Association of gene FRAP1 T/G (rs2295080) polymorphism with power-oriented athlete’s status

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Summary

Study background and hypothesis. The enzyme mTOR plays an important role in extracellular signal transduction, phosphorylates various protein metabolism enzymes, transcription, and translation factors and in this way regulates metabolism in skeletal muscles. mTOR is encoded by the mTOR (FRAP1) gene, which contains 8189 single nucleotide polymorphisms (SNPs). Their genetic contribution to mTOR protein activity is yet to be confirmed. We aimed to establish whether the SNPs (rs2295080 and rs11121704) in gene FRAP1 were associated with athlete’s status in different kinds of sport.

Study methods. During the course of the study, 251 highly qualified athletes of various sport backgrounds were enrolled. Athletes represented three functional groups: endurance-oriented (N=97), mixed sports (N=47), and power-oriented (N=107). A total of 390 subjects not involved in sport activities were recruited into the sedentary group. DNA samples were extracted from participants’ buccal epithelial cells. The real-time PCR by «7500 Fast Real-time PCR» was used to determine Т/G (rs2295080) and Т/С (rs11121704) of gene FRAP1 polymorphisms. A study of special performance in athletes with different genotypes who specialized in weight-lifting was conducted as well.

Study results. All genotype frequencies were within the Hardy-Weinberg equilibrium. There were no differences in genotype distribution of T/С (rs11121704) FRAP1 in athletes and sedentary group. There was no strong evidence of the association of Т/С (rs11121704) mTOR with athletes’ status but T-allele frequency was higher in endurance athletes and C-allele - in strength athletes. Higher C-allele frequency may lead to a positive influence in strength sports as it was previously shown that C-allele could lead to an increased expression of this factor.

Analysis of Т/G (rs2295080) revealed that the frequency of G/G-genotype average is as follows: sedentary group - 7.5%, endurance-oriented - 15.5%, mixed sports - 8.5%, power-oriented - 5.6 %. There is a reduction in the number of athletes who are carriers of G/G-genotype and allele among power-oriented athletes and an increase in the number of endurance-oriented athletes. We established the reduction of G-allele frequency in power-oriented athletes and the increase of T-allele frequency in this group of carriers. Probable difference in the distribution of alleles in athletes who specialized in endurance sports and power-oriented athletes (p=0.04) was found. Athletes who are carrier of G-allele of T/G polymorphism of gene FRAP1 show the tendency to decrease indicators of special performance compared to athletes with T/T genotype.

Discussion and conclusions. The association between Т/G (rs2295080) polymorphism of gene FRAP1 and athletes’ status was established. Association can be connected with the fact that T/G polymorphism located in the promoter region of the gene leads to changes in the level of mRNA. The research results are still controversial, require functional studies, and should be investigated in relevant cohorts. Our results can be used to design better selection and training processes in order to allow athletes to achieve their full potential.

Keywords: sports selection, sports genetics, gene polymorphism, power-oriented sports, mTOR, weightlifting.

Introduction

The modern level of development of muscular activity genetics allows to collect information on a huge amount of genes and polymorphisms, which are associated with muscular activity (Bray et al., 2009; Ahmetov et al., 2015; Bouchard, 2015). One of the important topics discussed in Exercise Genomics is the search for genetic markers of muscular strength and power (Sarzynski et al., 2016). Among the genes that may be predictors of intense muscular activity, genes whose protein products are involved in body’s response to muscle exercises are primarily considered in here. The gene encoding protein mTOR synthesis belongs to these genes.

The enzyme mTOR (mammalian target of rapamycin) transmits intracellular signals by phosphorylation of substrates in metabolic reactions of the human body. It is one of the regulators of protein synthesis in the body, including skeletal muscle, and, therefore, is considered a key factor in muscular response to power exercises (Golberg et al., 2014). This enzyme is proved to participate in anabolic processes at the single and regular power exercise (Dreyer et al., 2006; Leger et al., 2006; Wilkilson et al., 2008). It is found that power
exercises can activate mTORC1 and more efficiently increase the muscular protein synthesis (Deldieque et al., 2008). There was an increase in mTOR phosphorylation when power training and high-intensity interval training were combined (Fyfe et al., 2016). In addition, some authors consider activating mTOR pathway to be a key factor in the occurrence of exercise-induced cardiac hypertrophy (Liao et al., 2015).

