

Genetic Characteristics Of Athletes' Physical Training

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Abstract: A fundamentally new system of medical and genetic support for physical culture and sports will raise it to a higher level. It cannot be denied that athletic ability is genetically determined. Molecular genetic analysis shows that individual differences in the level of development of physical qualities in athletes are mainly associated with DNA polymorphism. The process of training athletes in weightlifting will be more effective in the process of training athletes, weightlifters, taking into account adaptation, individual genotypic capabilities, as well as the relationship between load values and the growth of athletes' functional capabilities.

Keywords: Strength, speed, endurance, genetic control, polymorphism, allele, angiotensin-converting enzyme gene.

INTRODUCTION:

Modern molecular genetic analyses demonstrate that individual differences in the development of physical qualities in athletes are primarily linked to DNA polymorphisms. By 2009, over 200 genes had been identified as associated with physical performance [1]. Most sports genetics research focuses on detecting genotypic differences between athletes and control groups. However, genetic variations should also exist among athletes of different skill levels, as the presence of sport-favorable alleles in an athlete's genotype correlates with higher performance outcomes. Furthermore, athletic talent for a specific sport depends not only on the presence of certain polymorphic gene variants but also on their expression levels.

LITERATURE REVIEW

Analysis of training practices in sports, including weightlifting, reveals that the effectiveness of athlete preparation within the long-term process of enhancing sports mastery remains insufficient. The efficiency of athlete training is estimated to be only 40–60%. This inefficiency can lead to wasted training time, excessive effort by coaches and athletes, and reduced training effectiveness [2].

N.V. Polikarpova emphasizes that adaptive responses to training and competitive loads are inadequately considered. Sports science data indicate that the primary limiting factor in athletic achievement and the rate of skill improvement is the genetic

characteristics of an athlete's body [3].

Developing the genetic basis of athletes' physical preparation, particularly identifying genetic markers that support and advance new approaches and technologies in weightlifting, is increasingly critical. The importance of identifying informative and modern methods for detecting these markers is becoming more evident, and the priority of research in this direction underscores its significance.

Studies by V.B. Shvarts on morphofunctional characteristics reveal that genetic influences are most pronounced in morphological traits, less so in physiological parameters, and even less in psychological aspects [3].

METHODOLOGY

Genetic factors, particularly those related to the physical preparation of weightlifting athletes, are often overlooked during training when assigning workloads. Consequently, these genetic factors limit the maximum potential for improving sports mastery.

The need to account for the genetic characteristics of athletes' training potential in weightlifting is driven by two key reasons:

- Hereditary influences on the development of physical qualities such as strength, endurance, speed, flexibility, and agility are most evident during youth, when individuals strive for peak athletic achievements.

- Genetic control manifests in routine daily activities and everyday life, but it is particularly significant in limiting sports achievements under the physical and psychological stress athletes endure.

Current sports genetics data [2] highlight individual differences across various sports. The genetic characteristics of athletes' physical preparation require stringent oversight.

Understanding hereditary genetic traits and markers critical for sports specialization is a prerequisite for athletic success. Due to the underdeveloped state of sports genetics, this research direction is highly relevant. The practice of athlete preparation, including in weightlifting, indicates that issues related to selecting and guiding children toward sports remain inadequately addressed.

Thus, improving athlete preparation in sports should focus on:

- Athletes' individual characteristics;
- Energy reserves;
- Enhancing sports selection efficiency through the evaluation of genetic predispositions.

RESULTS

Hereditary influences vary across body composition components: they are most pronounced in bone tissue, less in muscle tissue, and significantly less in fat tissue. Notable differences in genetic control are observed in biochemical and functional indicators [2; 6]. The greatest hereditary influence is seen in most metabolic processes. Recent studies have identified genes predisposing individuals to muscle activity [3].

Examinations of young athletes, elite athletes, and sports veterans have identified genes involved in developing protein structures and motor functions. Athletes carrying these genes exhibit a predisposition to sustaining specific workloads over extended periods [4].

