

NEW FRONTIERS IN SPORT TRAINING: GENETICS AND ARTISTIC GYMNASTICS

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ABSTRACT

Morucci, G, Punzi, T, Innocenti, G, Gulisano, M, Ceroti, M, and Pacini, S. New frontiers in sport training: Genetics and artistic gymnastics. *J Strength Cond Res* 28(2): 459–466, 2014—The increasing understanding of the genetic influences in sport has prompted an association study between the athletic performances and the polymorphisms of the angiotensin-converting enzyme (ACE), the α -actinin-3 (ACTN3), and the vitamin D receptor genes. The details of these gene polymorphisms can provide useful information to improve and plan new modern training programs for elite athletes. Eighty Italian male high level gymnasts were trained and tested for gymnastic-specific exercises and tested in all the men's artistic gymnastic apparatus (floor, pommel horse, rings, vault, parallel bars, and horizontal bar), and then genotyped. The training parameters of volume, intensity, and density of each gymnast were periodically measured during the season in each apparatus from the tests performed, and the seasonal average values were calculated. Gene polymorphisms were determined by polymerase chain reaction restriction fragment length polymorphism assay and studied in association with the performance results. The performances of ACE II gymnasts were significantly lower than that of the ACE ID/DD gymnasts in the apparatus expressing power features, confirming the predisposition of these athletes toward power-oriented sport. Gymnasts with ACTN3 RR/RX genotypes did not show a predisposition to the power-oriented apparatus, having worse performances compared with that of the ACTN3 XX gymnasts. Similarly, gymnasts with ACE II + ACTN3 RR/RX combined genotypes showed lower performances in comparison with that of the other gymnasts. Vitamin D receptor polymorphisms showed no significant association with the athletic performances. Because ACE insertion/deletion (I/D) and ACTN3 R577X polymorphisms heavily affect the physical performance of elite male gymnasts, the Italian Gymnastic

Federation trainers have started to customize the current high-level training programs.

KEY WORDS gene polymorphism, athletic performance, ACE, ACTN3, VDR

INTRODUCTION

Athletic performance can be considered a multifactorial condition determined by a complex and often poorly understood interaction between environmental and genetic factors. Athletes are a mix of many complex factors (sociocultural, psychological, anatomic, and physiological), so the physical performance is derived from a combination of inherent genes and the overall environmental conditions (5). Even though the skills required for success in sport at the elite level are mainly based on effective and individual training regimens, we may no longer ignore the ever-increasing findings for the genetic contributions made to the individual differences in physical performance. In recent years, significant data have been accumulated confirming the association between numerous genetic loci and physical performance (1,24).

In this study, we focused our attention on the gene polymorphisms of 3 genes that are considered to influence athletic performance: the insertion/deletion (I/D) polymorphism of the angiotensin-converting enzyme (ACE) gene; the single nucleotide polymorphism (SNP) of the α -actinin-3 (ACTN3) gene, and the SNP of the vitamin D receptor (VDR) gene.

In addition to being involved in regulating blood pressure homeostasis, ACE is expressed in skeletal muscle where its product (angiotensin II) acts as a growth factor inducing muscle hypertrophy and a gain in strength. Angiotensin-converting enzyme genotype is associated with the serum and tissue ACE activity: I and D alleles are related to a lower and higher ACE activity and consequently to low and high levels of angiotensin II, respectively. The higher frequency of ACE II genotype observed in endurance-oriented athletes suggests that the ACE I allele can favor the cardiorespiratory endurance performances. On the contrary, the association between ACE DD genotype and elite sprint and power athlete status seem to support the hypothesis that ACE D allele can predispose to power and strength-oriented performances (1,16,24).

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The ACTN3 gene codes for the α -actinin-3, a human skeletal muscle protein only found in fast twitch fibers that is responsible for generating fast powerful contractions. The ACTN3 R577X polymorphism is related to generate 2 possible variants of the protein, both common in the general population: the R allele generates the normal, functional ACTN3, whereas the X allele contains a premature stop codon preventing the production of a functional protein. Several studies report that ACTN3 RR genotype may confer some advantage in power performances, whereas the ACTN3 XX genotype is assumed to preclude top-level athletic performance in power and sprint sports (1,10,26). The absence of ACTN3 resulting in the XX genotype is believed to provide an advantage to endurance athletes by generating a more efficient energy storage or use of energy reserves (9,25).