The enzyme mTOR is encoded by gene FRAP1 containing 8189 polymorphisms and only a few of them have been investigated for the functional significance. Polymorphisms of this gene were actively studied in relation to cancer (Huang et al., 2012; Chen et al., 2012) to date. Individuals with T/T genotype of T/C polymorphism of gene FRAP1 (rs11121704) were established to be characterized with higher levels of this gene expression. T/C polymorphism of gene FRAP1 (rs11121704) is associated with the development of cancer, including the T/T genotype associated with increased risk of cancer (Shao et al., 2014).

The T/G polymorphism of gene FRAP1 (rs2295080) is located in the promoter region of the gene and results changes in mRNA levels and reduction in luciferase activity (Cao et al., 2012). Although the effect of enzyme on muscular activity and changes in its gene due to polymorphisms is proved, dependence of muscular activity in sports on polymorphisms of this gene has not been studied yet. The hypothesis states that gene FRAP1 polymorphisms are associated with susceptibility to intense muscular activity, making the said gene to be a candidate for inclusion in the list of genes, which are predictors of muscular activity susceptibility.

The purpose of study was to establish whether the SNPs in gene FRAP1 were to be associated with athlete status in different kind of sport.

Methods

DNAs of 641 individuals’ - 251 athletes and 390 persons with no regular engagement in sports - activities were studied. All the surveyed athletes, depending on the nature of muscular activity energy supply in the chosen kind of sports, were divided into three groups: 1) endurance-oriented (athletes who specialize in sports requiring endurance: rowing, skiing, walking trails, biathlon); 2) power-oriented (athletes who specialize in disciplines that require power and speed: weight-lifting, speed-power types of athletics, swimming short distances); 3) athletes who specialize in sports with the requirements to combine power and endurance. In our studies we included athletes who specialized in freestyle wrestling and swimming.

The group of athletes who specialized in weight-lifting included 31 males. Nine of them were candidates for sports master and 22 already were masters of sport. The average age was 19.6±3.4 years; the average height - 174.3±5.8 cm; the average weight - 85.8±7.6 kg; and BMI - 30.2±2.1. The 69.77 weight category included 11 athletes, the 85.94 weight category – 10 athletes, and the 105,±105 weight category – 10 athletes.

Pedagogical observation and sampling of biological material was held during the Ukrainian Championship between higher schools of sportsmanship. All athletes were prepared for higher achievements and individual fulfilment in the competitive period of a specialized preparatory phase. Athletes recorded both indicators of special performance and results of jerk and push-off demonstration and weight of a barbell as a percentage of an athlete body mass, weight of a barbell during the jerk as a percentage of weight of a barbell during the push-off, weight of a barbell including Sinclair factor, and body mass index (BMI) as well. The study of special working activity was conducted using a functional test with a barbell. The barbell test suggests specific weight-lifting loading (barbell raise) and includes the effect of muscular work on athletes’ autonomic systems and its adaptive flexibility. The functional test suggests performance of two series of load with a barbell, which are separated by resting intervals. The body response to the activity was assessed by heart rate. The first loading of a specific test for weight-lifters included 9 hang squats on the platform with weight of 30 or 40 % of the maximum push-off. The muscular activity was being performed for 3 minutes. The time from every barbell raise, lowering rod, and resting till the repeat was 20 sec (the barbell raise and lowering lasted for 3-5 sec., the rest interval between the raises was 15-17 sec). The rest period between the first and the second series of loading must be 3 minutes.

The capacity of mechanical work (N) performed by an athlete when lifting and lowering weights was calculated. N=Kp (M g x h + M 0 x g x 0,25 L) where Kp is a constant that takes into account athlete's
weight class; M - the barbell weight (kg); h - height, at which the barbell was raised (m); M₀ - lifter's weight (kg); g - the acceleration of gravity, which is 9.8; L - lifter's height (m). The Kp factor was calculated using the following formula: \( K_p = 5.1 \times (1 - \frac{M_k}{120}) \) where \( M_k \) is athlete's weight category. Determining \( N \) for the first and second series as well as heart rate (HR) at the end of each series, PWC₁₇₀ can be calculated by the formula: \( \text{PWC}_170 = N_1 + (N_2 - N_1) - \frac{F_1 - F_2}{P_1 - P_2} \) where \( \text{PWC}_170 \) is the capacity of mechanical work that athletes performed at HR of 170 bpm/min; \( N_1, N_2 \) is the load capacity in the first and second series of barbell lifting; \( F_1, F_2 \) - the heart rate at first and second series of load.

