N E W S
OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN
SERIES OF BIOLOGICAL AND MEDICAL
ISSN 2224-5308
Volume 4, Number 328 (2018), 77 – 85

UDC 37.015.2:577.2:796/799

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STUDYING THE I/D *ACE* AND R/X *ACTN* ASSOCIATIONS OF POLYMORPHISM WITH THE LEVEL OF PHYSICAL PREPATIBILITY OF KAZAKHSTAN'S FOOTBALLERS FOR DEVELOPMENT OF GENETIC AND PHYSIOLOGICAL METHODS OF SPORTS SELECTION

Abstract. In this research work on the basis of molecular genetic analysis and the study of basic physiological parameters, a correlation analysis was made between the genotypes of I/D *ACE* and R/X *ACTN* polymorphisms and the level of physical fitness of Kazakhstan professional football players. The obtained results testify to the prospects of using these polymorphisms for the development of genetic methods of sports selection.

Keywords: sports selection, molecular genetic markers, gene polymorphisms, physiological parameters, anthropometry, volumoscopy, bioimpedanceometry (Tanita), chronometry, lactometry.

Sports activities currently impose athletes high demands. In modern sports the great importance is for technical and tactical readiness of the athlete, psychological readiness to overcome large sports strain. Scientifically grounded search and selection of talented sports youth is a trend of the time and the main task of sports selection, therefore the role of the trainer is very important, he is capable to reveal sports opportunities of each individual and correctly organize training process. Important prerequisites that must be taken into account during the coach sports selection: biological factors, especially morphology (physique), the type of nervous activity, the level of aerobic and anaerobic capabilities, the ratio of fast and slow muscle fibers. The relevance of the problem of sports selection increases with renewed vigor, as the available methods of sports selection are not effective enough and do not meet all modern requirements. An important condition for the development of modern sports is a scientifically based search for talented youth, which can handle large sports strain and high rates of sports improvement.

Thus, sports selection is a system of organizational and methodical actions including pedagogical, psychological, sociological and medico-biological methods of research on the basis of which abilities of children, teenagers and young men for specialization in a certain sport or group of different sports are revealed [1].

Throughout the world, at the initial stage, the determining markers of predisposition to sports activities were: blood groups, body type, dermatoglyphics, the composition of muscle fibers, the type of sensorimotor reactions and other phenotypic features. According to the history of sports selection, earlier success of the athlete judged on the basis of studying of morphometric and physiometric parameters of the individual [2]. Today genetics of physical activity develops rapidly, it includes sports genetics and some areas of anthropogenetics and medical genetics. Molecular genetic studies allow to achieve the highest success in sports, improve and help sports-orientation selection of young athletes, to optimize the level

and intensity of training strain develop for each athlete a special diet, because success in any sphere of human activity, including sports, depends on the genotype by 75-80%, and only 15-20% of success is due to education, training level and all other environmental factors [3].

Expression of interest and the future success of the individual in a particular sport, depends largely on the correct choice of sports specialization, in accordance with genetic factors possessed by the individual. The most important thing is that after the birth of a child, it is possible to predict and diagnose its future abilities and strong qualities, determine its future potential. For a sports-oriented selection of young athletes, despite the long experience of the trainers and teachers very often are wrong, incorrect predictions, subsequently, the athlete does not achieve considerable results in this sport, and it increases the risk of genetically - determined diseases. Thus, sports genetics is a much-needed area of research, on the basis of sports genetics will decrease the number of erroneous predictions, under the action of which many athletes are faced with a serious sports injury, which ultimately can even lead to death [4].

Hereditary information has a great impact on the morphological and functional characteristics and physical qualities of a person. The study of the degree of inheritance of various physiological parameters of the human body, shows the variability of the influence of genetics on physiology and the more pronounced hereditary effects on the signs of the body, the greater their account should be in sports selection. The greatest hereditary conditionality is revealed for morphological indicators of an organism, smaller for physiological parameters and the smallest for psychological parameters.

The most significant influence of inheritance on the following morphological features: longitudinal body size, volume size, body composition. The value of the coefficient of inheritance is the highest for bone tissue, less for muscle and the lowest for fat.