The role of some VDR gene polymorphisms in affecting the physical performance was hypothesized because of the pleiotropic effects of vitamin D in bone formation and mineralization and in muscle function. The single nucleotide BsmI, ApaI, TaqI, and functional FokI VDR polymorphisms were specifically studied. Some of these polymorphisms were related to differences in strength and changes in bone mineral density because of a response in training (15), but very few studies exist overall on the direct relationship between the VDR gene polymorphisms and sport performance.

In this study, we selected a group of high-level male gymnasts participating in national and international competitions. The study was to evaluate the role of these genetic factors in affecting athletic performance in gymnastics and to acquire new components useful to improve the new gymnastic top-level training programs. Each athlete was genotyped for the ACE I/D, R577X ACTN3 and BsmI, ApaI, TaqI, and FokI VDR polymorphisms. The athletes were scored for their athletic and technical performance in each of the men's artistic gymnastic apparatus (i.e., floor, pommel horse, rings, vault, parallel bars, and horizontal bar) and in generic physical performance evaluations.

Finally, the association between gene polymorphisms and athletic performance results was statistically analyzed.

METHODS

Experimental Approach to the Problem

The association between the ACE, ACTN3, and VDR polymorphisms, and the athletic performance tests of the male gymnasts was studied to clarify the role of the genetic factors in affecting athletic ability in gymnastics.

Subjects

Eighty white male gymnasts from the Italian gymnastic team participating in international competitions were enrolled in this study. The sample size and distribution were representative for the referring population by both category and agonistic level. The average age of the gymnasts had a mean of 14.5 ± 4.2 years. The average training time was $31 \pm 1 \text{ h} \cdot \text{wk}^{-1}$. The study was performed in accordance with the required ethical

standards and was approved by the president and the ethic committee of the Italian Gymnastic Federation (FGI). All participants in the study provided informed consent, and all subjects under 18 years of age provided informed consent from a parent or guardian. The study protocol was in accordance with the Declaration of Helsinki for Human Research.

Procedures

Data collection occurred between 2009 and 2011. At the beginning of the preseason training, aptitude, and athletic performance tests were administered to each gymnast as a prognostic evaluation of their physical fitness status. All the tests administered were performed following the standards and guidelines established by the National Strength and Conditioning Association and the EUROFIT, European Tests of Physical Fitness (3,20).

The aptitude prognostic tests included the evaluation of body size and composition by the measurement of height, weight, circumferences of the waist, the dominant arm and thigh, and body fat percentage by the 3-site skin fold test (8). The athletic prognostic tests included a cardiovascular endurance test (3-minute Young Men's Christian Association [YMCA] step test), strength tests (1 repetition maximum [1RM] power clean, 1RM bench press, 1RM back squat, and 1RM leg press), local muscular endurance tests (curl-up, push-up, pull-up, and YMCA bench press tests performed in burnout sets and supersets), flexibility tests (YMCA sit and reach, goniometer, and shoulder flexibility tests), a balance test (Flamingo balance test) (19), a speed test (30-m sprint test to assess the ability to cover quickly a straight line distance) and a quickness test (Harre circuit test to assess the ability to react quickly and move over a short distance changing directions) (7,22,23,27). Some tests on the theoretical athletic performance gradient (providing a prognosis of the "trainability" of the athlete) were also administered and included an explosive strength test (40-, 80-, and 120-cm drop jump test for 15, 30, and 60 seconds, respectively), an explosive resistance test (40-, 80-, and 120-cm rebound jump test for 15, 30, and 60 seconds, respectively), and the Wiener Koordinationsparcours (WKP) test, a measure of the ability to combine the best possible performance to the shortest available time to perform it (6).

The second stage of the study occurred after a 2-month common training program based on the average physical fitness status of the gymnasts. Additional technical-tactical performance tests were administered to each gymnast. The administered technical-tactical performance tests were the Variability Speed in Technical Circuit test, the Interval and Intermittent Technical Training test, the Circuit and Cross Technical Training, and the Power and Pace-time Technical Training test (4). These performance tests are based on the intermittent training programs and are specifically designed for artistic gymnastics following the methodological guidelines of the Fédération Internationale de Gymnastique (21).

