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GENETIC CHARACTERISTICS OF PHYSICAL PERFORMANCE OF ROWING ATHLETES

Mavlyanov I.R.,. Usmonalieva N.Sh.

Republican Scientific and Practical Center of Sports Medicine

✓ ***Resume***

This scientific paper presents the genetic characteristics of physical performance, allelic-genotypic variants of some sports genes, and their associations in rowing athletes.

Keywords: Genotype, Allele, Gene polymorphism, Allele-genotype variant, Sports genes, Rowing athletes.

ЭШКАК ЭШУВЧИ СПОРТЧИЛАРНИНГ ЖИСМОНИЙ ИШ ҚОБИЛИЯТИНИНГ ГЕНЕТИК ХУСУСИЯТЛАРИ

Мавлянов И.Р.,. Усмоналиева Н.Ш.

Спорт тиббиёти Республика илмий – амалий маркзи

✓ ***Резюме***

Ушбу илмий ишда эшкак эшувчи спортчиларнинг жисмоний иш қобилиятининг генетик хусусиятлари, ҳамда баъзи спорт генларининг аллел-генотипик вариантларининг хусусиятлари, ҳамда уларнинг ассоциациясининг ўрганиш натижалари келтирилган.

Калит сўзлар: генотип, аллел, генлар полиморфизми, аллел-генотип вариант, спорт генлари,эшкак эшувчи спортчилар.

ГЕНЕТИЧЕСКИЕ ХАРАКТЕРИСТИКИ ФИЗИЧЕСКИХ РАБОТОСПОСОБНОСТИ ГРЕБНЫХ СПОРТСМЕНОВ

Мавлянов И.Р.,. Усмоналиева Н.Ш.

Республиканский научно-практический центр спортивной медицины

✓ ***Резюме***

В данной статье приведены результаты изучения генетических особенностей физической работоспособности спортсменов, аллельно-генотипные варианты некоторых спортивных генов и их ассоциации у спортсменов гребцов.

Ключевые слова: генотип, аллель, полиморфизм генов, аллельно-генотипный вариант, спортивные гены, спортсмены - гребцы.

Relevance

It is known that sports results are primarily determined by the degree of expression in an athlete, such qualities as endurance, speed, strength, coordination, flexibility, as well as their combination [1]. Success in every sport requires different athletic qualities. So, if sprinter-runners need high-speed qualities, then marathon runners - long-distance runners - need endurance, so on [10]. Only under the conditions of an optimal combination of these qualities, which are genetically determined, and creating a good training process, taking into account these qualities, it is possible to achieve good sports results [3].

It is well known that any physical activity requires active muscular work. This is associated with energy consumption formed during the oxidation of the primary energy substrates - carbohydrates, fats and proteins. Specific genes also control Simulta, the metabolism of these substrates. It is known that the genes of proliferator-activated peroxisomes (PAPs), belonging to the family of nuclear receptors, are involved in the formation of proteins that can specifically bind to PAP-sensitive elements of promoters of genes for fat and carbohydrate metabolism and regulate their transcription [1]. These genes expressed in those tissues where

increased fat catabolism occurs, particularly in slow muscle fibres, liver, heart and brown adipose tissue. According to O. Braissant et al., the PAP gene is expressed in muscles 7 times more than in adipose tissue [11]. The primary purpose of the PPARα protein is to regulate lipid metabolism, glucose and energy homeostasis, body weight and inflammation by controlling the expression of genes involved in peroxisomal and mitochondrial oxidation, fatty acid transport, lipoprotein synthesis, triglyceride catabolism, and metabolism of inflammatory factors [19]. Fatty acids (FA) are primary energy substrates and are of great importance during physical activity. Under conditions of aerobic physical activity, the expression of the PAP gene and the cascade of genes subordinate to them increases. The utilization of FAs increases, which ultimately leads to an increase in the oxidative potential of skeletal muscles [17]. Under conditions of low expression of the PAP gene, the intensity of β-oxidation of FAs decreases and tissue metabolism switches to the glycolytic method of obtaining energy, and, conversely, in conditions of over-increased expression of this gene, a significant decrease in carbohydrate utilization and intensification of FA oxidation occurs [13]. Consequently, these genes, controlling the process of energy production in the cells and tissues of the body, indirectly affect muscle activity and, ultimately, the performance of a person as a whole.