One such gene is the insertion/deletion (I/D) polymorphism of the angiotensin-converting enzyme (ACE) gene. The ACE gene polymorphism is categorized into three genotypes: I/I, I/D, and D/D. The ACE enzyme, a zinc-containing protease, catalyzes the conversion of angiotensin-I to angiotensin-II [4]. The localization variants of ACE include:

- Local peptide formation (AT-II and bradykinin) in the endothelium of lung, brain, and peripheral blood vessel walls, aiding in maintaining vascular tone;
- In heart tissue, ACE regulates myocardial contractile function as part of the local renin-

angiotensin system, influencing cardiomyocyte growth and cardiac hypertrophy;

- In blood serum, where ACE activity is relatively low, it forms in tissues (primarily lungs) and contributes to systemic AT-II production. ACE is also present in mononuclear cells, T-lymphocytes, and fibroblasts;

- In epithelial cells of the kidneys, placenta, and intestines, involved in adsorption and transport processes;

- In brain tissues, including the endothelium of cerebral blood vessels, nerve cell bodies, and axons;

- In seminal fluid and reproductive organs, where ACE exhibits the highest activity.

Additionally, ACE inactivates bradykinin into inactive metabolites.

The AT-II level is regulated by ACE, with its signals mediated through type 1 and type 2 receptors [4]. Type 1 receptors (angiotensin II receptors, type 1; AGTR1), found in the heart, lungs, kidneys, pituitary, adrenal glands, and arteries, exert physiological effects such as vasoconstriction, stimulation of aldosterone synthesis and secretion, reabsorption, cardiomyocyte hypertrophy, proliferation of vascular smooth muscle cells, increased peripheral noradrenaline activity, enhanced central sympathetic nervous system activity, vasopressin release stimulation, reduced renal blood flow, and slowed renin secretion [5].

Type 2 receptors (angiotensin II receptors, type 2; AGTR2), primarily located in fetal kidneys and intestines, suppress cell growth, mediate apoptosis, and contribute to fetal tissue development and nerve tissue regeneration [5].

In the heart, angiotensin II (AngII) is a potent cell growth factor. Although left ventricular mass increase in individuals with different ACE genotypes has not been studied, AngII secretion rises in response to exercise-induced mechanical overload. Left ventricular hypertrophy is a hallmark of elite athletes. ACE regulates the degradation of the vasodilator kinin bradykinin, inflammatory responses, aldosterone synthesis, erythropoiesis, and tissue oxygenation.

The structural polymorphism of the ACE gene has well-defined functional significance. Located on chromosome 17 at the q23.3 locus, the ACE gene contains 26 exons. A specific DNA sequence deletion can occur in the 16th intron, known as insertion-deletion (I/D) polymorphism.

The I allele is associated with lower ACE gene activity and sports endurance, while the D allele correlates

with higher ACE activity and enhanced speed, strength, and coordination in athletes.

The ACE I allele is linked to a predisposition for sports requiring endurance and resistance to hypoxia in high-altitude conditions. The ACE I allele (or ACE I/I genotype) is more prevalent in British long-distance runners (5000 m and beyond) compared to control groups or sprinters [7], as well as in elite mountaineers. It has also been observed in Russian athletes with mixed energy muscle activity (wrestlers, gamers, middle-distance specialists) [8; 9], Australian, Croatian [10], and Russian academic rowers [5], as well as Turkish middle-distance runners and football players [6].

Studies have shown that the ACE I/I genotype is associated with high mechanical efficiency of skeletal muscles, superior aerobic performance, faster heart rate recovery post-exercise, greater endurance improvements in young skiers, higher arterial blood oxygen saturation at altitude, enhanced peripheral tissue oxygenation during physical exertion, and resistance to muscle fatigue. The ACE I allele plays a significant role in endurance development [1; 2; 4; 5; 6].

The ACE D allele is critical in regulating the renin-angiotensin system's activity and is associated with high tissue enzyme activity and muscle strength [7]. This is driven by ACE-mediated activation of the growth factor angiotensin-II and enhanced degradation of bradykinin (a growth inhibitor).