A new gymnastic-specific training program based on these tests was planned and administered to each gymnast during

the season (9 months). It included specific physical exercises, exercise circuits, and tests in all the men's artistic gymnastic apparatus (i.e., floor, pommel horse, rings, vault, parallel bars, and horizontal bar) and other generic athletic performance evaluations named Propaedeutic Physical Preparation (PPP) and Physical/Athletic Ability (PAA) based on the incremental training load. The parameters of volume, intensity, and density of the gymnasts were periodically measured for each apparatus from the tests performed. The volume (V) represents a derived measure of the total amount of the load performed during a training session. In gymnastics, V is based on the summation of the single training units, movements (M_v), elements (E_i), and exercises (E_s); $V = \sum(M_v; E_i; E_s)$. The intensity (I) is a measure of the volume related to the available time during the performance (t). The I represents an index of the performance gradient; $I = V/t$. The density (D) is expressed by the ratio of the time that the athlete needs to restore a normal heart rate after the performance (T , recovery time) and the time of the performance (t); $D = T/t$. This means that the lower is the recovery time, the greater is the adaptation of the athlete to the training load. Hence, D is considered an appropriate parameter for the evaluation of the endogenous capability of the athlete to adapt to the training load. The seasonal average values of V , I , and D for each gymnast were calculated from each apparatus and studied in conjunction with the results of the genetic analyses.