Therefore, the study of gene polymorphism directly or indirectly affecting athletic qualities is one of the priority areas in sports medicine and genetics. Among the candidate genes responsible for the body's endurance to physical activity are genes for the angiotensin-converting enzyme - ACE [24] and PAP [2,3,4,7,10].

We studied the frequency of distribution of allelic-genotypic variants of the ACE and PPAR genes in this work.

The purpose of the research. The study consisted of studying the distribution of the allele frequencies of the ACE and PPAR genes and their associations in rowers. We studied the frequency of distribution of allelic-genotypic variants of the ACE and PPAR genes in this work.

Materials and methods

The studies were conducted based on a sample of athletes in 2018. The number of athletes was 20, at the age of 17-30. When selecting specific individuals, their nationality was not taken into account. The collection of biological material for DNA extraction was carried out, taking into account the established procedure for human rights, which was carried out with the written consent of the subjects [6].

The collection of blood samples from athletes was carried out based on the sports federation of Uzbekistan. Venous blood in an amount of 1.5ml was collected in 3ml of EDTA (ethylenediaminetetraacetic acid) solution and stored at -20℃.

Isolation of DNA from whole blood was carried out using a Ribot-prep reagent kit (manufactured by Interlabservice, Russia).

Detection of polymorphism of the studied genes was determined by the Real-Time PCR method (the kit was manufactured by OOO NPF Litekh, Moscow, Russia). GeneAmp® PCR - ABI 7500 Fast Real-Time PCR with a 96-well block was used for real-time PCR amplification. The real-time amplification program included 100 sec of preliminary denaturation at 95 ° C once, at 95 ° C for 15 sec, and at 64 ° C for 40 sec included 45 repetitions. The FAM and JOE detectors were introduced into the program. The results obtained were documented in the form of the growth of curves for two detectors FAM and JOE, in a graphical model using the appropriate program (Figures 1, 2).

