Effect of ACTN3 R577X Genotypes on Muscle Strength and Power in Brazilian Mixed Martial Arts Athletes

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¹Center of Study of Physical Performance, Federal University of Paraná, Curitiba, Brazil, ²Univali, Itajaí, Brazil, ³University Tuiuti of Paraná, Curitiba, Brazil, ⁴UniBrasil, Curitiba, Brazil, ⁵Faculty of Health, School of Exercise and Nutrition Sciences, Queensland University of Technology, Brisbane, Australia

ABSTRACT

Oliveira EC, Rodrigues P, Salgueiro FM, Seniski GG, Wharton L, Osiecki R. Effect of ACTN3 R577X Genotypes on Muscle Strength and Power in Brazilian Mixed Martial Arts Athletes. JEPonline 2018;21(2):202-213. The purpose of this study was to compare the muscular performance of Brazilian MMA athletes in strength and power tests for different genotype groups of ACTN3 R577X polymorphism. Eighteen male professional Brazilian MMA athletes (RR=6, RX=9, XX=3) participated in this study. Subjects performed handgrip test, supine and squat exercises in 1RM and 70% of 1RM tests, and countermovement jump test. The subjects' blood samples were drawn from an antecubital arm vein. Genomic DNA was extracted from leukocytes using the salting-out technique. ACTN3 R577X polymorphism was determined by PCR test. Although the findings indicate there was no association between the ACTN3 and upper body muscle performance (handgrip test, 1RM supine test, and 70% of 1RM supine test) (P>0.05), the MMA athletes with ACTN3 RX genotype presented better local muscle endurance than the RR athletes (P=0.02). Also, the dominant model (RR vs. RX+XX) of ACTN3 genotype presented better local muscle endurance (P=0.04). Regarding the explosive muscle power of the MMA athletes' lower limbs, the recessive model (RR+RX vs. XX) of ACTN3 genotype showed greater responses (P=0.03).

Key Words: ACTN3, Mixed Martial Arts, Muscular Performance
INTRODUCTION

High performance results are based on a combination of environmental factors, such as suitable training loads and nutrition. However, such factors are not able to explain the large variation in training responses. This knowledge presents a new important component for determining the phenotype of physical performance, that being, the genetic component (9). The concept of human variation in the ability to respond to training was proposed three decades ago, and since then several studies conducted with monozygotic twins have confirmed a substantial genetic component in response to training (5).

A change in the DNA base sequences (polymorphisms) may influence the expression and activity of certain proteins and, therefore, in number of forms involved in the variation of the physical performance phenotype. It is believed that ~200 genetic variations (candidate genes) are related to phenotypes of physical performance, fitness, and health (6). Among the candidate genes studied, the gene encoding α-actinin-3 (ACTN3) has been shown to be promising in studies that have a focus on training responses (23). The scientific literature points out that ACTN3 may contribute to differentiated phenotypic manifestations. More specifically, the R577X polymorphism of ACTN3 gene is present in the entire world population and characterizes sports communities in particular according to the predominance of their frequency distribution (8,37). In addition, over the last two decades, many sport science studies have been conducted to investigate the relationship between genetics and elite athletic performance (18). It is expected that with the rapid development of gene-based technologies, further research will be carried out in order to identify genetic predispositions as a contributing factor to athletic abilities and performance (25).

The ACTN3 R577X polymorphism promotes an arginine (R) to premature stop codon (X) change in the 577 residue (24), resulting in a complete absence of the protein α-actinin-3 in type II muscles in individuals carrying the XX genotype. This absence might have some consequences. It has been demonstrated that the α-actinin-3 absence induces metabolic changes towards oxidative metabolism, resulting in higher activity of oxidative enzymes (e.g., citrate synthase) and lower activity of glycolytic enzymes (e.g., lactate dehydrogenase and glycogen phosphorylase) (28). Because of this, it has been observed that XX individuals are over-represented among long-distance athletes (37). It has also been observed that the presence of α-actinin-3 leads to an increased force generation, increased growth in fast fiber diameter and higher strength capacity (20). Hence, RR individuals are over-represented among power-oriented athletes (10). These results indicate that X and R alleles of the ACTN3 R577X polymorphism could lead to opposite phenotypes resulting in specific advantages in activities presenting distinct characteristics.

