

No Association Between *ACTN3* R577X Polymorphism and Elite Judo Athletic Status

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The authors compared *ACTN3* R577X genotype and allele frequencies in the majority of all-time-best Spanish judo male athletes ($n = 108$) and 343 ethnically matched nonathletic men. No between-groups differences were found in allele ($P = .077$) or genotype distributions ($P = .178$). Thus, the R577X polymorphism was not significantly associated with the status of being an elite judo athlete, at least in the Spanish population. The contribution of genetics to sports-related phenotype traits is undeniable with some genotypes, of which *ACTN3* R577X is currently the leading candidate, partly distinguishing individuals predisposed to either endurance or power sports. However, few athletic events can be categorized as purely power or endurance based. Although genetic testing (ie, for *ACTN3* R577X) is already being marketed to predict sports talent and potential of young children, its usefulness is still questionable, at least in competitive judo.

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How the millions of variations in the human genome influence athletic performance is virtually unknown. Although 200+ and 20+ polymorphisms could be influential to fitness-related phenotypes and elite athletic status, respectively, published results are often controversial. Probably the only strong evidence is that speed/power and endurance genes differ. During human evolution, tradeoff of these genes would have inherently predisposed individuals to be more sprinters or more endurers.¹ This phenomenon is illustrated by the R577X variation in *ACTN3*, the strongest “sports-gene” candidate. *ACTN3* encodes α -actinin-3, a sarcomeric protein required for explosive, powerful muscle contractions that is almost exclusively expressed in fast-twitch muscle fibers.² Approximately 1 billion people worldwide are α -actinin-3-deficient due to a genetic defect in both gene copies—they have the null 577XX genotype, which theoretically precludes them from ever becoming Olympic champions in “pure” sprint or power events, but not in endurance sports.³

No study has specifically assessed the *ACTN3* R577X genotype of elite judo athletes, which is of potential interest for professionals involved in the sport, for example, for eventual talent detection based on genetic testing. Competitive judo is a combative, high-intensity intermittent sport in which the athlete tries to throw the opponent onto his back or to control him during groundwork combat, both of which attempts depend on complex tactical skills and high muscle anaerobic power, especially in the upper body.⁴ Since 2003 the format of international judo competition has been 1 continuous 5-minute period, which can be complemented by additional time until 1 judoka scores or until the end of the new 5-minute bout.⁵ Thus, the mean duration of a men’s match is ~7 minutes,⁴ and, although anaerobic metabolism is thought to be the primary energy source for this sport (eg, with mean plasma lactate concentrations of ~12 mmol/L at the end of a match), aerobic pathways (involving carbohydrate, as well as lipid and protein, metabolism) are also involved.⁶ Furthermore, although maximal aerobic capacity (VO_{2max}) is not a discriminatory variable in competitive performance, it is a valuable one; judokas with higher VO_{2max} values might have an advantage in combats lasting the maximal 10-minute duration allowed.⁵

We determined *ACTN3* R577X genotype and allele frequencies in the majority of all-time-best Spanish judo male athletes ($n = 111$, current age range 18–75 y, 57.7% still active). All had experience in international competitions and had been medalists in at least 1 Spanish judo championship. They can be classified according to athletic level following the criteria by Druzhevskaya et al⁷ as

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follows: 7 (6.3% of total) were highly elite, being at least winners of the World Championships, World Cups, and Olympic Games; 15 (13.5%) were elite, being at least silver or bronze medalists of the World Championships, World Cups, and Olympic Games or prize winners of Europe Championships; and 89 (80.2%) were subelite, participants in international competitions. The results obtained in the whole judo group were compared with those we recently reported in 343 ethnically matched nonathletic men.⁸ The study was approved by the ethics committee of the European University of Madrid.

Genomic DNA was isolated from athletes' buccal epithelium, and genotyping was performed with pre-designed Applied Biosystems TaqMan SNP genotyping assays on demand. Polymerase chain reaction amplification was performed using a StepOne real-time PCR system (Applied Biosystems, Foster City, CA), with a denaturation stage at 95°C for 10 minutes, 50 cycles of denaturation at 92°C for 15 seconds, annealing/extension at 60°C for 1 minute, and a final extension stage of 30 seconds at 60°C. We tested Hardy-Weinberg equilibrium and compared allele and genotype frequencies between the 2 groups with the χ^2 test ($\alpha = .05$).