For physiological indicators revealed significant genetic conditionality, including most of the metabolic characteristics of the body, aerobic and anaerobic capabilities, the ratio of fast and slow fibers in the muscles, the volume and size of the heart, the characteristics of ECG, systolic and minute volume of blood at rest, heart rate during exercise, blood pressure, lung capacity and vital signs, the frequency and depth of breathing, minute volume of breathing, blood cholesterol, ESR and others.

The most psychological, psycho-physiological, sensor-motoric indicators placed under the expressed genetic control: rate of information processing, IQ coefficient, temperament, motor and sensor functional asymmetry and others. According to the results of scientific-research works, the fast movements that require specific rate of nervous system are affected by genetic control, high lability and nervous processes mobility, also development of organism's anaerobic abilities and the presence of fast fibers in skeleton muscles. Thus, the most trainable physical features are agility and general endurance, the less trainable – rapidity and flexibility.

The knowledge of hereditary influence level on morpho-functional traits of human and his physical features give possibility during sports selection to lean on indexes, which are under genetic control, i.e more perspective and less changeable during training [5].

On the example of a number of European and Asian countries, we can see that sports results largely depend on the achievements of sports genetics. In developed countries, where sports genetics have long been recognized, there are high sporting achievements. World leaders in this area are the United Kingdom, Australia, China, Germany. Unfortunately, sports genetics is just beginning to develop in Kazakhstan. The use of ready-made commercial panels of genetic markers is impractical without studying the genotypic characteristics of domestic athletes, since sporting opportunities are determined by the interaction of the genotype with the ethnic background, specific living conditions (geography) and lifestyle. Therefore, to begin with, it is necessary to develop a panel of genetic markers applicable to the analysis of domestic athletes by testing the association of candidate genes with existing sports achievements and then become a real scientifically-based preparation of elite athletes for international competitions.

Kazakhstan's entry into the international sports arena and tough competition in all sports require new approaches to the development of physical culture and sports of the country. As foreign practice shows, the growth of sports achievements in Kazakhstan will not be possible without careful research and use of scientific developments, primarily sports genetics.

In accordance with the above, this study examined the association of polymorphisms I/D *ACE* and R/X *ACTN* with the level of physical fitness of football players in Kazakhstan for further development of educational and methodological approaches to determining the predisposition of students and schoolchildren to various sports.

Materials and methods

The work was performed on the basis of the laboratory of Molecular genetics RSE "Institute of General Genetics and Cytology" MES RK (Almaty). To conduct the research, an agreement was reached with the "Institute of sport in KazAST" on the collection of biological samples for molecular-genetic and physiological study. Thus, an experienced group consisting of 23 high-level football players was formed. Participation in this research was voluntary, all participants were familiarized with the main objectives of the research, completed questionnaires and signed informed consent to participate in the study. For each studied the questionnaire was composed and subsequently each athlete was taken buccally scraping from the inside of the cheeks.

DNA isolation. DNA from buccal scrapings was isolated using a kit of reagents for DNA extraction from clinical material "AmpliPrep DNA-Sorb-B", according to the manufacturer's protocol. The quantity and quality of the isolated DNA were estimated by a spectrophotometer, horizontal electrophoresis in 1,4% agarose gel. DNA samples were stored at -20°C and -80°C.

PCR. To detect polymorphisms of *ACE* I/D and *ACTN* R/X, the PCR method was used. Amplification was carried out in 20 μl of the total volume of the mixture containing 50 ng of genomic DNA. 10 μl 2xPCR Master Mix (0.05 U/μl TaqDNA polymerases, reaction buffer, 4 mM $MgCl_2$,0.4 mM of each dNTP (Thermo Fisher Scientific, USA) and 5pM of each primer. The following optimal conditions were selected for PCR: initial denaturation of 3 min at 95°C followed by 35 amplification cycles at 95°C for 30 sec., 56°C for r577x *ACTN*; 60°C for 287I/D *ACE* - 30 sec., 72°C 1 min and a final cycle of 72°C 7 min. PCR products were analyzed in 8% polyacrylamide gel and 1.4% agarose gel followed by visualization in passing UV light. The variants of genotypes were determined by the size of the allele-specific fragments: 287I/D *ACE* 190 pb – 287D allele and 480 bp – 287I allele. For the study R577X *ACTN* has set the restriction and fragmentation at the sites: 86 bp, 97 bp, 108 bp, 205 bp. PCR-RFLP mixture includes the PCR-product, buffer Tango, restrictase Ddel and H_2O.