Fighting is one of the world’s oldest physical activities practiced by humans (11). In fact combat sports, in many forms are practiced worldwide (17). In terms of formal competition, combat sports have an important impact on the medal table of multi-sports events, such as the Olympic Games, where they represent approximately 20 to 25% of all medals awarded (12). More recently, the popularity of fighting has been enhanced by the evolution of the mixed martial arts (MMA) championships, where most of the technical fundamentals come from combative sports that are contested at the Olympic Games (13). MMA is a combat sport that allows striking and grappling, fighting standing and on the ground, utilizing techniques
from Boxing, Judo, Karate, Taekwondo, Muay Thai, Brazilian Jiu-Jitsu, Wrestling, and Wushu Sanshou among others.

The intensity levels and dynamic nature of MMA fights places high physiological demands on the contestants (2). The MMA contests involve many explosive actions such as kicking and striking, the effectiveness of which is often crucial in determining the final result of a competition (38). The focus of training for combat sports, including MMA, is on building athletes’ muscular strength and improving the dynamics of movements (34). As such, muscular strength and power constitute the fundamental elements for good physical performance in the sport of MMA (29). Moreover, the nature of MMA demands high muscle strength endurance of the forearm to ensure that the athlete can endure the physiological stress associated with the sport that requires specific positioning of the hands for both grappling and absorbing strikes (38). More specifically, MMA fighters rely heavily on their flexor digitorum superficialis and flexor digitorum profundus to shape their hands in a closed fist. These forearm muscles keep their fists tight in this position, which requires significant and prolonged isometric muscle contraction. It is a much greater contraction than that which is required in boxing or other combat sports (14).

Of recent times, the most popular MMA promotion company is the Ultimate Fighting Championship (UFC). The UFC was originally promoted as a competition to find the most effective martial arts for real unarmed combat and, consequently, competitors from different fighting styles are pitted against one another in adjudicated contests (27). Initially, athletes from various styles of martial arts became involved in UFC competitions for recognition and financial return. While the UFC is a truly international sport, Brazil is one country that is most prevalently involved in UFC competition. In the last 10 yrs, Brazil has had champions in 6 of the 8 men’s divisions: Heavyweight (Fabricio Werdum and Junior dos Santos); Light Heavyweight (Mauricio Shogun Rua and Lyoto Machida); Middleweight (Anderson Silva); Lightweight (Rafael dos Anjos); Featherweight (José Aldo); and in Bantamweight (Renan Barão). Brazil can also lay claim to the current UFC champion in two women’s division: Featherweight (Cristiane Justino) and Bantamweight (Amanda Nunes).

Given the aforementioned context, an enhanced understanding of the effect of ACTN3 on muscle strength and power of MMA athletes seems prudent. However, at this point, there are no studies that have examined the effect of the ACTN3 R577X polymorphism on human performance in a group of professional MMA athletes and tested whether there is an association of ACTN3 R577X polymorphism with muscular strength and power performance. The results of this study can provide technical staff with important information concerning the maximum strength and power of each MMA athlete as determined by their specific genotype. This knowledge will enable professional coaches and athletes better scheduling and planning for personalized training programs for MMA competitors. Therefore, the aim of this study is to compare the muscular performance of Brazilian MMA athletes in strength and power tests for different genotype groups of ACTN3 R577X polymorphism.

**METHODS**

**Subjects**

Eighteen male professional Brazilian MMA athletes (mean ± SD; age: 26.30 ± 4.00 yrs; height: 176.50 ± 7.60 cm; weight: 79.90 ± 11.01 kg; body fat: 11.31 ± 2.35 %) that maintained
regular training sessions and competed in official MMA events participated in this study. This study was approved by the Research Ethics Committee of the Department of the Health Sciences of the Dom Bosco University (protocol: 225.747), and is in compliance with all the norms established by the National Health Council (Res. 196/96) regarding research with human subjects. Following the subjects receiving a comprehensive verbal and written explanation about the benefits and risks of the study, they signed the informed consent document that was institutionally approved.