Genotype success in athletes was 97.3%; their genotype distribution met Hardy-Weinberg equilibrium ($P >$

.1). No between-groups differences were found in allele ($P = .077$) or genotype distribution ($P = .178$; Figure 1). Thus, the R577X polymorphism was not significantly associated with the status of being an elite judo athlete, at least in the Spanish population. Despite muscle power being considered a determinant phenotype for elite judo success⁴ (and in fact the classic paper that first reported an association between *ACTN3* R577X and sports performance included 9 judo players in the whole cohort [N = 107] of power athletes³) and the 577X-allele's being theoretically detrimental to power-sports performance,^{1,3} the 577X allele and the 577XX genotype were clearly not underrepresented in our judo group. In fact, both power (R577) and endurance (577X) alleles were almost equally frequent (~50% each) in the whole judo group, which largely discards a major performance influence of this polymorphism.

Our findings suggest that, at least with regard to the *ACTN3* R577X polymorphism, the genotype of elite judo athletes resembles that of mixed-type-sport athletes more than that of pure power athletes. This is in line with research pointing to a relevant contribution of oxidative pathways, together with anaerobic metabolism, to the muscle energy output of a judo match and its recovery,⁶ with elite judo players being powerful athletes but also

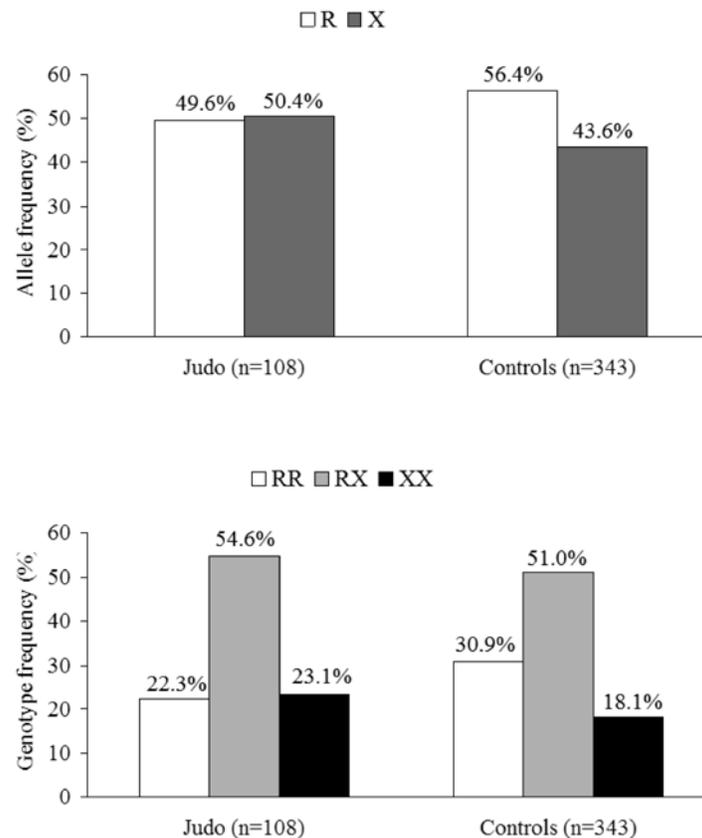


Figure 1 — Allele and genotype frequency distribution by group. No significant between-groups differences were found (allele, $\chi^2 = 3.136$, $P = .077$; genotype, $\chi^2 = 3.449$, $P = .178$).

having above-average endurance capacity. In fact, recent research showed higher frequency of the I allele and II genotype in the angiotensin-converting enzyme (*ACE*) gene (which theoretically would favor endurance performance) in elite Polish and Lithuanian judokas, suggesting that genetic predisposition for longer fighting is at least as important (if not more so) than genetic predispositions to speed or power.⁹

Although the contribution of genetics to sports-related phenotype traits is undeniable with some genotypes, of which *ACTN3* R577X is currently the leading candidate, partly distinguishing individuals predisposed to either endurance or power sports, few athletic events can be categorized as purely power or endurance based; as such, sports performance is usually polygenic and not simply reducible to single candidate gene variants. There are indeed numerous other contributors to the complex trait of being an athletic champion that are likely not reducible to defined genetic polymorphisms, included complex gene–gene and gene–environment interaction and interactions between genetic variants that might not influence sports performance individually. In addition, a potential confounder to be kept in mind is that control groups in sports genetics association studies might also include some apparently nonathletic individuals who have a favorable genetic predisposition to sports performance of which they and researchers are unaware. Indeed, only an extremely small fraction of the population of a given country (irrespective of genetic endowment) participates in the artificial selection process (including stringent training regimens starting in childhood) that ends with the attainment of elite sports performance. Although genetic testing (ie, of *ACTN3* R577X) is already being marketed to predict sports talent and potential of young children, its usefulness is still questionable, at least in competitive judo.

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