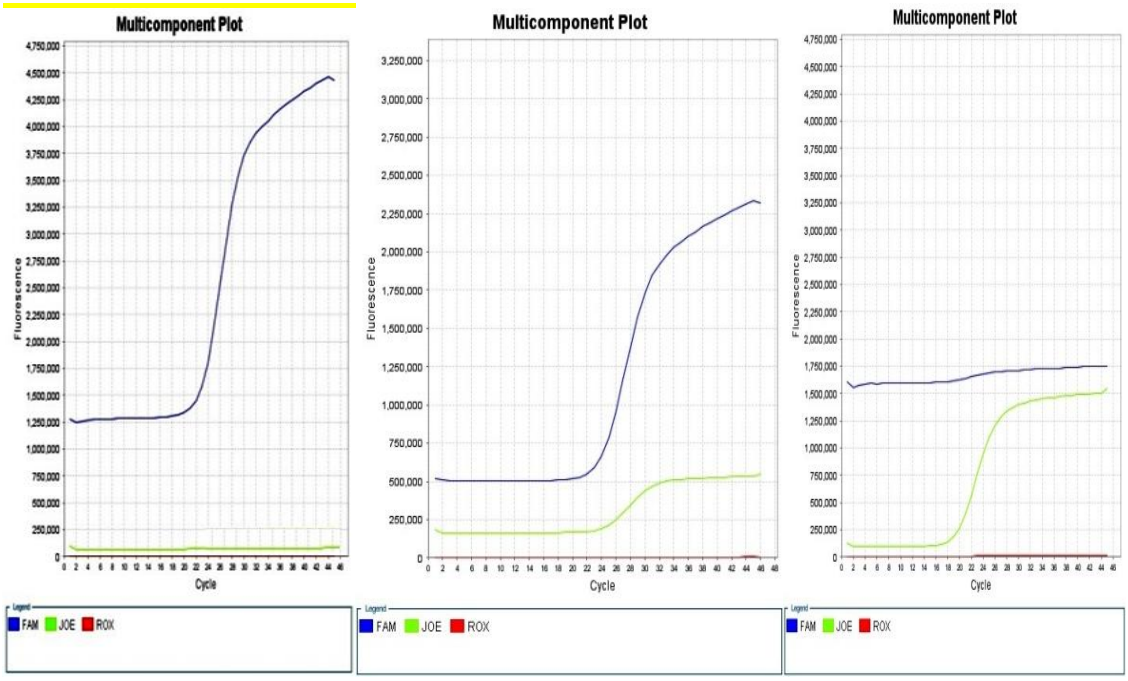

Figure 1. Result of real-time PCR of the ACE Ins / Del gene: A - homozygous Ins / Ins genotype; B - heterozygous genotype - Ins / Del and B-homozygous Del / Del genotype.

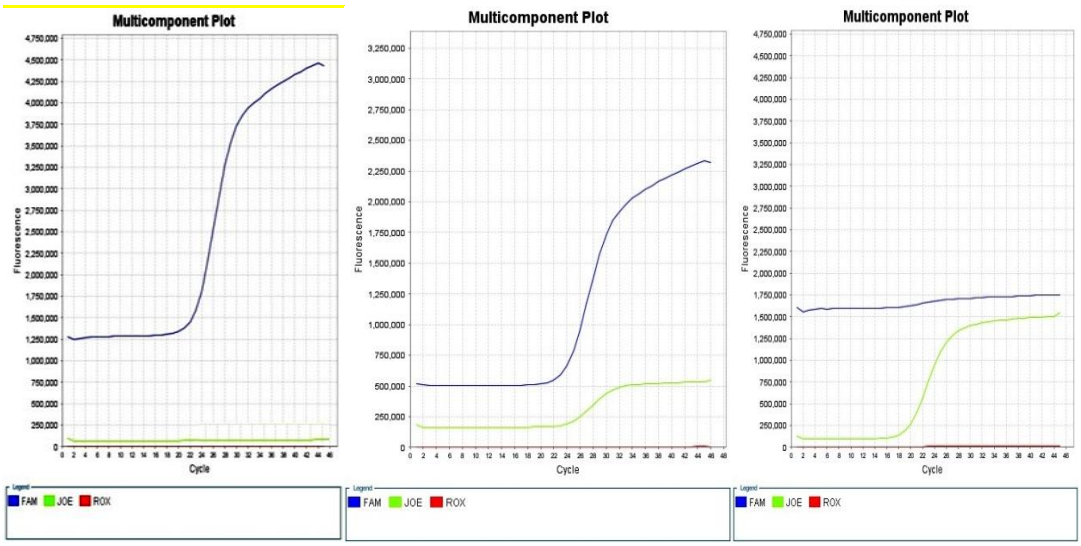

Figure 2. The result of real-time PCR of the PPARA gene: A - homozygous genotype G / G; B - heterozygous genotype - G / C and B-homozygous genotype C / C.