Methods of statistical processing of results. Significance level (*p*) was determined using Chi2 and student's t-test and Chi-square test for degrees of freedom = 1 using the Calculator software for statistical calculation in "case-control" studies (http://www.tapotili.ru) with the additional amendment of Yates, provided for small samples. Differences between groups were considered statistically insignificant at $p>0.05$. To calculate OR and CI 95% used online calculator Medical statistics [6] and Biometrics [7].

Results and their discussion

The results of molecular genetic analysis of polymorphisms in genes 287I/D *ACE* and R577X *ACTN* of Kazakhstan football players. Gene *ACE* (angiotensin-1 converting enzyme-ACE) mapped in locus 17q23.3. More than 100 allelic variants of this gene are known, of which the most important in relation to physical activity is I/D polymorphism. Much attention paid to the study of the influence of muscle activity on the physiological parameters of the body in connection with the various allelic variants of *ACE*. Thus, a high correlation was established between the increase in the mass of the left ventricle of the heart after endurance training with an increased level of *ACE* in the blood and the D/D genotype. The association of its strength with D allele of *ACE* gene was established in the force training of the thigh quadriceps muscle [8].

These data were later confirmed in the measurement of isometric and isokinetic strength of this muscle in carriers of the genotype D/D [9].

Genotype I/I is associated with low activity of *ACE* gene and increased athletic endurance, human predisposition to successful sports aimed at the development of endurance and resistance to hypoxia in high altitude conditions. Carriers of genotype I/I have the greatest endurance. Also genotype I/I is associated with a higher percentage of type 1 fibers (slow-cutting fibers), which are more effective at long-term physical activity than fast-cutting type 2 fibers. Carriers of genotype I/I have the greatest endurance. The probability of age-related macular degeneration (the main cause of vision loss in old age) is 4.5 times lower than in groups with the genotype D/D and I/D. This genotype in most cases prevails in the group of stayers. Genotype I/I is the most favorable for such sports as marathon running, long distance swimming, skiing, biathlon, mountaineering, football, rugby, basketball, sports, martial arts that require endurance [10, 11]. Genotype D/D, on the contrary, is associated with higher activity of *ACE* gene and

manifestation of speed, strength and coordination abilities of sportsmen. The level of angiotensin-converting enzyme in carriers of genotype D/D increased in 2 times compared with genotype I/I. People with genotype D/D have lower stamina and they are not recommended excessive exercise. Carriers of D/D genotype have a risk of developing a large number of pathologies, in particular, such as myocardial infarction, arterial hypertension, hypertrophic cardiomyopathy. The effectiveness of muscle training in carriers of genotype D/D in 2 times lower than in individuals with genotype I/I. There is also a high risk of developing nephropathy in patients with diabetes [12, 13].

People with a heterozygous variant of I/D genotype have both variants of the gene and are carriers of the complex variant of the genotype and, as a rule, have good endurance, strength and speed. However, due to the presence of D allele, individuals with heterozygous *ACE* gene are not recommended excessive prolonged physical activity [14].

The distribution of genotypes according to the studied polymorphism of *ACE* gene (I/I, I/D, D/D) among athletes is indicated in figyre 1. In the research group were detected homozygous genotype 287I/I *ACE* gene. The frequency of homozygous genotype 287D/D of gene *ACE* (speed-strength qualities, coordination capabilities) amounting to 30.4 %. The frequency of heterozygous variant 287I/D of *ACE* gene (endurance, strength, speed, the presence of type 1 muscle fibers – slowly decreasing) was 69.6 %.