The ACE D allele significantly enhances strength in extensor strength exercises or mixed (strength and endurance) training. While the D allele is linked to dynamic strength and muscle mass increase, the I allele is associated with isometric strength gains (enhancing muscle endurance).

Research on Russian young skiers showed that the ACE D allele is associated with improved speed qualities and explosive strength (e.g., 60-meter sprint, long jump). The D allele promotes fast-twitch white muscle fiber dominance, high speed and strength, and skeletal muscle hypertrophy [8].

The frequency of the ACE D allele or D/D genotype is significantly higher in athletes engaged in speed- and power-oriented sports compared to control groups [9].

Thus, the ACE D allele is linked to speed, strength, and muscle mass development. However, it is associated with increased risks of myocardial infarction, arterial hypertension, hypertrophic cardiomyopathy, obesity, kidney diseases, vascular complications, and type 2 diabetes mellitus.

An increased frequency of the ACE I allele correlates with high endurance in athletes, while a higher frequency of the D allele is observed in elite sprint weightlifters. The D allele's association with power-oriented, anaerobic sports may be mediated by differences in skeletal muscle strength enhancement, as training-related strength increases in fast-twitch muscles are linked to the D allele. Conversely, the I allele enhances endurance by improving substrate delivery, conserving energy reserves, and increasing skeletal muscle efficiency [10].

CONCLUSION AND RECOMMENDATIONS

Genetic analyses in sports indicate that approximately 60% of an athlete's success is determined by genetics, with the remaining 40% attributed to personal effort, coaching expertise, medical support, and other factors. Priority should be given to assessing a child's abilities and potential. Physical education and sports are distinct concepts with different objectives: physical education aims to strengthen physical health, while sports focus on achieving victories and results. To develop a child's innate abilities, attention must be paid to their genetic characteristics. By doing so, they can achieve optimal results in sports if they choose to pursue it.

REFERENCES

1. Bray MS, Hagberg JM, Pérusse L, et al. The human gene map for performance and health-related fitness phenotypes: the 2006–2007 update. *Med Sci Sports Exerc.* 2009 Jan; 41 (1): 35-73.
2. Сологуб Е.Б., Таймазов В.А. Спортивная генетика: учеб. пособие. – М.: Терра- Спорт, 2000. – 127 с.
3. Рогозкин В.А., Ахметов И.И., Астратенкова И.В. Перспективы использования ДНК-технологий в спорте // Теория и практика физической культуры. – 2006. – №7. – С. 45–47.
4. Ахмедов И.И. Молекулярная генетика спорта. //Москва-2009.
5. Ахметов И.И. Молекулярно-генетические маркеры физических качеств человека / И. И. Ахметов. – Москва : Медико-генетический научный центр РАМН, 2010.
6. Аксенов М. О. Генетические факторы адаптации к тренировочным нагрузкам в тяжелоатлетических видах спорта / М. О. Аксенов // Вестник Бурятского государственного университета. – 2017. – Вып. 1. – С. 126– 136.
7. Ассоциации четырех полиморфных генетических систем (ACE, EPAS1, ACTN3 и

NOS3) со спортивной успешностью в борьбе самбо. Э.А. Бондарева, В.В. Шиян, В.А. Спицын, Е.З. Година. Вестник Московского университета. Серия XXIII, Антропология № 1/2010: 36-45

8. Ахметов И. И. Молекулярно-генетические маркеры в спортивном отборе / И. И. Ахметов, В. Ильин, С. Дроздовская // Наука в олимпийском спорте. – 2013. – № 4. – С. 26–31.
9. Рогозкин В. А. Гены-маркеры предрасположенности к скоростно- силовым видам спорта / В. А. Рогозкин // Теория и практика физической культуры. – 2005. – № 1. – С. 2–4.
10. Moran CN, Vassilopoulos C, Tsiokanos A, et al. The associations of ACE polymorphisms with physical, physiological and skill parameters in adolescents, Eur J Hum Genet 2006, vol. 14 (pg. 332-339)