Results and discussion

The analysis results of the distribution frequencies of allelic-genotypic variants of the ACE gene in rowers are presented in Fig. 3. As can be seen from the presented data, among the surveyed rowers' athletes, carriers of the Ins / Ins genotype were 35.0%, and the Ins / Del genotype - 50.0%. Simultaneously, among them, the proportion of carriers of the Del / Del genotype of the ACE gene was only 15.0%. Consequently, the study results indicate the association of the ACE polymorphism with a predisposition to sports, distributed as follows: the Ins allele, which is responsible for endurance, prevails in the examined athletes compared to the Del allele, which is responsible for strength and speed. However, the most common among athletes of this sport is the heterozygous Ins / Del genotype. It is known that the ACE gene in the body controls the production of the angiotensin-converting enzyme, ACE, which catalyzes the conversion of angiotensin I to angiotensin II, and also participates in the inactivation of the vasodilating factor, bradykinin, to inactive

metabolites [16]. The influence of this gene on human physical activity is mediated through the components of the renin-angiotensin and kallikrein-kinin systems. The predisposition of people to sports-related endurance and resistance to hypoxia is associated with the Ins allele of the ACE gene. So, according to S. Myerson et al. [27], the prevalence of the Ins allele of the ACE gene in comparison with the control group was revealed in British distance runners - in long-distance runners. Studies by H.E. Montgomery et al. [25] show similar results in elite climbers.

Similar data were obtained by several researchers from Russian athletes specializing in middle distances [8], Australian [32], Croatian [24], Russian rowers-academicians and other athletes, distance runners, marathon runners [1]. The results of our research also show that carriers of the Ins allele of the ACE gene are quite common among rowing athletes. The increased endurance associated with the carriage of the Ins / Ins genotype of the ACE gene is due to the high mechanical efficiency of skeletal muscles [28]. B. Zhang et al. [33] showed the ACE Ins / Ins genotype association with the predominance of slow muscle fibres in the quadriceps femoris muscle.

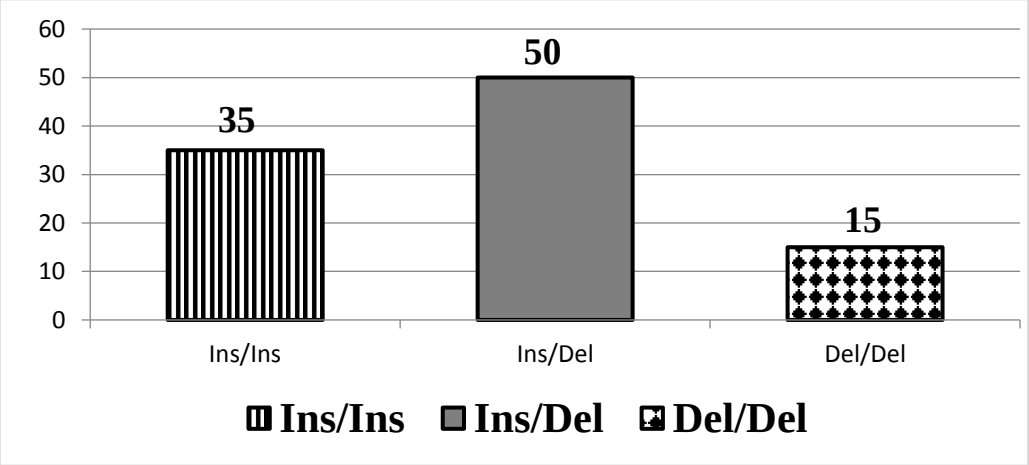

Fig. 3. Distribution of ACE gene genotypes among athletes rowers (in%).

It was found that insertion-deletion polymorphism was revealed in the ACE gene, in which the presence of the ACE Del allele is associated with a relatively high content of circulating angiotensin-converting enzyme and a higher activity of its tissue component [10]. A.G. Williams et al. [31] established a positive correlation between the circulating angiotensin-converting enzyme and the strength parameters of the quadriceps femoris muscle in the subjects. According to Y. Liu et al. [22], this effect is due to ACE-mediated activation of the growth factor angiotensin II. At the same time, L.J. Murphey et al. [26] consider the increased degradation of bradykinin to be significant in this case. Therefore, unlike the ACE Ins allele, the carriage of the ACE Del allele provides the athlete's strength and speed qualities. Indeed, many studies have shown a significant increase in the strength indices of the hip extensors [30], flexors of the shoulder [24], as well as pronounced hypertrophy of the biceps and left ventricular myocardium [16] in athletes with ACE Del allele as a result of training aimed at improving strength and endurance. Analysis of our results indicates a relatively lower proportion of carriers of this allele-genotypic variant of the ACE gene among the surveyed rowers.

