the risk of burnout and improve recovery.

Thus, the assessment of recovery capabilities using RESTQ- Sport and HRR demonstrated that differences in burnout levels emphasize the need for individualization of training programs. Sanguine and phlegmatic people require minimal adjustments in recovery measures, while melancholic and choleric people need special methods of psychological support aimed at reducing anxiety and improving emotional state. The statistical significance of the differences ($p<0.05$) confirms the need to take into account the type of higher nervous activity when developing strategies to improve athletic performance.

Our data confirm that athletes with the AA genotype need stress management methods and additional psychological support to enhance their adaptive capabilities. Athletes with the AG genotype (43%) demonstrated a balanced psychoemotional state and good adaptation to physical activity. The frequency of vegetative disorders in this group was 25.6%. Similar results were obtained in the study by Alexeeva et al. (2019), where the Met allele was associated with emotional lability and susceptibility to anxiety. The Smith study et al. (2020) emphasizes that AG genotypes provide an optimal combination of stress resistance and adaptive capabilities, which is consistent with our observations, where athletes with the AG genotype demonstrate stability and minimal need for additional support. The GG genotype (17%) is characterized by high stress resistance due to low dopamine levels, but reduced motivation. The frequency of autonomic disorders is minimal 11.8%. Results of the Yadav study et al. (2018) also

indicate a link between the GG genotype and low motivation, despite high stress resistance. Our data highlight the need to work on motivation in athletes with the GG genotype. Differences by sport showed, football players: allele frequency Val reaches 43.5%, which is associated with the need for high concentration and cognitive flexibility. Track and field athletes: allele frequency Met is 64.0%, reflecting the need for rapid adaptation to intense loads. Comparative analysis with international data, such as the Bahareh study et al . (2015) confirms that the Met allele is more common in athletes requiring high adaptive abilities.

Sport and genotypes: football players more likely to have allele Val (43.5%), which is associated with the need for concentration and cognitive flexibility. Track and field athletes demonstrate a predominance of the allele Met (64.0%), associated with rapid adaptation to intense loads. Practical significance: for GG carriers: intense loads with short recovery time, emphasis on cognitive training. For AG carriers: balanced loads and regular monitoring of psychoemotional state. For AA carriers: reduced load intensity, use of relaxation techniques and psychological support.

Thus, the distribution of COMT Val158Met genotypes significantly affects the adaptation, stress resistance and physical performance of athletes. Individualized approaches to training based on genetic characteristics allow to optimize the load, increase the efficiency of recovery and reduce the risk of burnout.

Main results: distribution of genotypes and their characteristics: Genotype AA (40%): is associated with high anxiety (median 53) and stress (median 26). Carriers have increased emotional reactivity and frequency of autonomic disorders (47.5%). Genotype AG (43%): provides a balanced psychoemotional state with moderate levels of anxiety (median 43) and stress (median 21). Frequency of autonomic disorders is 25.6%. Genotype GG (17%): demonstrates low levels of anxiety (median 33) and stress (median 15), which provides high stress resistance and minimal frequency of autonomic disorders (11.8%).

Relationship between genotypes and higher nervous activity types: The AG genotype predominates in sanguine individuals (45.2%, p=0.04), which corresponds to their low levels of anxiety (42.7±3.2) and stress (20.5±2.3). Choleric individuals are evenly represented by the AA (36.7%) and AG (43.3%) genotypes with moderate levels of anxiety (48.1±4.5) and stress (22.4±3.0). Phlegmatic individuals are distributed between AG (41.2%) and GG (29.4%) with moderately low levels of anxiety (52.4±4.1) and stress (24.7±3.2). Melancholics have a predominant AA genotype (45.5%, p=0.01), which explains their high anxiety (53.2±3.5) and perceived stress (26.4±2.7).