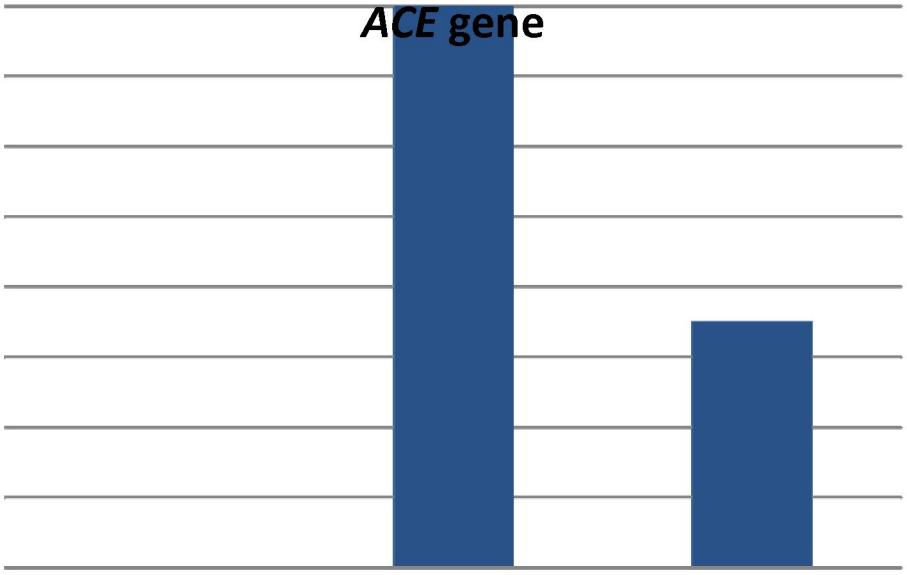

Figure 1 – Distribution of genotypes by the studied polymorphism of *ACE* gene (I/I, I/D, D/D) among the studied sportsmen

Our data confirmed the literature sources on the highest occurrence among athletes of complex heterozygous and the most favorable genotype I/D compared with homozygous variants [10, 11].

Thus, the analysis of the polymorphism association 287 I/D *ACE* in the group of young Kazakh professional athletes confirmed the trends noted by other scientific studies in the analysis of different populations.

ACTN3 gene is the first gene of the structural protein of skeletal muscles α-actinin-3, for which the connection with the manifestation of physical qualities of athletes, and genotypes *ACTN3* – one of the factors affecting the normal functioning of muscles. The product of the *ACTN3* gene is responsible for the synthesis of α-actin-3, which is the main component of the Z-lines of muscle sarcomeres, which determines the development of fast type II muscle fibers. The *ACTN3* gene is located in the long arm of 11 chromosomes (11q13-q14), consists of 20 exons and 19 introns.

Most people (6% in Africa, 19% in Europe, up to 25% in Asia) are homozygous for the X-allele polymorphism R577X of this gene [15].

As a result of replacement in 16 exons there is a stop codon, blocking the process of broadcasting iRNA, which leads to a deficiency of α-actinin-3. As a result of mutation, α-actin-3 is replaced by α-actin-

2, which leads to a decrease in the speed and power parameters of the athlete. R gene allele - presence of arginine – Arg amino acid at position 577 of *ACTN3* protein amino acid sequence. Gene X allele-designation of the terminal codon (stop codon)-Ter at the position 577 of the amino acid sequence of the protein *ACTN3*.

The R allele is more frequently diagnosed in athletes in sports that require explosive speed and power. Therefore, the carrier of R allele of *ACTN3* gene, the presence of alpha-actinin-3 protein in skeletal muscles, gives an advantage in the performance of speed-power strain, the energy supply of which is carried out by anaerobic mechanisms of ATP resynthesis. Carriers of genotype R/X is able to achieve good results at medium ranges and in sports that require a combination of speed, power and endurance. The X allele is prevalent in athletes who to achieve good results need endurance.

1. R/R (alpha-actinin-3 is present in sufficient quantities in muscle fibers);
2. R/X (alpha-actinin-3 is present in fewer muscle fibers than the RR genotype);
3. X/X (deficiency of alpha-actinin-3 in skeletal muscle).