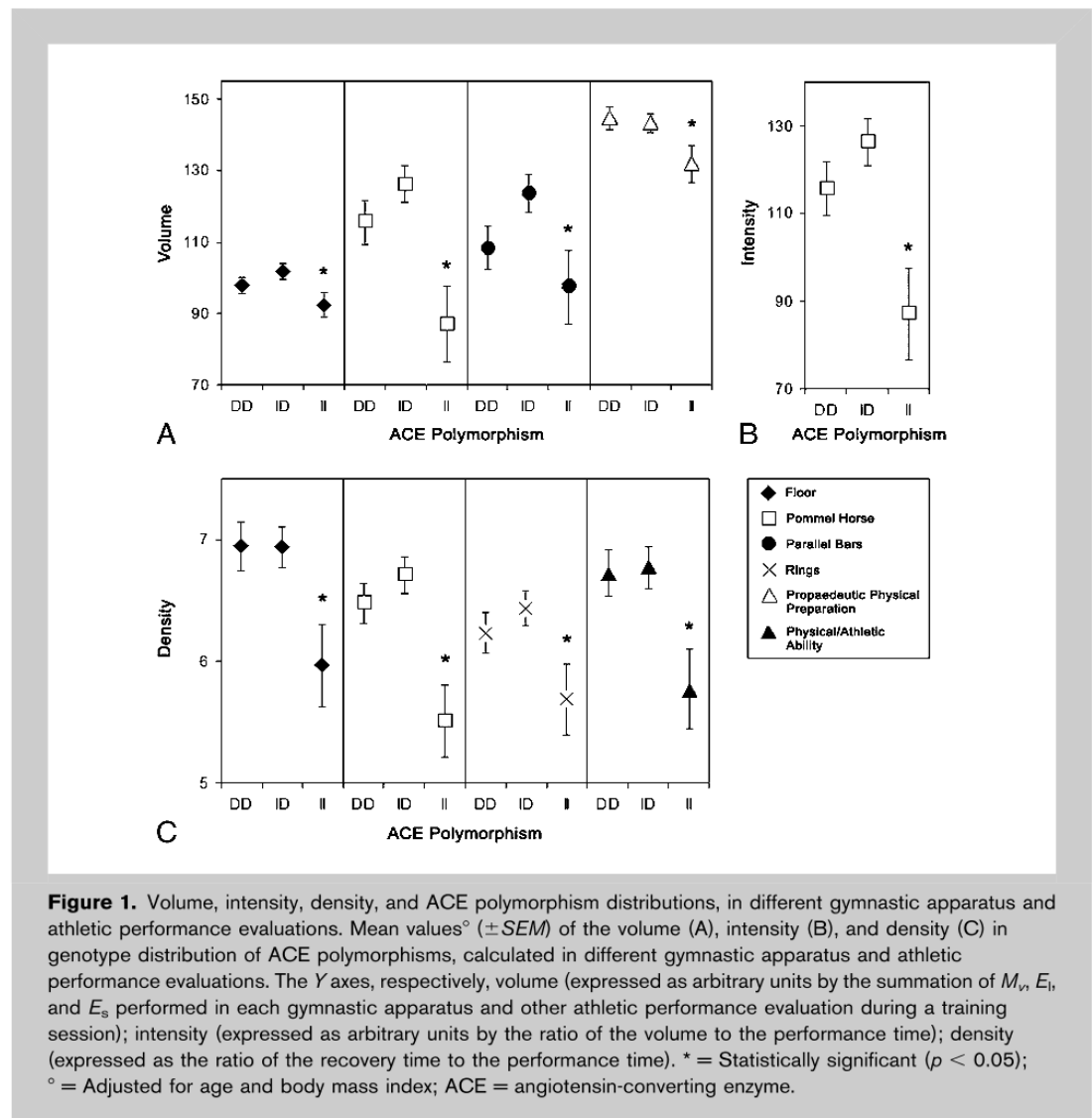
Genetic Analyses

At the beginning of the season 100 μ l of peripheral blood from each gymnast was collected by lancing the finger using a Softclix lancet (Boehringer Mannheim GmbH, Mannheim, Germany). The sample was used to extract genomic DNA using a Qiagen kit (QIAamp DNA Blood Mini Kit; Qiagen Srl, Milan, Italy). Genotyping of the ACE I/D, ACTN3 R577X, and VDR BsmI, FokI, ApaI, and TaqI polymorphisms was performed by polymerase chain reaction (PCR) amplification and restriction fragment length polymorphism (RFLP) assays. The I and D alleles of the ACE gene were detected as described previously (11,17).

The ACTN3 R577X genotypes were determined by a new PCR RFLP assay (14) with amplicons digested by *DdeI* restriction enzyme (Fermentas/M-Medical Srl, Milan, Italy). The polymorphisms of the VDR gene, BsmI, FokI, ApaI, and TaqI, were digested, respectively, with *BsmI*, *FokI*, *ApaI*, and *TaqI* restriction enzymes (Fermentas/M-Medical Srl) (2). All the reaction products were visualized by electrophoresis on a 2% agarose gel stained with ethidium bromide. The PCR amplifications (Type-it Microsatellite PCR Kit; Qiagen Srl, Milan, Italy) were performed by a Mini Cycler (MJ Research, Waltham, MA, USA). The restriction enzyme digestion protocols were performed according to the manufacturer's specifications.

Statistical Analyses

Group comparisons were carried out by means of 1-way analysis of covariance for multiple comparisons adjusted for relevant confounders (age and body mass index [BMI]). The χ^2 test was performed both to confirm that the ACE, ACTN3, and VDR observed genotype frequencies were in the Hardy-Weinberg equilibrium and to compare the genotype frequencies



of the gymnasts examined in this study with data from the literature. Student's *t*-test was performed to compare specific genotype combinations with the sum of the other combinations to better analyze specific polygenic profiles. All the analyses were performed using Statistical Analysis Systems (SAS/STAT module version 9.2; SAS Institute, Cary, NC, USA). A *p* value ≤ 0.05 was considered to be statistically significant.

RESULTS

Angiotensin-Converting Enzyme Polymorphism and Performance

The mean values (adjusted for age and BMI) of *V*, *I*, and *D*, calculated over the entire group of gymnasts in each gymnastic apparatus (floor, pommel horse, rings, vault, parallel bars, and horizontal bar) and in the other performance evaluations (PPP and PAA), resulted in significant differences within the genotype distribution of ACE I/D polymorphisms (Figure 1).

In particular, the mean values of *V* in the gymnasts carrying the ACE II genotype ($n = 10$) were significantly lower when compared with those of the gymnasts carrying the ID and DD genotypes ($n = 40$ and $n = 30$, respectively) for exercises in the floor (II vs. ID, $p = 0.02$), pommel horse (II vs. ID, $p = 0.002$; II vs. DD, $p = 0.02$), and parallel bars (II vs. ID, $p = 0.03$), and in the PPP (II vs. DD, $p = 0.04$) (Figure 1A). In addition, the mean values of *I* in the II genotypes resulted in being significantly lower than in the other ACE genotypes in the pommel horse apparatus (II vs. ID, $p = 0.03$; II vs. DD, $p = 0.02$) (Figure 1B). Finally, the II genotypes showed mean values of *D* significantly lower than in the other ACE genotypes in the floor (II vs. ID, $p = 0.01$; II vs. DD, $p = 0.01$), pommel horse (II vs. ID, $p = 0.001$; II vs. DD, $p = 0.006$), and rings (II vs. ID, $p = 0.02$) apparatus, and in the PAA (II vs. ID, $p = 0.01$; II vs. DD, $p = 0.02$) (Figure 1C).