Physical performance and recovery: PWC170: Highest values in GG (9.4±0.8 W/kg), surpassing AA (8.1±1.2 W/kg) and AG (9.2±1.0 W/kg). VO2max: High values in GG (52.0±3.6 ml/kg/min) compared to AG (50.3±4.2 ml/kg/min) and AA (45.6±3.8 ml/kg/min). HRR: Fastest recovery in GG (HRR1=45±3.8 bpm, HRR2=55±4.0 bpm), reflecting high parasympathetic activity.

Differences by sport: Football players are more likely to have the Val allele (43.5%), which is associated with cognitive flexibility and concentration. Track and field athletes are more likely to have the Met allele (64.0%), which ensures adaptation to intense loads.

The conducted analysis of the influence of COMT Val158Met genotypes on the psychoemotional state, stress resistance, physical performance and recovery abilities of athletes with different types of higher nervous activity (HNA) made it possible to determine the physiological mechanisms underlying the identified differences and to develop personalized recommendations for optimizing the training process.

All study participants received a basic training and recovery program (exercise therapy, massage, physiotherapy, recovery exercises). For athletes in the main group, the program was supplemented with balance training, cognitive training, and stress management methods, which is especially important for choleric and melancholic people. Athletes with the GG genotype received intense physical activity with minimal recovery time, and for carriers of the AA genotype, relaxation techniques and psychological support were introduced.

Knowledge of the influence of COMT Val158Met genotypes and HNA types on the adaptive capacity of athletes allowed us to develop a personalized training and recovery program, including stress management methods, cognitive training, and recovery activities. To assess the effectiveness of the proposed program, an analysis of physical performance, recovery capabilities, and psychoemotional state was performed in two study groups: the control group (CG) (n=65; 45.8%) included athletes who underwent a standard training process; the study group (SG) (n=77; 54.2%) underwent a similar

program, but taking into account individual recommendations based on HNA types and COMT genotypes.

The results showed that the study group showed improvements in aerobic endurance (Cooper test: from 2700.1±150.6 m to 2850.4±160.3 m, $p<0.05$) and VO2max (from 46.3±2.8 ml/kg/min to 49.8±3.2 ml/kg/min, $p<0.05$). Participants with the GG genotype demonstrated the greatest increase in physical performance and recovery rate (HRR1: from 45.2±3.1 bpm to 48.5±3.4 bpm, $p< 0.05$). In the control group, the changes were less pronounced (Cooper test: from 2650.4±140.8 m to 2675.3±145.7 m, $p>0.05$; VO2max: from 45.1±3.0 ml/kg/min to 45.9±3.1 ml/kg/min, $p>0.05$).

The effectiveness of the program is explained by its focus on the individual characteristics of athletes, which allows not only to correct disorders that arise as a result of physical activity, but also to prevent fatigue, improve emotional state and increase the body's adaptive capacity. The proposed program helps to increase the level of physical performance, recovery capabilities and reduce the risk of emotional burnout in athletes.

These activities include the development of individualized training programs based on genetic and psychophysiological characteristics, optimization of rehabilitation measures, regular monitoring of the athletes' condition, as well as training of the coaching staff in methods of a personalized approach. The use of these measures will help increase the physical and psychoemotional stability of athletes, reduce the risk of emotional burnout, improve athletic performance and strengthen their overall health.

Conclusions

1. Personalization of training programs based on genetic analysis of the COMT gene . Athletes with the GG genotype are recommended intensive training with short recovery periods, including cognitive exercises to increase motivation; with the AG genotype - a balance between load and recovery, as well as regular monitoring of the psycho-emotional state; with the AA genotype - moderate loads, relaxation techniques and cognitive-behavioral therapy to reduce anxiety.
2. Optimization of recovery measures based on heart rate variability data and stress tolerance testing data. Continuous recovery monitoring with additional recovery measures for choleric and melancholic people with an emphasis on stress management.
3. Early identification of risk factors through the introduction of genetic testing to assess predisposition to stress and professional burnout with the development of diagnostic protocols for assessing autonomic dysfunctions (for track and field athletes, development of adaptation programs to intense loads; for football players, emphasis on developing concentration and cognitive flexibility).

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Entered 20.01.2025