Low frequency 577XX-genotype among athletes compared to the control indicates that in the process of sports selection has been the screening of athletes, whose muscle cells contained this myofibrillar protein.

Among skilled and highly skilled athletes discovered significant decrease in the percentage of XX-genotype in the group of speed-power kinds of sports and athletes involved in sports requiring endurance. Thus, functionally active α-actinin-3 (genotypes R/X and R/R) provides certain advantages for different types of human physical activity [16].

The distribution of genotypes according to the studied *ACTN* gene polymorphism (R/R, R/X, X/X) among Kazakhstan's athletes given in the figure 2. The frequency of homozygous genotype R/R of the *ACTN* gene was 21.7 %. The frequency of homozygous genotype X/X of *ACTN* gene was 30.4%. The frequency of occurrence of heterozygous variant R/X of *ACTN* gene (alpha-actinin – 3 is present in muscle fibers in smaller quantities, compared with the genotype R/R, rather good aerobic endurance, high speed-power abilities) was 47.9%.

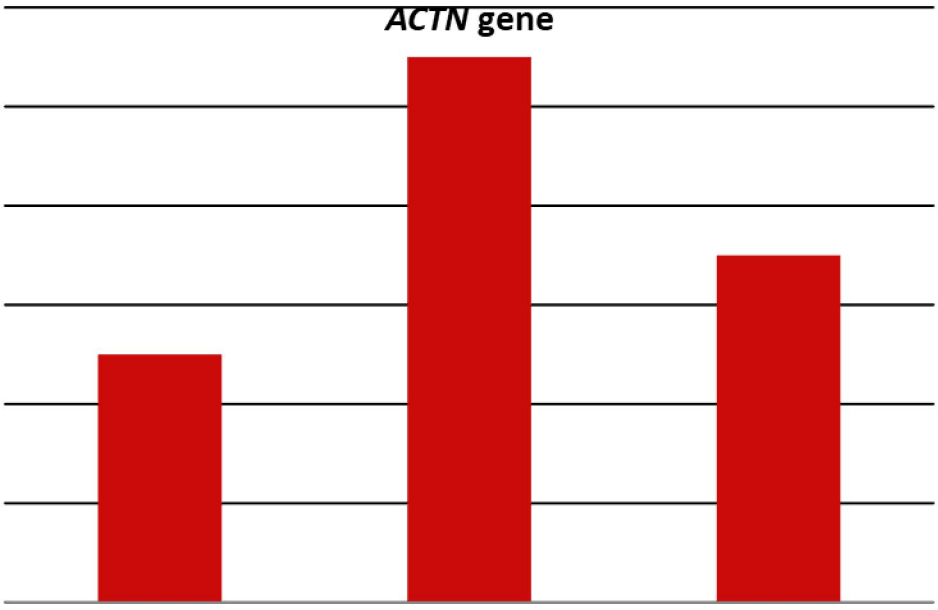

Figure 2 – Distribution of genotypes according to *ACTN3* (R/R, R/X, X/X) gene polymorphism among studied athletes

In the studied group of players, the most common are heterozygous variants of genes, which indicate the joint activity of favorable alleles. Due to the fact that the specific nature of football requires speed-strength qualities and a lot of endurance, that is the predominance of the heterozygous genotype in the studied group is expected and justified.

Association of genetic and physiological parameters of athletes. Most of the known performance parameters, both aerobic and anaerobic are important for the work of the players and achieve high results. So, on the one hand, the duration of the football match is more than 90 minutes, which indicates a high proportion of the aerobic mechanism, and on the other hand, short-term spurts are essential for the outcome of the match, in which the anaerobic source of energy is also crucial.

For the successful development of athletes training in terms of selection and projection is required 2 factors: genetic dispositions for adequate choice of sports specialization, style of competitive activity; multistage sampling at every stage of many years of training, taking into account genetically inherent in the athlete's speed of adaptation to specialized strain. High training, reducing the time of preparation of a highly qualified athlete, allows to perform biological (preservation of his health), social tasks (victory in competitions) and to achieve the high economic effect of the training process.