The molecular and genetic analysis was performed in the laboratory of the Department of General and Molecular Pathophysiology, O. Bohomolets Institute of Physiology, National Academy of Sciences of Ukraine). The DNA was extracted from the buccal epithelium using a set of reagents Diatom™ DNAPrep (Biokom, Russia).

T/C polymorphism of gene FRAP1 (rs11121704) and T/G polymorphism of gene FRAP1 (rs2295080) were determined by real-time PCR using a “7500 Fast Real-time PCR” device (Applied Biosystems, USA) and TaqMan® Master Mix (2x) (Applied Biosystem, USA) (assay S_31720978_30 and S_16189146_10, respectively). And 2 μl of DNA to a test tube containing the reaction mixture consisted of 2 μl of 10-log Taq-buffer (+(NH₄)₂SO₄-MgCl₂, 0.4 μl of deoxynucleotide triphosphate (2 mM dNTP Mix), 2 μl of MgCl₂, 0.3 μl of assay, 0.1 ml of Dream Taq-polymerase, 0.04 μl of ROX (reference fluorescence carrier), and 13,16 μl of dH₂O. The program amplification includes 50 cycles.

Genotype distribution and allele frequencies between each of the three athletes’ and control groups were compared using χ² tests. \( P \) values < 0.05 were considered statistically significant.

The Regional Ethics Committee (Kiev, Ukraine) approved the study and written consent was obtained from each participant. All experiments were performed according to the ethical standards of Helsinki Declaration. All genotyping analyses were conducted blind to subject identity.

**Results and discussion**

The observed genotype frequencies of SNPs (rs2295080 and rs11121704) of FRAP1 in the control group were all in agreement with Hardy-Weinberg equilibrium (\( P > 0.05 \)).

**A study of association of gene FRAP1 T/C polymorphism with athlete’s status.** In order to determine T/C polymorphism of gene FRAP1 (rs11121704) for athlete’s status and muscular activity, there was a study of the frequency of allelic variants of gene FRAP1 T/C polymorphism in groups of individuals with different modes of motor activity (athletes who specialized in various sports and healthy individuals not engaged in sports). Table 1 summarizes the genotype and allele distributions of T/C polymorphism among the different groups of athletes and controls.

The FRAP1 C-allele - minor allele frequency (MAF) in the control group (0.312) approached the results of the NCBI database (0.299).

A decrease in frequency of genotype C/C and C-allele was determined in all athletes but genotype T/T frequency in athletes’ engaged in speed-power sports was the lowest among all groups (by 16 %

<table>
<thead>
<tr>
<th>Genotype</th>
<th>All athletes</th>
<th>Power-oriented</th>
<th>Endurance-oriented</th>
<th>Sedentary, control</th>
</tr>
</thead>
<tbody>
<tr>
<td>T/T</td>
<td>53.5</td>
<td>42.3</td>
<td>58.3</td>
<td>48.5</td>
</tr>
<tr>
<td>T/C</td>
<td>38.4</td>
<td>50</td>
<td>33.3</td>
<td>40.8</td>
</tr>
<tr>
<td>C/C</td>
<td>8.1</td>
<td>7.7</td>
<td>8.3</td>
<td>10.8</td>
</tr>
<tr>
<td>T-allele</td>
<td>72.7</td>
<td>67.3</td>
<td>75</td>
<td>68.8</td>
</tr>
<tr>
<td>C-allele</td>
<td>27.3</td>
<td>32.7</td>
<td>25</td>
<td>31.2</td>
</tr>
<tr>
<td>N</td>
<td>86</td>
<td>26</td>
<td>60</td>
<td>390</td>
</tr>
<tr>
<td>P1al</td>
<td>0.32</td>
<td>0.82</td>
<td>0.17</td>
<td>-</td>
</tr>
<tr>
<td>P1gen</td>
<td>0.63</td>
<td>0.63</td>
<td>0.36</td>
<td>-</td>
</tr>
<tr>
<td>P2al</td>
<td>0.3</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>P2gen</td>
<td>0.33</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: P1al is a statistical probability of differences in the distribution of alleles compared to control group; P1gen is a statistical probability of differences in the distribution of genotypes compared to control group; P2al is statistical probability of differences in the distribution of alleles compared to endurance-oriented athletes; gene P2 is statistical probability of differences in the distribution of genotypes compared to endurance-oriented athletes; * – probable differences according to \( \chi^2 \)-criterion \( P < 0.05 \).
lower than in the group of athletes who specialized in endurance sports and by 6.7% lower than in the control group). Athletes who specialized in sports with primary development of endurance were characterized with the lowest frequency of C-allele (0.250). Obviously, C-allele limits physical performance in endurance sports. Thus, athletes engaged in speed-power sports revealed the lowest frequency of genotype T/T but athletes who specialized in endurance sports had the highest one. There is evidence that T/C polymorphism is in the intron region of gene FRAP1 (rs11121704) can cause the level of mRNA. It was found previously that individuals with genotype T/T of gene FRAP1 T/C polymorphism were characterized with higher levels of this gene expression (Shao et al., 2014).