Alpha-Actinin-3 Polymorphism and Performance

The mean values for the ACTN3 R/X genotypes (adjusted for age and BMI) of *V*, *I*, and *D* were significantly different for various

gymnastic apparatus (Figure 2). In particular, gymnasts with the XX ($n = 13$) genotype showed mean values of *V* significantly higher than those of the gymnasts with the other ACTN3 genotypes (RX genotype, $n = 46$; RR genotype, $n = 21$) in the parallel bars (XX vs. RR, $p = 0.02$; XX vs. RX, $p = 0.005$) and horizontal bar (XX vs. RR, $p = 0.04$; XX vs. RX, $p = 0.03$) apparatus (Figure 2A). Also, the mean values of *I* in the XX genotypes resulted in being significantly higher than in the other genotypes in the parallel bars (XX vs. RR, $p = 0.01$; XX vs. RX, $p = 0.008$) and vault (XX vs. RR, $p = 0.02$; XX vs. RX, $p = 0.05$) apparatus (Figure 2B). Furthermore, XX genotypes showed mean values of *D* as being significantly higher than in the other ACTN3 genotypes in the pommel horse (XX vs. RR, $p = 0.05$), parallel bars (XX vs. RR, $p = 0.05$; XX vs. RX, $p = 0.05$), and horizontal bar (XX vs. RR, $p = 0.04$; XX vs. RX, $p = 0.03$) apparatus (Figure 2C).

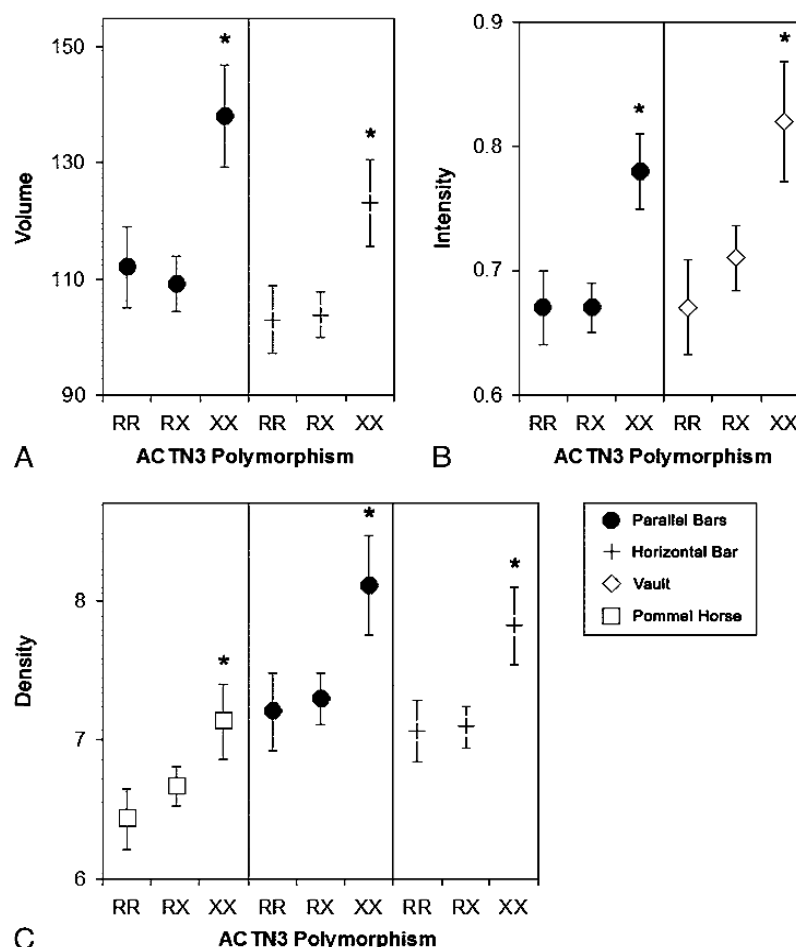


Figure 2. Volume, intensity, density, and ACTN3 polymorphism distributions, in different gymnastic apparatus/athletic performance evaluations. Mean values (\pm SEM) of the volume (A), intensity (B), and density (C) in genotype distribution of ACTN3 polymorphisms, calculated in different gymnastic apparatus/athletic performance evaluations. The Y-axes, respectively, volume (expressed as arbitrary units by the summation of M_v , E_v , and E_s performed in each gymnastic apparatus/other athletic performance evaluation during a training session); intensity (expressed as arbitrary units by the ratio of the volume to the performance time); density (expressed as the ratio of the recovery time to the performance time). * = Statistically significant ($p < 0.05$); ° = Adjusted for age and body mass index; ACTN3 = α -actinin-3.