The examined athletes in terms of BMI body mass index were divided into two groups: control (model indicators included athletes with BMI < 20 at the age of 19-24 years, BMI=20-25 at the age of 25-34 years) and the case (players with BMI indicators that do not match the model).

Limits from 75 to 80 ml/kg were taken as a norm for such physiological parameter as a Life index (LI).

Also on the basis of the received data, the coefficient of speed endurance – CSE which indicators are shown in table 2 was calculated. The control group included athletes with CSE model indices 63% and more, other players joined the group – case. Therefore, there is a need to strengthen measures for the development of high-speed qualities of football players.

On such an important physiological parameter, such as lung capacity, the control group included athletes with LC=5100 and above, with LC to 5100 ml – group case.

On muscular weight, the athletes who were included in group – control had muscular weight 36 and above (good data), and in group a case < 36.

Regarding lactate, one of the main and indicative physiological indicators, measurements were made after 1 min., 3 and 5 minutes after exercise. The quantity of lactate after 5 minutes was taken as an indicative measurement. Above 15.3 mmol/l indicates an increased content of lactate, anaerobic endurance.

The volume and fullness of any function is determined by the possibility of energy exchange. Scientific research in the field of clinical and sports physiology has established that one of the parameters that most accurately reflects the state of energy processes in the body is the metabolite of glycolysis-lactate. When performing the limiting short-time strain the high athlete performance is characterized by a high level of concentration of lactic acid. Peak lactate values after 1, 3 and 5 minutes of recovery ranged from 15.3 to 21.3 mmol/l. These data indicate the high anaerobic performance of athletes. It should also be noted that the maximum lactate levels were recorded at different times during the recovery period. High concentration of lactic acid at rather low test indicators testifies to the lowered aerobic working capacity of athletes.

On all studied physiological parameters athletes were divided into groups control and a case (table 1). The distribution of genotypes by polymorphisms studied in the formed groups is presented in table 1.

Table 1 – Distribution of genotypes by polymorphisms 287 I/D *ACE*, R577X ACTN in groups of athletes

№	Parameters	Genotypes (number of people)	*ACE*			*ACTN*		
			I/I	I/D	D/D	R/R	R/X	X/X
1	BMI	Control (BMI < 20 at the 19-24 ages, BMI =20-25 at the 25-34 ages)	0	8	4	3	6	3
		Case	0	6	2	2	3	3
2	LI	Control – (normal limits 75 – 80 ml/kg.)	0	5	0	1	3	1
		Case	0	9	6	4	6	5
3	CSE	Control (athletes with model indexes of CSE 63% and >)	0	5	3	2	6	0
		Case	0	9	3	3	3	6
4	LC	Control (LC=5100 and >)	0	10	6	3	8	5
		Case (LC to 5100 ml)	0	5	0	2	1	2
5	Lactate	Control (<15.3 mmol/l)	0	4	1	0	3	2
		Case (>15.3 mmol/l)	0	9	3	5	4	3
6	Muscle bulk	Control (36 and >)	0	3	3	1	4	1
		Case (< 36)	0	11	3	4	5	5

Table 2 – Polymorphism associations of 287I/D *ACE*, R577X *ACTN* with physiological parameters