Consequently, the athletes of the surveyed cohort are more predisposed to the distance requiring the predominance of endurance. If the ACE Del allele is associated with an increase in dynamic strength and muscle mass, then the ACE Ins allele is associated with an increase in isometric strength [24]. It should be taken into account that, despite the associations of the ACE Del allele and the ACE Del / Del genotype with the development of speed, strength and muscle mass, this allele-genotypic variant of the ACE gene is associated with the risk of myocardial infarction, arterial hypertension, hypertrophic cardiomyopathy, obesity. Kidney disease and vascular complications, type 2 diabetes mellitus [1]. Therefore, when developing individual training programs for athletes, these circumstances should be taken into account.

The analysis results of the frequencies of the distribution of allelic-genotypic variants of the

studied polymorphisms of another gene, particularly G2528C (rs4253778) of the PAP gene polymorphism, are presented in Fig. 4A. As can be seen from the data presented, among the surveyed athletes, carriers of the G / G genotype were 65.0% and the G / C genotype carriers - 35.0%. At the same time, carriers of the C / C genotype of the PAP gene were absent among them.

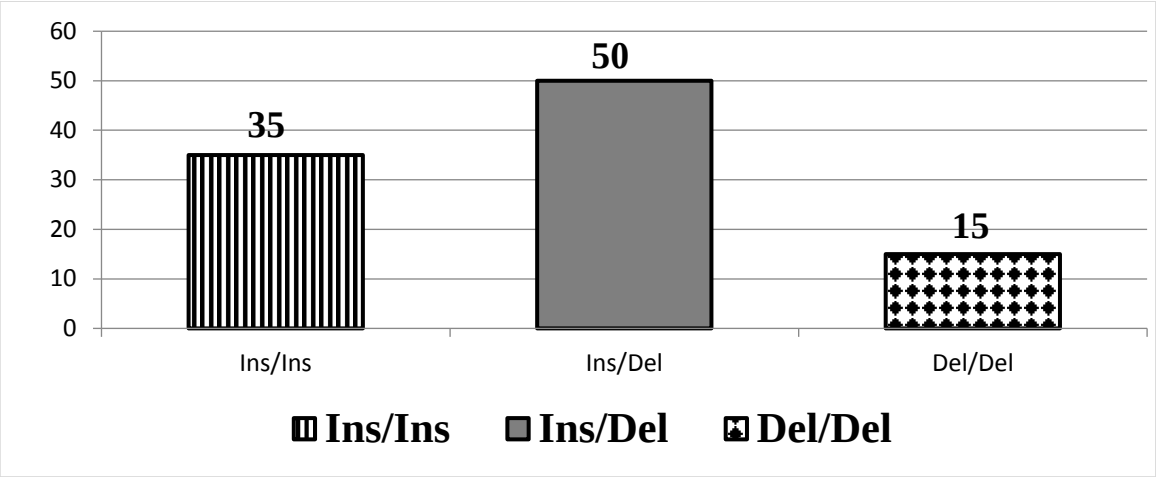

Fig. 3. Distribution of ACE gene genotypes among athletes rowers (in%).

Consequently, the study results indicate that according to the polymorphism G2528C (rs4253778) of the PAP gene, the genotypes among athletes of rowers are distributed as follows: the C allele and the C / C genotype prevail even in comparison with the heterozygous G / C genotype. Moreover, the genotype G / G did not occur among the surveyed rowers (Fig. 4A).