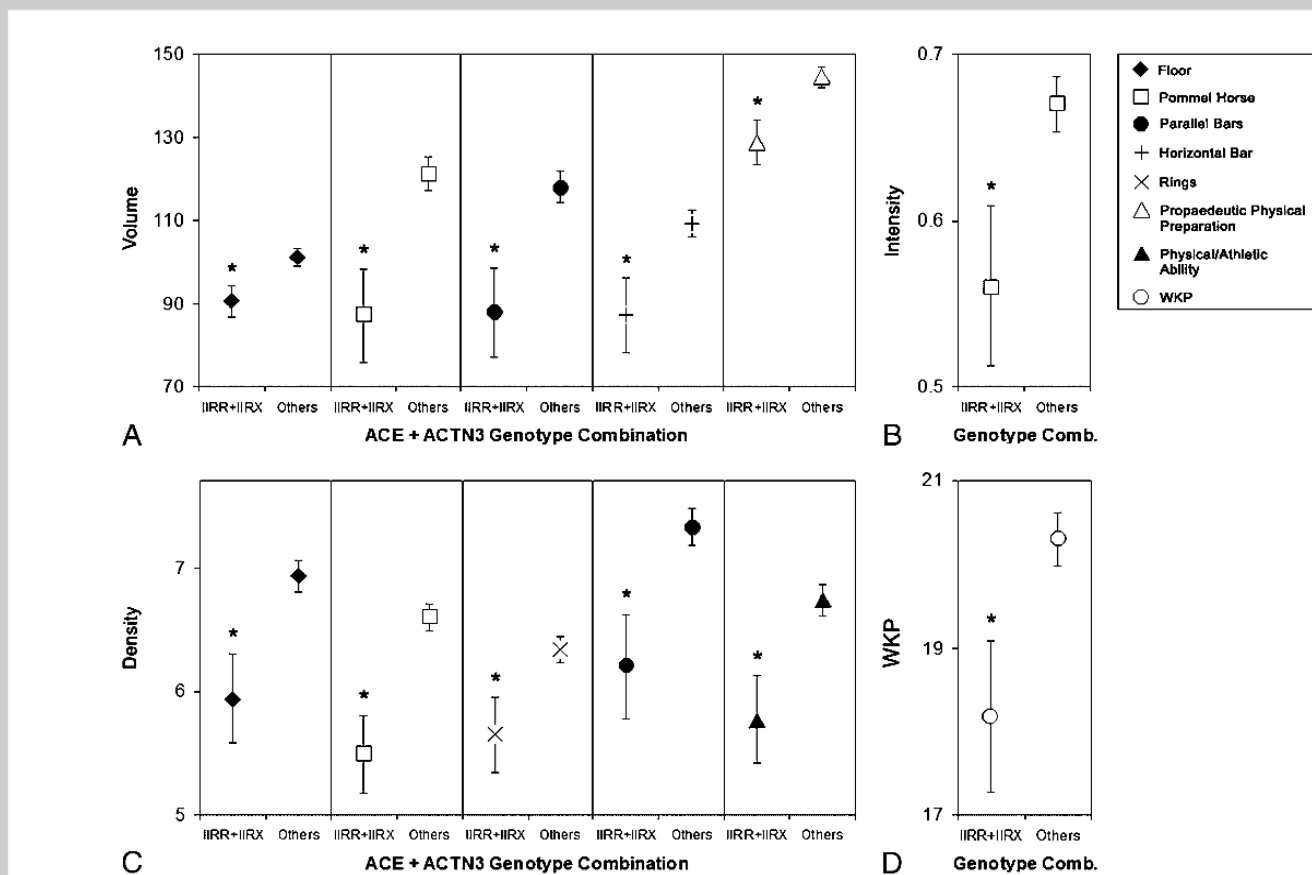


Figure 3. Volume, intensity, density, and WKP time, and combined ACE and ACTN3 polymorphisms distributions, in different gymnastic apparatus/athletic performance evaluations. Mean values (\pm SEM) of the volume (A), intensity (B), density (C), and WKP time (D) in the ACE II + ACTN3 RR/RX genotype combinations vs. the other genotype combinations, calculated in different apparatus/other athletic performance evaluations. The Y-axes, respectively, volume (expressed as arbitrary units by the summation of M_v , E_v , and E_s performed in each gymnastic apparatus/other athletic performance evaluation during a training session); intensity (expressed as arbitrary units by the ratio of the volume to the performance time); density (expressed as the ratio of the recovery time to the performance time); WKP (expressed in seconds needed to perform the test). * = Statistically significant ($p < 0.05$); ° = Adjusted for age and body mass index; ACE = angiotensin-converting enzyme; ACTN3 = α -actinin-3; WKP = Wiener Koordinationsparcours.