Parameters		*ACE* gene I/D polymorphism					
		Control	Case	χ2	*p*	OR	CI
BMI	I allele	0,333	0,375	0,073	0,787	1,20	0,32-4,50
	D allele	0,667	0,625			0,83	0,22-3,12
LI	I allele	0,50	0,30	1,319	0,251	0,43	0,10-1,85
	D allele	0,50	0,70			**2,33**	0,54-10,10
CSE	I allele	0,312	0,375	0,165	0,685	**1,32**	0,35-5,05
	D allele	0,688	0,625			0,76	0,20-2,90
LC	I allele	0,312	0,50	1,167	0,280	**2,20**	0,52-9,36
	D allele	0,688	0,50			0,45	0,11-1,93
Lactate	I allele	0,40	0,375	0,019	0,891	0,90	0,20-4,08
	D allele	0,60	0,625			1,11	0,25-5,04
MB	I allele	0,250	0,393	0,754	0,385	**1,94**	0,43-8,79
	D allele	0,750	0,607			0,52	0,11-2,33
		ACTN gene R/X polymorphism					
		Control	Case	χ2	*p*	OR	CI
BMI	R allele	0,50	0,438	0,150	0,698	0,78	0,22-2,77
	X allele	0,50	0,563			**1,29**	0,36-4,58
LI	R allele	0,50	0,467	0,033	0,855	0,88	0,21-3,66
	X allele	0,50	0,533			1,14	0,27-4,79
CSE	R allele	0,625	0,375	2,406	0,121	0,36	0,10-1,33
	X allele	0,375	0,625			**2,78**	0,75-10,26
LC	R allele	0,438	0,50	0,120	0,729	**1,29**	0,31-5,33
	X allele	0,563	0,50			0,78	0,19-3,23
Lactate	R allele	0,30	0,583	2,267	0,132	**3,27**	0,67-15,82
	X allele	0,70	0,417			0,31	0,06-1,48
MB	R allele	0,50	0,464	0,043	0,836	0,87	0,22-3,36
	X allele	0,50	0,536			1,15	0,30-4,47

The results of statistical analysis of the Association of polymorphisms of *ACE* 287I/D, R577X *ACTN* with physiological parameters using the Yets'correction are presented in table 2. Outlines the following trends: the D allele is associated with lower performance of LI, the I allele with less indicators of CSE, LC, MB.

In respect of *ACTN* gene polymorphism, the R allele correlated with high levels of lactate and less with LC, the X allele with increased BMI, with the worst performance of CSE. However, it should be noted that due to the small sample data are not statistically significant, it is necessary to further study on a larger number of athletes to obtain more reliable data.

Thus, in this paper, a cohort for the study was formed, consisting of 23 players of professional level and an electronic database was created for the study group according to the survey data. Polymorphic loci of *ACE* I/D and *ACTN* R/X genes are genotyped in this cohort.

Due to the small number of control and experimental samples, the obtained data are not statistically significant, but it can be concluded that heterozygous variants of genes are the most common in the study group of football players, which indicates the joint activity of favorable alleles. Athletes in the presence of heterozygous genotype for both genes have both good aerobic and anaerobic performance, due to the

presence of slowly contracting and rapidly contracting muscle fibers, characterized by an optimal combination of speed-strength and endurance.

Thus, our data confirmed previously identified genetic conditionality of many physiological parameters, including most of the metabolic characteristics of the body, aerobic and anaerobic capabilities, the percentage of fast and slow fibers in the muscles and others. This proves the necessity of multi-stage selection of young athletes on the basis of complex testing and analysis of their genetic and physiological parameters.

REFERENCES

[1] Bryankin S.V., Zhdanov L.N., Shustin V.N. Sports selection and orientation: Textbook. allowance. Smolensk, 1977. 67 p. (In Russ.)

[2] Shvarts V.B., Khrushchev S.V. Medical-biological aspects of sports orientation and selection. (In Russ.)

[3] Glotov A.S., Glotov O.S., Panin V.S. SPbGu "NIIAG them. D.O. Otta 2000". "Heredity and sport" // Lecture course-2013. (In Russ.)

[4] Methodical recommendations on the selection of athletes in the Youth Sports School of Moscow for the early detection of predisposition to engage in certain sports on the basis of molecular genetic methods. 2012. P. 2-3. (In Russ.)

[5] Solodkov A.S., Sologub Ye.B. Human physiology. The General. Sports. Age: the textbook / Ed. 3rd, corrected. and additional. M.: Soviet sport, 2008. 620 p. (In Russ.)

[6] http://medstatistic.ru/calculators.html

[7] http://www.biometrica.tomsk.ru/freq2.htm

[8] Human gene for physical performance. H.E. Montgomery // Nature. 1998. Vol. 393. P. 221-222. (In Engl.)

[9] Williams R.P. Biochemical individuality: The basis for Genotrophic concept. New York, 2005. 327 p. (In Engl.)

[10] Polymorphic markers I/D and G7831A of the enzyme gene converting angiotensin 1 and myocardial hypertrophy in patients with arterial hypertension // Brazhnik VA [and others] // Cardiology. 2003. N 2. P. 44-49. (In Russ.)