Given that this polymorphism is in the intron region and, therefore, cannot influence gene expression, the relation of this polymorphism with the level of gene FRAP1 expression can be obviously explained because of its linkage disequilibrium with other functionally more important loci.

Thus, T/C polymorphism of gene FRAP1 may be a candidate marker for determination of predisposition for power quality manifestation but the mentioned hypothesis requires increasing of the athletes sampling.

**Association of T/G polymorphism of gene FRAP1 (rs2295080) with athlete’s status.**

The results of frequencies distribution analysis for allele variants of gene FRAP1 T/G polymorphism are presented in Table 2. The frequency of MAF G-allele in the control group is 0.316. The specified value is similar to the results obtained in other populations. In particular, according to the NCBI database, the average MAF is 0.462 but it varies in different populations. For example, in European studies MAF was 0.3, in Japan - 0.209, while in Africa - 0.9. In the Chinese population the frequency of G-allele was 0.2 (Huang et al., 2012).

Analysis of T/G (rs2295080) reveals that the frequency of G/G-genotype average is as follows: sedentary group - 7.5%, endurance-oriented - 15.5%, mixed sports - 8.5%, power-oriented - 5.6%. There is a reduction in the number of athletes who are carriers of G/G-genotype and G-allele among power-oriented athletes and an increase in the number of endurance-oriented athletes, although the distribution of genotypes and alleles in these groups probably do not differ from the distribution in the control group. Thus, the G-allele frequency in power-oriented athletes is lower than in the control group by 6.4% and, in the group of endurance-oriented athletes, it is higher than in the control group by 2.9%.

Statistically significant differences in alleles distribution were observed in endurance-oriented and power-oriented athletes (p=0.04): 9.3% the G-allele frequency is higher in the group of endurance-oriented athletes. This may indicate that T-allele is favourable for power-oriented sports and G-allele provides benefits in sports with primary development of endurance.

The results obtained by other researchers confirm the pattern mentioned above. Thus, it was found that the stated polymorphism can affect the

**Table 2**

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Power-oriented</th>
<th>Endurance-oriented</th>
<th>Mixed kinds</th>
<th>Sedentary, control</th>
</tr>
</thead>
<tbody>
<tr>
<td>T/T</td>
<td>55.1</td>
<td>46.4</td>
<td>57.4</td>
<td>44.4</td>
</tr>
<tr>
<td>T/G</td>
<td>39.3</td>
<td>38.1</td>
<td>34</td>
<td>48.1</td>
</tr>
<tr>
<td>G/G</td>
<td>5.6</td>
<td>15.5</td>
<td>8.5</td>
<td>7.5</td>
</tr>
<tr>
<td>T-allele</td>
<td>0.748</td>
<td>0.655</td>
<td>0.745</td>
<td>0.684</td>
</tr>
<tr>
<td>G-allele</td>
<td>0.252</td>
<td>0.345</td>
<td>0.255</td>
<td>0.316</td>
</tr>
<tr>
<td>N</td>
<td>107</td>
<td>97</td>
<td>47</td>
<td>106</td>
</tr>
<tr>
<td>P1gen</td>
<td>0.29</td>
<td>0.13</td>
<td>0.27</td>
<td>-</td>
</tr>
<tr>
<td>P1al</td>
<td>0.15</td>
<td>0.53</td>
<td>0.26</td>
<td>-</td>
</tr>
<tr>
<td>P2gen</td>
<td>0.06</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>P2al</td>
<td>0.04*</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**Note:** P1al is a statistical probability of differences in the distribution of alleles compared to control group; P1gen is a statistical probability of differences in the distribution of genotypes compared to control group; P2al is statistical probability of differences in the distribution of alleles compared to endurance-oriented athletes; P2gen is statistical probability of differences in the distribution of genotypes compared to endurance-oriented athletes; * – probable differences according to χ²-criterion p<0.05.
level of mRNA by reducing it (Cao et al., 2012). The elevated levels of this enzyme are believed to increase the probability of cancer development. Moreover, the individuals carrying G-allele had a significantly decreased risk of cancer compared with those carrying T-allele. The meta-analysis results showed that the wild genotype T/T of rs2295080 polymorphism was associated with increased cancer risk (Shao et al., 2014). This indirectly shows the influence of polymorphisms on the expression of gene FRAP1.