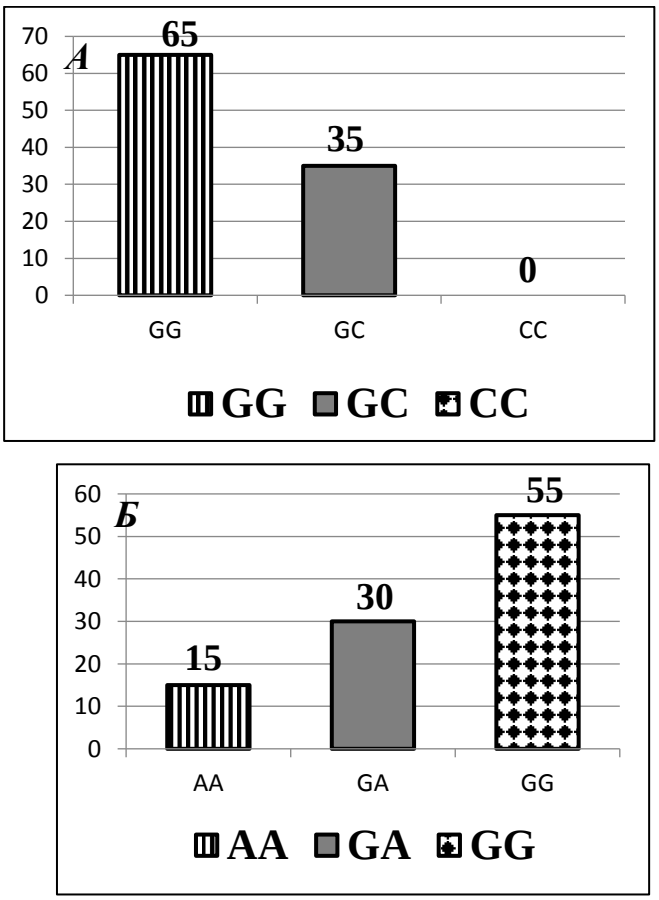

Fig. 4. Distribution of genotypes G2528C (rs4253778) (A) and G> A (GLY482SER) (rs8192678) (B) of the PPAR gene among rowers (in%).

As stated above, the G allele of the PAP gene is associated with the predominance of slow muscle fibres, high muscle endurance and the ratio of BMD (maximum oxygen consumption) to heart rate, as well as with a low risk of obesity [2, 5, 7, 10].

Consequently, in most of the athletes we examined, endurance is genetically determined. It can be assumed that these athletes can perform better in long-distance athletic performance. Indeed, a study conducted by N. Eynon et al. [12] showed in Israeli athletes that the frequency of the GG genotype of the PAP gene among long-distance runners was higher compared to sprinters. At the same time, it is impossible to consider the final forecast that most examined athletes can show the best results at long distances. As mentioned above, transcription factors regulate the expression of several dozen genes from the PAP family, increasing the activity of some and suppressing others. In this regard, it is required to assess their activity (their methylation) - the epigenetic status of an athlete [9]. This would make it possible to predict his sports results in varying degrees of accuracy in an athlete carrying specific alleles of sports genes.

The results of the conducted studies indicate that the frequency of heterozygous genotypes of the studied polymorphisms of the PAP gene is also noticeable. Research conducted by D.M. Flavell et al. [14, 15] suggests that the replacement of nucleotide G by C at position 2528 of the PAP gene is accompanied by a decrease in gene expression and causes dysregulation of lipid and carbohydrate metabolism. Moreover, the study of the carriage of this genotype among patients and healthy people shows that carriers of the C allele PAP have a relatively high risk of developing atherosclerosis, type 2 diabetes mellitus, and coronary heart disease [14, 15]. At the same time, a study conducted by Y. Jamshidi et al. [18] indicates that in carriers of the G / C genotype, the increase in left ventricular mass is 2 times, and in carriers of the C / C genotype, 3 times more than in carriers of the G / G genotype. Therefore, if we take into account that myocardial hypertrophy is due to a decrease in the expression of the PAP gene and a decrease in FA oxidation, the hypertrophic effect of the C allele is likely associated with a decrease in the absorption of FA by the myocardium and an increase in the use of glucose for its energy needs.