**Procedures**
Athletes visited the Center of Study of Physical Performance Laboratory (CEPEFIS) three times to complete the experimental protocol of this study, with each visit following a 48 hrs rest period. During the first visit, the subjects' body weight, height, and fat percentage were determined. They were familiarized with the test procedures of all experimental protocols and blood samples were collected. In the second visit, a maximal voluntary contraction test (MVCT) (1RM) by two different exercises (supine and squat) and a countermovement jump (CMJ) test were performed. In the third visit, a local muscle endurance strength test (70% of 1RM) in supine and squat exercises and a handgrip test were completed. Subjects were refrained from taking any medication or dietary supplements with anti-inflammatory action for 2 wks before the study. They were also instructed not to do any physical activity for 48 hrs before the tests were initiated, and not to drink caffeine-containing beverages on the day of the tests.

**Assessment of Muscle Strength and Power**
The maximal isometric strength of the forearm muscles was measured in the MMA athletes with a manual hydraulic dynamometer (Jamar®). The test was performed with athletes in standing position in the dominant hand side with elbow joint fixed at 90°, they were instructed to squeeze the dynamometer as hard as they could for 5 sec (38). The test consisted of three trials with a 1-min rest interval between each trial. The highest single forearm isometric strength reading among the three was considered the representative measure.

To determine the assessment of dynamic muscle strength of the athletes, supine (Olympic Flat Bench – LifeFitness) and free squat (Technogym) MVCT by 1RM were performed according to Bacurau et al. (4). The MMA athletes performed the 1RM supine or squat after a specific warm-up. The initial load used for these tests was that obtained in the familiarization session. Then, an increment of 2, 3, or 4% was used per trial to achieve the 1RM load. A 3-min rest interval was required between each trial. A maximal of four trials was allowed to achieve the 1RM load. All MMA athletes performed a specific warm-up that was composed of 5 reps of the supine or squat exercise with 50% of the 1RM load obtained during the familiarization session. Forty-eight hrs after the 1RM MVCT session, a local muscle endurance strength test was done. The athletes performed another supine and squat test with the load set at 70% of 1RM, which was recorded during the previous visit. This time the test consisted of one trial. The athletes were encouraged to perform a maximal number of repetitions until the concentric fail (3).

A CMJ test was performed to determine the explosive muscle power of MMA athletes' lower limbs. Athletes stood on a portable jump platform (Jump System Pro – CEFISE, SP-Brazil) with arms akimbo (i.e., hands on the hips with elbows directed outwards) and were instructed to perform a maximal-height CMJ. The best of 3 trials was retained. The jump platform
software (Software Jump System 1.0) presents the contact time, flight time, and maximal reached height. Then, it provides the data of the jump in centimeters, Watts, and Watts/Kg. The data of the maximal CMJ test are presented in Watts.

Sample Collection and DNA Extraction
Blood samples from the MMA athletes were drawn from an antecubital arm vein using a 20-gauge disposable needle equipped with a Vacutainer tube holder (Becton Dickinson, Franklin Lakes, NJ). The collected samples (10 mL) were held in Vacutainer tubes containing SST-Gel and a Clot Activator. The samples in the tubes were then stored under refrigeration (2° to 8°C) for a maximum of 7 days until the DNA extraction. Genomic DNA was extracted from leukocytes in samples of whole blood using the salting-out technique (kit: BioPur Spin 50 - Biometrix, Curitiba) as recommended by the manufacturer's instructions.

ACTN3 R577X Single Nucleotide Polymorphism Genotyping
A DNA fragment carrying the exon 16 from the ACTN3 gene R577X polymorphism was amplified from the genomic DNA and the following initiators were used: 5'-CTGTGCTGCTGTGGTAAGTGGG-3'; reverse, 5'-TGGTCACAGTATGCAGGAGGG-3', correlated to the adjacent intronic sequences (22). The polymerase chain reaction (PCR) analysis was used in the same manner as in Pimenta et al. (26). The amplification program consisted of an initial denaturation at 94°C for 5 min, followed by 30 cycles, comprising 94°C for 1 min, 64°C for 1 min, and 72°C for 1 min with a final extension of 72°C for 5 min. The R577X alleles (codons CGA and TGA) were distinguished by the presence (577X) or absence (577R) of a restriction site of the enzyme DdeI (22). The ACTN3 577R allele generates fragments in 205 and 86 base pairs (bp), while the ACTN3 577X allele generates fragments in 108, 97, and 86 (37).

Statistical Analyses
SPSS 20.0 for Windows (SPSS, Inc., New York, USA) was used for the data analysis. A one-way analysis of variance followed by the post hoc Tukey’s test was used to compare the MMA athletes’ muscle strength and power for different genotype groups of ACTN3 (RR, RX and XX). To analyze the dominant (RR vs. RX+XX) and recessive model (RR+RX vs. XX), an independent t test was used. The level of significance was set at P<0.05. The data are presented in this study as mean ± SD.