Since the power-oriented athletes demonstrated a reduction in G-allele frequency and an increase in the T-allele frequency, it gave us the opportunity to assume that the T-allele contributes to the development of power characteristics.

To verify this hypothesis, we conducted the following studies: we have analysed the frequency of this polymorphisms in athletes where the power is a major physical characteristics that contributes to athletic performance. Since FRAP1 is a key gene in development of muscular hypertrophy, it is evident that, where maximum power is a crucial indicator, polymorphisms of this gene will play an important role.

It was found that power-oriented athletes are genetically heterogeneous. The frequency of genotypes in athletes who specialized in weight-lifting was: T/T - 67.7%; T/G - 25.7%; G/G - 6.5%. The G-allele frequency was 0.258, which was 5.8% less than in the control group; in the group of athletes specialized in speed-power sports, this indicator was 5.3%.

**A study of special performance in weight-lifters with different genotypes of T/G (rs2295080) polymorphism.** To establish the role of T/G (rs2295080) polymorphism in the development of power characteristics, all athletes who specialized in weight-lifting were divided into two groups by genotype of T/G polymorphism of the gene FRAP1: weightlifters with genotype T/T and weightlifters with genotypes T/G and G/G. The differences in terms of special performance of weight-lifters with different genotypes are presented in Table 3.

The study results suggest that athletes the G-allele carriers (genotypes T/G and G/G) show relatively lower power characteristics compared to athletes with genotype T/T. All these changes are observed at trends that can be a cause of a not large-scale sampling of athletes.

These results are well explained, given that the G-allele carriers show the low level of mRNA, and, therefore, the protein synthesis activity reduces compared with native genotype T/T. Our results confirmed the fact that G-allele carriers had a reduced luciferase activity, which was an indicator of reduced formation of ATP. Given the location where T/G polymorphism located (in the promotor region) and in silico analysis the T to G base change of rs2295080 may change the predicted binding of the Cap and GATA-1 transcription factors subsequently resulting in a decrease of gene FRAP1 expression (Chen et al., 2012).

Special performance of weight-lifters, which give an opportunity to assess the response of athlete’s body to the load, was evaluated using tests with a barbell. The value of special performance was calculated taking into account the weights of a barbell, weight of a lifter and heart rate ranged from 1288 to 2362 kg/min and was associated with the different anthropometric data and weight categories. The differentiation of athletes by genotypes revealed that in athletes who were carriers of the G-allele specific performance was somewhat reduced but probable differences could not be established because there was one representative of genotype G/G in each weight category.

**Conclusions**

In conclusion, T/G polymorphism of gene FRAP1 is associated with the status of athletes. There is a reduction in frequency of G-allele in power-oriented athletes and an increase in frequency of T-allele in this group of carriers. Statistically significant differences in the distribution of alleles is found in endurance-oriented and power-oriented athletes (p=0.04). In athletes who are carriers of G-allele of gene FRAP1 T/G polymorphism, there is a tendency
to decrease special power performance compared to athletes with T/T genotype. Specifically, the FRAP1 T/T genotype is more favourable for weightlifters.