[11] Aristova I.K., Sobyanin F.N. On the use of polymorphism of the *ACE* gene for angiotensin-converting enzyme for determining predisposition to different sports. Belgorod State National Research University. // Scientific bulletin, series Medicine. 2013. N 11(154). Release 22. (In Russ.)

[12] Orlova N.V., Sitnikov V.F., Chukaeva I.I., Prokhin A.V. Study of the genetic conditioning of arterial hypertension as a risk factor for cardiovascular diseases. Russian State Medical University. (In Russ.)

[13] Belyakov A.M., Lidov P.I., Sechenova I.M., Gavrilov D.A. Analysis of the polymorphism of the ACE and BDKRB2 genes in athletes. FGUZ "MSCh M 143. (In Russ.)

[14] North K. A common nonsense mutation results in alpha-actinin-3 deficiency in general population / North K., Nan Yang, Mills M. // Nature genetics. 1999. Vol. 21. P. 353-354. (In Engl.)

[15] Druzhevskaya A.M. Association of polymorphism of the *ACTN3* gene with physical activity and skeletal muscle hypertrophy in strength training / Druzhevskaya A.M., Lyubaeva E.V., Netreba A.I., Popov D.V. // Sat. sci. Tr. SPbNIIFK. SP., 2006. P. 206-211. (In Russ.)

[16] Ordzhonikidze Z.G., Pavlov V.I. Physiology of football. M.: Human, 2008. 240 p. (In Russ.)

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СПОРТТЫҚ ІРІКТЕУГЕ АРНАЛҒАН ГЕНЕТИКАЛЫҚ ӘДІСТЕРДІ ҚОЛДАНУ АРҚЫЛЫ ҚАЗАҚСТАН ФУТБОЛШЫЛАРЫНЫҢ ФИЗИОЛОГИЯЛЫҚ КӨРСЕТКІШТЕРІ МЕН I/D *ACE* ЖӘНЕ R/X *ACTN* ГЕНДЕРІ ПОЛИМОРФИЗМДЕРІ АРАСЫНДАҒЫ БАЙЛАНЫСТАРДЫ ЗЕРТТЕУ

Аннотация. Жұмыста молекулалы-генетикалық талдау және негізгі физиологиялық көрсеткіштер деңгейлерін зерттеу негізінде I/D *ACE* және R/X *ACTN* гендері полиморфизмдерінің кәсіби Қазақстандық футболшылардың дене шынықтыру дайындығы арасындағы байланыстарына талдаулар жүргізілген. Алынған нәтижелер аталған гендердің полиморфизмдері спорттық іріктеуде тиімді қолдануға болатындығын дәлелдейді.

Түйін сөздер: спорттық іріктеу, молекулалы-генетикалық маркерлер, ген полиморфизмі, физиологиялық көрсеткіштер, антропометрия, волюмоспирометрия, биоимпедансометрия (Танита), хронометрия, лактометрия.

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ИЗУЧЕНИЕ АССОЦИАЦИИ ПОЛИМОРФИЗМОВ I/D *ACE* И R/X *ACTN* С ФИЗИОЛОГИЧЕСКИМИ ПАРАМЕТРАМИ ФУТБОЛИСТОВ КАЗАХСТАНА ДЛЯ РАЗРАБОТКИ ГЕНЕТИЧЕСКИХ МЕТОДОВ СПОРТИВНОГО ОТБОРА

Аннотация. В научно-исследовательской работе на основе молекулярно-генетического анализа и изучения основных физиологических параметров был проведен корреляционный анализ между генотипами полиморфизмов I/D *ACE* и R/X *ACTN* и уровнем физической подготовленности казахстанских футболистов профессионального уровня. Полученные результаты свидетельствуют о перспективности применения данных полиморфизмов для разработки генетических методов спортивного отбора.

Ключевые слова: спортивный отбор, молекулярно-генетические маркеры, полиморфизмы генов, физиологические параметры, антропометрия, волюмоспирометрия, биоимпедансометрия (Танита), хронометрия, лактометрия.

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