Analysis of the distribution frequencies of the allele-genotypic variant G> A (GLY482SER) (rs8192678) of the PAPGC1A gene polymorphism, as can be seen from Figure 4B, shows that the A allele and the A / A genotype of the GLY482 PAP gene occurred in 15% of the surveyed rowers. Simultaneously, the G allele and the G / G genotype of the studied polymorphism of the PAP gene among athletes of rowers were 2 times more common than the A allele and A / A genotype. As for the heterozygous G / A genotype, this genotype was found in almost every second athlete. According to B.N.Finck and D.P. Kelly, [13] the PAPGC1A gene is expressed predominantly in slow muscle fibres of skeletal muscles, myocardium, brown fat, kidneys and, to a lesser extent, in the liver, pancreas, and brain. The expression of this gene is regulated by proteins of various signalling pathways, such as CAMKIV, CREB, AMPK, p38 MAPK, calcineurin A, EBox binding proteins, GATA, MEF2, NF-κB, NRs, NRF-1, FOXO1, p53, SRE. It can be supported by its expression product and nitric oxide [1]. It should be noted that the PAPGC1A gene, along with PAP, is involved in the switch of metabolism in the myocardium from carbohydrate to fat metabolism immediately after birth. It should also be noted that the increased expression of this gene, as shown by the results of the study by J.J. Lehman et al. [20], can lead to uncontrolled proliferation of mitochondria in cardiomyocytes and disruption of the sarcomeric structure in them with the development of cardiomyopathy.

Among the detected variations in the PAPGC1A gene, the Gly482Ser polymorphism, consisting of the G nucleotide replacement by A at position 1444 of the 8th exon, is of great importance. According to C. Ling et al. [21], the 482Ser allele of the PAPGC1A gene is associated with decreased oxidative processes and mitochondrial biogenesis in cells to a decrease in the expression level of this gene. Indeed, in highly qualified Spanish athletes involved in endurance sports, the Gly482 allele of the PAPRGC1A gene was found to be associated with high BMD and high physical performance; the frequency of the other 482Ser allele in these athletes was significantly lower than in the control group [23]. The role of the 482Ser allele of the PAPRGC1A gene in suppressing the development and manifestation of endurance is evidenced by the results of studies by N. Stefan et al. [29], that carriers of the PAPGC1A 482Ser allele show a low increase in aerobic performance compared with homozygotes for the Gly482 allele against the

background of training aimed at developing endurance.

Consequently, our results indicate that there is a rather high proportion of those whose muscle endurance due to the intensification of fat oxidation is of priority importance among the studied athletes. Although, at the same time, many athletes may have strength qualities. However, their specific gravity is noticeably less than that of athletes with potential endurance.

We also analyzed the association of allelic-genotypic variants of the genes studied in rowers and their genetic affiliation to one or another motor activity. The results of this analysis are presented in Table 1.

Table 1

Distribution of genotypes of the studied genes and their associations among the examined athletes