RESULTS
It has been noted that RX individuals are able to complete more repetitions (19.66 ± 2.34) than RR individuals (15.00 ± 3.68) in the squat exercise performed with 70% of 1RM (P=0.02), while XX individuals did not show any difference with other groups. No other differences were observed among the ACTN3 genotype groups in the handgrip, 1RM supine and squat exercises, 70% of 1RM supine exercise and CMJ tests (Table 1). Regarding the dominant model (RR vs. RX+XX) of ACTN3 genotype, only a single statistical difference was detected among the muscle strength and power tests, where RX+XX group completed more repetition (18.75 ± 2.73) in the squat exercise with 70% of 1RM than RR individuals (15.00 ± 3.68) (P=0.04) (Table 2). In the recessive model (RR+RX vs. XX) of ACTN3 genotype, the difference found was in the CMJ test, where the power of the jump test of the RR+RX group
(5631.31 ± 421.67 Watts) was higher than the XX group (5141.75 ± 17.84 Watts) (P=0.03) (Table 3).

Table 1. Comparison of Different Groups of ACTN3 Genotype Expressions (RR, RX and XX) in the Muscle Strength and Power Phenotypes of MMA Athletes (mean ± SD).

<table>
<thead>
<tr>
<th></th>
<th>RR</th>
<th>RX</th>
<th>XX</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N = 6</td>
<td>N = 9</td>
<td>N = 3</td>
<td></td>
</tr>
<tr>
<td>Handgrip Test</td>
<td>39.50 ± 11.79</td>
<td>46.44 ± 9.68</td>
<td>36.33 ± 3.21</td>
<td>0.24</td>
</tr>
<tr>
<td>1RM Supine</td>
<td>1.27 ± 0.14</td>
<td>1.19 ± 0.14</td>
<td>1.18 ± 0.1</td>
<td>0.50</td>
</tr>
<tr>
<td>1RM Squat</td>
<td>1.64 ± 0.27</td>
<td>1.40 ± 0.21</td>
<td>1.49 ± 0.19</td>
<td>0.19</td>
</tr>
<tr>
<td>70% of 1RM Supine</td>
<td>15.83 ± 3.25</td>
<td>15.33 ± 2.44</td>
<td>14.00 ± 0.00</td>
<td>0.61</td>
</tr>
<tr>
<td>70% of 1RM Squat</td>
<td>15.00 ± 3.68*</td>
<td>19.66 ± 2.34*</td>
<td>16.00 ± 2.00</td>
<td>0.02</td>
</tr>
<tr>
<td>CMJ</td>
<td>5529.82 ± 356.56</td>
<td>5698.00 ± 467.78</td>
<td>5141.75 ± 17.83</td>
<td>0.14</td>
</tr>
</tbody>
</table>

Handgrip test expressed in Kilogram-force (Kgf); 1RM Supine and Squat tests expressed in relative strength (maximal achieved load / body weight); 70% of 1RM Supine and Squat tests expressed in number of repetitions; CMJ expressed in Watts. *Statistical difference by ANOVA test (P<0.05).

Table 2. Comparison of Dominant Model (RR vs. RX+XX) of ACTN3 Genotype in the Muscle Strength and Power Phenotypes of MMA Athletes (mean ± SD).

<table>
<thead>
<tr>
<th></th>
<th>RR</th>
<th>RX+XX</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N = 6</td>
<td>N = 12</td>
<td></td>
</tr>
<tr>
<td>Handgrip Test</td>
<td>39.50 ± 11.79</td>
<td>43.91 ± 9.54</td>
<td>0.45</td>
</tr>
<tr>
<td>1RM Supine</td>
<td>1.27 ± 0.14</td>
<td>1.19 ± 0.12</td>
<td>0.30</td>
</tr>
<tr>
<td>1RM Squat</td>
<td>1.64 ± 0.27</td>
<td>1.43 ± 0.20</td>
<td>0.30</td>
</tr>
<tr>
<td>70% of 1RM Supine</td>
<td>15.83 ± 3.25</td>
<td>15.00 ± 2.17</td>
<td>0.70</td>
</tr>
<tr>
<td>70% of 1RM Squat</td>
<td>15.00 ± 3.68*</td>
<td>18.75 ± 2.73*</td>
<td>0.04</td>
</tr>
<tr>
<td>CMJ</td>
<td>5529.82 ± 356.56</td>
<td>5559.66 ± 471.92</td>
<td>0.92</td>
</tr>
</tbody>
</table>