Combined Angiotensin-Converting Enzyme and ACTN3 Polymorphisms and Performance

Considering the previous results, the gymnasts carrying 2 genotype combinations, that is, ACE II and ACTN3 RR/RX (the resulting profiles more unsuitable for the exercise tasks; $n = 9$), were directly compared with the athletes carrying all the other different genotype combinations ($n = 71$) to investigate the possible combined effect of ACE I/D and ACTN3 R577X polymorphisms. The results showed that the mean values (adjusted for age and BMI) of V , I , and D in the gymnasts with II + RR/RX genotype combinations were significantly lower than those in the gymnasts with the other genotype combinations in different apparatus (Figure 3). In particular, the gymnasts with II + RR/RX combinations showed mean values of V significantly lower than those of all the other gymnasts in the floor ($p = 0.02$), pommel horse ($p = 0.006$), parallel bars ($p = 0.01$), and horizontal bar ($p = 0.02$) apparatus, and in the PPP ($p = 0.01$) (Figure 3A). The gymnasts with II + RR/RX combinations showed also mean values of I that were significantly lower in comparison with

those observed in the other gymnasts in the pommel horse apparatus ($p = 0.04$) (Figure 3B) and mean values of D were lower than those of the other gymnasts in the floor ($p = 0.02$), pommel horse ($p = 0.006$), rings ($p = 0.03$), and parallel bars ($p = 0.01$) apparatus, and in the PAA ($p = 0.01$) (Figure 3C). Finally, also the time mean values (adjusted for age and BMI) calculated by the WKP test for the gymnasts with II + RR/RX genotype combinations were significantly lower than those of the other gymnasts ($p = 0.03$).

Vitamin D Receptor Polymorphism and Performance

The association analysis of the VDR polymorphisms (BsmI, ApaI, TaqI, and FokI) with the athletic performances evaluated by measuring V , I , and D both in each gymnastic apparatus and in the other athletic performance tests (i.e., PPP, PAA, and the WKP tests) did not show any statistical significance (graphic outputs not shown).

DISCUSSION

A large number of studies have examined the effects of ACE I/D and other gene polymorphisms on athletic status

(24). Numerous studies suggest that ACE I allele may favor the endurance performances, and a higher frequency of ACE II genotype was observed in endurance-oriented athletes. On the contrary, the ACE D allele would predispose to power and strength performances confirming the higher frequency of ACE DD genotype in elite sprint and power-oriented athlete (1,16). Our results showed that in both gymnastic-specific and other generic athletic performance evaluations, gymnasts with ACE II genotype obtained statistically significant lower results in terms of V , I , and D , than those of gymnasts with ACE ID/DD genotypes in those gymnastic apparatus expressing power features (i.e., floor, pommel horse, parallel bars, and rings). The performance results among the different genotype groups showed critical differences: our results confirm that the men's floor, pommel horse, parallel bars, and rings apparatus are sport disciplines where the power/strength is more crucial than the endurance. On these bases and according to the literature (1,16), the genetically power-oriented athletes result to be favored in the above mentioned gymnastic apparatus. Practical application of these results should drive gymnastic trainers to carefully plan new specific individual training programs for gymnasts with ACE II genotype. This could improve their power abilities in which they are less genetically predisposed but without overlooking their endurance abilities to which they are naturally oriented. On the other hand, a careful specific training program for the endurance abilities, ever more basic in gymnastics, would improve also the performances of those ACE ID/DD gymnasts, more genetically predisposed to power than to endurance.

The ACTN3 R577X gene polymorphism has been widely studied in association with the athletic performances (25). Several case-control studies reported that the frequency of ACTN3 RR genotype (coding for a fully functional protein) is higher (and consequently ACTN3 XX genotype lower) in power/sprint athletes compared with that in controls (1), so suggesting that ACTN3 R allele may confer some advantage in power performance events. From our results, the gymnasts with ACTN3 RR/RX genotypes (and so genetically more favored in power/sprint abilities) showed a decreased athletic performances (V , I , and D mean values significant lower) compared with those of the gymnasts with XX genotype, in the apparatus expressing power features, such as parallel bars, horizontal bar, and pommel horse. These results seem to be contradictory with those obtained in our association study of ACE I/D gene polymorphism with the athletic performance, but the paradox could be only apparent; in fact, we hypothesize that the ACTN3 in the fast twitch muscle fibers of the gymnasts with ACTN3 RR/RX genotypes may confer some advantage and predispose to those power/sprint-oriented sports where the anaerobic alactic component is predominant, that is, sports with brief and intermittent tasks requiring very high fast power output such as sprint running, baseball or others (13,18). On