№	Genes responsible for athletic performance						Character associations of genotypes
	ACE (rs4646994) _Alu_Ins/Del	Sport activities	PAP (rs4253778) G2528C	Sport activities	PAPGC1A (rs8192678_ Gly482Ser	Sport activities	
1	Ins/Del	±	G/G	+	A/A	-	+
2	Ins/Ins	+	G/G	+	G/A	±	++
3	Ins/Ins	+	G/G	+	G/G	+	+++
4	Ins/Ins	+	G/C	±	G/G	+	++
5	Ins/Del	±	G/G	+	G/A	±	+
6	Ins/Del	±	G/G	+	G/A	±	+
7	Ins/Ins	+	G/C	±	G/A	±	+
8	Ins/Del	±	G/C	±	G/A	±	± ± ±
9	Ins/Ins	+	G/G	+	G/A	±	++
10	Del/Del	-	G/G	+	G/A	±	-+
11	Ins/Del	±	G/G	+	G/G	+	++
12	Ins/Ins	+	G/G	+	G/G	+	+++
13	Ins/Ins	+	G/C	±	G/A	±	+
14	Ins/Del	±	G/G	+	G/A	±	+
15	Ins/Del	±	G/G	+	G/G	+	++
16	Ins/Del	±	G/G	+	A/A	-	+-
17	Ins/Del	±	G/C	±	G/A	±	± ± ±
18	Ins/Del	±	G/C	±	A/A	-	-
19	Del/Del	-	G/C	±	G/G	+	-+
20	Del/Del	-	G/G	+	G/A	±	-+

Note: + - genotypes responsible for endurance; - - genotypes responsible for speed and strength; ± - heterozygous genotypes

As can be seen from the data presented in Table 1, among the surveyed rowers, the association of genotypes responsible for the endurance of the three studied genes occurs only in 10%, two genes - in 25%, one gene in 30% of athletes, respectively. Simultaneously, the carriage of the genotype of speed and strength took place in 5% of athletes, only to one studied gene. Furthermore, 20% of athletes had a combination of genotypes responsible for endurance, speed, and strength (mixed genotype).

Consequently, 1/3 of the rowers' athletes have a pronounced or predominance of endurance properties. Moreover, the rest have either moderately expressed endurance or a combination of endurance with strength and speed. Thus, the results of the conducted studies indicate that among the athletes involved in the studied sports, there is a relatively high proportion of carriers of the Ins / Ins genotype of the ACE gene, as well as the G / G genotype of both the G2528C (rs4253778) polymorphism of the PAP gene and the GLY482 polymorphism of the PAPGC1A gene. Consequently, there is a rather high frequency of athletes in whom muscle endurance and FA utilization are genetically

determined among rowers. Simultaneously, among the surveyed athletes, there is a carriage of the association of allelic-genotypic variants of the studied genes in various combinations, making it difficult to conclude the predominance of one or the qualities of another sport. Our data in this regard indicate the advisability of choosing a rowing distance considering the association of genotypes of the genes we studied. So, in athletes with the carriage of the endurance genotype of three genes for longer distances, the carriage of the endurance genotype of two genes - medium distances and the carriage of the endurance genotype of one gene or the carriage of a mixed variant - short distances, respectively. Indeed, I.I. [1] shows that for rowing and canoeing in short distances (200 m), the most demanded are speed and strength. Instantaneously, rowing and canoeing at distances of 500 and 1000 m (medium distances) require speed endurance. And for rowing athletes - endurance and speed. Proceeding from this, it is essential to correctly determine rowers' specialization in this sport, considering the individual genetic predisposition to particular motor activity. In this regard, the data obtained by us are a kind of help in assessing the physical capabilities and prospects for the success of the sport of athletes in the studied sport. Moreover, this indicates the need to consider the obtained genetic determinants when planning and forming individual training programs in the pre-competition stages of their preparation.

Conclusion

1. Among the surveyed rowers, the alleles of endurance predisposition are represented by the Ins allele of the ACE gene and the G allele of the PAPGC1A gene, and the predisposition to speed and strength - by the C allele of the PAPRA gene and the A allele of the PAPGC1A gene.

2. Among athletes rowers, the highest proportion of carriers of Ins / Ins genotype of ACE gene, G / G genotype of PPARA gene and G / G genotype of PAPGC1A gene.

3. When an athlete choosed a type of rowing sport and distance, it was necessary to consider the carriage of allelic-genotypic variants of the ACE, PAP and PAPGC1A genes.

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