Handgrip test expressed in Kilogram-force (Kgf); 1RM Supine and Squat tests expressed in relative strength (maximal achieved load / body weight); 70% of 1RM Supine and Squat tests expressed in number of repetitions; CMJ expressed in Watts. *Statistical difference by independent t test (P<0.05).
Table 3. Comparison of Recessive model (RR+RX vs. XX) of ACTN3 Genotype in the Muscle Strength and Power Phenotype of MMA Athletes (mean ± SD).

<table>
<thead>
<tr>
<th></th>
<th>RR+RX</th>
<th>XX</th>
<th>P - Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N = 15</td>
<td>N = 3</td>
<td></td>
</tr>
<tr>
<td>Handgrip Test</td>
<td>43.66 ± 10.75</td>
<td>36.33 ± 3.21</td>
<td>0.19</td>
</tr>
<tr>
<td>1RM Supine</td>
<td>1.22 ± 0.14</td>
<td>1.18 ± 0.06</td>
<td>0.76</td>
</tr>
<tr>
<td>1RM Squat</td>
<td>1.50 ± 0.26</td>
<td>1.49 ± 0.19</td>
<td>0.95</td>
</tr>
<tr>
<td>70% of 1RM Supine</td>
<td>15.53 ± 2.69</td>
<td>14.00 ± 0.00</td>
<td>0.28</td>
</tr>
<tr>
<td>70% of 1RM Squat</td>
<td>17.80 ± 3.68</td>
<td>16.00 ± 2.00</td>
<td>0.40</td>
</tr>
<tr>
<td>CMJ</td>
<td>5631.31 ± 421.67*</td>
<td>5141.75 ± 17.84*</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Handgrip test expressed in Kilo gram-force (Kgf); 1RM Supine and Squat tests expressed in relative strength (maximal achieved load / body weight); 70% of 1RM Supine and Squat tests expressed in number of repetitions; CMJ expressed in Watts. *Statistical difference by independent t test (P<0.05).

DISCUSSION

The aim of this study was to compare the skeletal muscular strength and power phenotypes of Brazilian MMA athletes separated in different groups of ACTN3 R577X genotypes. This study tested the isometric forearm strength by a handgrip test, the maximal capacity of upper and lower body force production by supine and squat 1RM tests, the local muscular endurance of the upper and lower body by supine and squat tests with load set at 70% of 1RM, and the explosive muscular power of the lower body by a CMJ test. First, the MMA athletes were separated into three groups of ACTN3 genotypes (RR, RX and XX) to compare the differences of the muscular performance phenotype tests. Next, they were separated in dominant (RR vs. RX+XX) and recessive model (RR+RX vs. XX) of ACTN3 genotypes to compare the same muscular tests.

This study did not find any difference in the muscular strength of MMA athletes in the upper body tests (isometric forearm strength, 1RM, and 70% of 1RM in the supine test). However, in the lower body tests several differences were observed. Individuals with RX genotype completed more repetitions (19.66 ± 2.34) in the squat exercise with 70% of 1RM than individuals with RR genotype (15.00 ± 3.68) (P=0.02) (Table 1). Also, the dominant model of ACTN3 genotype showed that the RX+XX group completed more repetitions (18.75 ± 2.73) in the squat exercise with 70% of 1RM than the RR group (15.00 ± 3.68) (P=0.04) (Table 2). As to the explosive muscular power phenotype, it was the recessive model group (RR+RX) that presented the higher score in the CMJ test than the XX group (5631.31 ± 421.67 and 5141.75 ± 17.84 Watts, respectively) (P=0.03) (Table 3).
The ACTN3 RR and RX genotypes have generally been associated with high speed and strength athletes (20,35), while the XX genotype has been associated with aerobic endurance performance (1,7). Furthermore, Yang et al. (37) identified a higher frequency of ACTN3 RR genotype and allele R in professional athletes involved in tasks that require physical strength and power capacities. The data from this research did not indicate any associations between ACTN3 R577X genotypes and isometric or dynamic maximal strength in the MMA athletes. These results were theoretically unexpected based on the role of ACTN3 on skeletal muscle phenotypes (20). Nevertheless, it did show an association between muscular power and the RR+RX group in the lower body jumping test. Moreover, another interesting association that did emerge was the muscle strength endurance of RX individuals when compared with the RR genotype and with the dominant model of ACTN3 genotype group (RX+XX).