REFERENCES


FRAP1 GENO T/G (RS 2295080) POLIMORFIZMO ASOCIACIJA SU SPORTININKŲ GREITUMO IR JĖGOS SAVYBĖMIS

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SANTRAUKA

Fermentas mTOR vaidina svarbų vaidmenį ekstraląstelinio signalo transdukcijoje, fosforilinant įvairius baltymus, dalyvaujančius fermentų apykaita – etapa, reguliuoją metabolizmą griauciuų raumenyse. Fermentas mTOR koduojamas mTOR (FRAP1) geno, kurio sudėtyje yra 8189 vieno nukleotido polimorfizmai (SNPs). Jų genetinis indėlis į baltymų aktyvumą dar nėra pakankamai ištirtas.

Darbo tikslas – nustatyti asociaciją FRAP1 geno SNPs (rs 2295080 ir rs11121704) su įvairių šakų sportininkų fiziiniu pajėgumu. Tyrime dalyvavo 251 įvairių šakų didelio meistriškumo sportininkai. Tiriamieji buvo suskirstyti į tris grupes: pirmąją grupę sudarė 47, antrąją grupę mišrūs (“mix”) sportininkai, kurių energetinė gamyba daugiau vyrauja glikolitinė reakcijos. Tvirtinantys darbo rezultatus, galbūt reikėtų atkreipti dėmesį į įvairių šakų didelio meistriškumo sportininkų genetinę atšaką.
(rs11121704) polimorfizmas buvo nustatytas realaus laiko polimerazės grandinės reakcijos metodu naudojant „7500 Fast Real-time PCR“ įrangą. Tyrimo metu nustatytais įvairiais genotipo sunkiosios atletikos sportininkų specialusis darbingumas.

Paaškėjo, kad genotipų pasiskirstymas tirtose grupėse atitiko Hardžio ir Vainbergo pusiausvyrą. Lyginant FRAP1 geno T/C (rs11121704) polimorfizmo genotipų dažniausią pasiskirstymą tarp sportininkų ir kontrolinės grupės asmenų, reikšmingų skirstumų nenusidaryta. Nors reikšminga asociacija FRAP1 geno T/C (rs11121704) polimorfizmo su sportininkų fiziniu pajegumu nebuvo nustatyta, tačiau pastebėta, kad T-alelis buvo dažnusis tarp ištvermės ugdančių sportininkų, o C-alelis – tarp greitumui ir jėgą ugdančių sportininkų. Kitų autorių duomenimis, C-alelis gali padidinti mTOR raišką, todėl matome, kad C -alelio dažnis gali daryti teigiamą įtaką sportininkų greitumui ir jėgai. Polimorfizmo T/G (rs 2295080) tyrimas parodė skirtingą G/G genotipų pasiskirstymą tarp grupių: kontrolinės grupės G/G dažnis siekia 7,5 %; ištvermės ugdančių sportininkų grupės – 15,5 %; aerobinę ir anaerobinę ištvermę ugdančių sportininkų grupės – 8,5 %; greitumui ir jėgai – 5,6 %. Tarp sportininkų, ugdančių greitumui ir jėgą, G/G genotipas resnės, o tarp ištvermės ugdančių sportininkų jis dažnesnis. Iš tyrimo rezultatų matyti, kad T-alelis dažnesnis, o G-alelis resnės tarp greitumui ir jėgą ugdančių sportininkų nei kitų šakų sportininkų. Nustatyta statistiškai patikima alelių dažnio pasiskirstymas tarp ištvermės bei greitumui ir jėgą ugdančių sportininkų grupių (p = 0,04). Tarp sportininkų, turinčių FRAP1 geno T/G polimorfizmo G-alelį, pastebėta specialiojo darbingumo mažėjimo tendencija, palyginus su T/T genotipo sportininkais.

Tiriant nustatyta asociacija FRAP1 geno T/G (rs 2295080) polimorfizmo su sportininko fizine būkle. Ši asociacija gali būti paaškinta faktu, kad nurodytas polimorfizmas yra išsidėstęs geno promotoriaus sri-tyje ir sukelia DNR pokyčius. Gauti rezultatai turėtų būti dar patvirtinti funkciniais didesnio skaičiaus sportininkų grupėse tyrimus. Tyrimo rezultatai gali būti ypač vertingi jaunųjų sportininkų atrankai, treniruotės proceso korekcijai, rengiant greitumui ir jėgą ugdančius sportininkus.

Raktažodžiai: sportininkų atranka, sporto genetika, genų polimorfizmas, greitumui ir jėgą ugdantis sportininkai, mTOR.

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