Case control studies regarding the association of the effect of the ACTN3 R577X polymorphism on muscular strength and power phenotypes have uncovered some contradictions. Whereas some studies recorded no effect (21,33), others have reported an advantageous effect of the RR genotype (8,36). The study of Pimenta et al. (26) showed that RR soccer players have higher rates in jump test than RX and XX players. The association of muscle power with the recessive model of ACTN3 in the present study seems to confirm the R allele of ACTN3 role on the muscle power (20). In contrast however, Ruiz et al. (31) allege that ACTN3 R577X polymorphism does not influence the leg muscle power by jump test in volleyball players. This contradiction may indicate that the ACTN3 has different effects in skeletal muscle power phenotype in elite athletes of different sports (e.g., soccer, volleyball, and MMA). Clarkson et al. (8) reported no association between the ACTN3 and isometric strength in men, yet they showed that women with XX genotype had lower isometric strength than those with RX. The present study showed that XX individuals have 21.77% lower forearm isometric strength than those with RX genotype (P=0.24) and 16.79% lower than the RR+RX group (P=0.19). However, not one of these results presented a statistical difference. Perhaps, this incongruity arose because of the relatively small number of MMA athletes in each group of genotypes.

Some exercise physiologists and sports scientists have searched for potential genetic factors contributing to high-level physical performance in combat sports (candidate gene or candidate polymorphism) (11). ACNT3 is one of the most extensively studied gene so far. A number of studies (15,16,30) have found higher frequency of the R577X variant of the ACTN3 gene in wrestlers than in the general population or control groups. Kikuchi and colleagues (15,16) have found higher frequency of R allele in combat sport athletes than control groups. Ribas and colleagues (30) found higher frequency of RR genotype in Brazilian elite fighters than in the control group drawn from the general population and concluded that the genotypic distribution of Brazilian fighters were favorable to activities of strength and power.

To explain the differences in ACTN3 between athletes involved in combat sports and controls, Kikuchi and colleagues (16) suggested that XX genotype individuals, being completely deficient in ACTN3 protein, would have inferior function of skeletal muscles during the force generation of contraction or a low ability to recover from high-intensive intermittent sports. These factors might determine some aspects of performance in fight matches, which
could explain why the ACTN3 RR and RX genotypes and R allele would be associated with the level of combat sport athletes' performance. On the other hand, the present study observed that the RX athletes had a more prominent effect on the skeletal muscle endurance performance than RR. Moreover, the RX+XX group also presented better a result in the same muscular endurance test than RR athletes. This finding indicated that X allele may play an important role on the local muscular endurance of the MMA athletes.

However, the knowledge of associations of ACTN3 and skeletal muscle phenotypes must be analyzed and interpreted with caution. Although a lower prevalence of the XX genotype was observed in muscle power athletes (32,37), notable exceptions have been reported. One good example is the Spanish Olympian long jump athlete (personal best of 8.26 m), whose genotype is XX (19). Another example is the Russian world record holder in hammer throwing whose genotype is XX (11). The aforementioned studies have demonstrated an associated between ACTN3 and skeletal muscle performance, and they have used a large number of individuals of a specific group of athletes or people at a rate of 95% of probability. Previous studies (19,11) indicate that ACTN3 R577R polymorphism should not be taken into account when considering the physical performance of the individual athlete.

CONCLUSIONS

The data in this study did not find an association between the ACTN3 R577X polymorphism and upper body muscle performance (isometric forearm maximal strength, dynamic maximal voluntary strength by 1RM supine test, and maximal endurance strength by 70% of 1RM supine test). However, the findings do support MMA athletes with ACTN3 RX genotype present better local muscle endurance than RR athletes. Moreover, the dominant model (RR vs. RX+XX) of ACTN3 genotype also presented greater local muscle endurance. As to the explosive muscle power of MMA athletes' lower limbs, the recessive model (RR+RX vs. XX) of ACTN3 genotype showed greater responses, confirming the ACTN3 role on the muscle power phenotype.

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