the other hand, the genetic predisposition to power/sprint sports of the gymnasts with ACE DD/ID genotypes compared with gymnasts with II genotype would come from a greater skeletal muscle hypertrophy because of their higher activity of ACE and consequent higher level of the angiotensin II acting in the muscle tissue as a growth factor. The different anatomical and physiological features of the muscle tissue (9,25) could explain the higher level of athletic performance reached by the athletes with XX genotype in comparison with the athletes with RX/RR genotypes both in the endurance-oriented sports and in power-oriented sports with a prevalent anaerobic lactic component such as soccer and dance (13). We propose that having genetic-anatomical traits favoring anaerobic alactic power performances, such as ACTN3 RR/RX genotypes, does not confer any advantage in those gymnastic apparatus characterized mainly by "pure" strength and an anaerobic lactic component, such as parallel bars, horizontal bar, and pommel horse. These observations were also confirmed by the ACTN3 R577X polymorphism frequencies: if compared with the frequencies observed in the literature (12,26), no statistically significant differences arose between our male gymnasts and male sprint athletes, male endurance athletes, and the common European population examined. Practical applications from these results point out the need to plan new individual-specific training programs carefully oriented to the improvement of the anaerobic lactic component for those gymnasts carrying the ACTN3 RR/RX genotypes.

A separate discussion is necessary for the results obtained for the vault. The vault is an artistic gymnastics apparatus where the anaerobic alactic component plays a key role (specifically in the power expressed during the initial sprint run). Despite this, the mean values of I , an effective index of the performance quality, obtained by the gymnasts with ACTN3 XX genotype in the vault performances were better than those of the gymnasts with RR/RX genotypes. This result could be explained by the fact that the gymnasts with the XX genotype, not having muscle fast fibers as efficient as the gymnasts with RX and especially RR genotypes, were "forced" to best develop and exploit their neuromotor component of intermuscular coordination, thus expressing a more efficient power during the initial run and an overall better performance. Our results highlight the inability of gymnasts with ACTN3 RR/RX genotypes to fully express their potential, suggesting modification of their individual training program, and providing at the same time an index of the potential "trainability" of their anaerobic lactic component and neuromotor coordination. The gymnasts with the ACE II + ACTN3 RR/RX polygenic profile (i.e., the resulting profile more unsuitable for the exercise tasks) confirmed statistically significant lower athletic performances (V , I , and D mean values) when compared with the athletes carrying the other ACE/ACTN3 genotype combinations, both for the gymnastic apparatus expressing "pure" power features (i.e., floor, pommel horse, parallel bars, horizontal

bar, and rings) and for the other more generic physical performance evaluations (i.e., PPP and PAA).

Concerning the VDR, our results showed no statistically significant association between VDR polymorphisms (BsmI, ApaI, TaqI, and FokI) and the athletic performances. This lack of association agrees with the data from the literature indicating that the most studied VDR polymorphisms do not affect physical performances.

The r -squared value for our results was 0.30–0.32, indicating that approximately 30% of the variance observed can be accounted for the variables examined in our model (ACE and ACTN3 genotypes, age, and BMI). Other factors possibly genetic and anatomic, physiological, psychological, environmental, etc., may account for the remaining 70% of the variance. Even though the sample size was small, the specific group studied (white men) and the multifactorial conditions affecting the athletic performance limit the possibilities to draw definite conclusions, this study suggests useful information and potential tool to improve the individual training programs and achieve better athletic results in men's artistic gymnastics.

PRACTICAL APPLICATIONS

In gymnastic apparatus, expressing power features, gymnasts with ACE II genotype obtained significantly lower athletic performances than did gymnasts with ACE ID/DD genotypes.

The gymnasts with ACTN3 XX genotype significantly outperformed the gymnasts with ACTN3 RR/RX genotypes in gymnastic apparatus expressing power features with a predominant anaerobic lactic component. Vitamin D receptor genotype did not affect the athletic performances in gymnastic apparatus.

Bearing in mind the growth and performance route in gymnastics, each male gymnast should be genotyped during the so-called "introduction/recruitment to the high level" step, that is, 8–10 years old in men's artistic gymnastics. Identifying the ACE ID and ACTN3 R577X polymorphism polygenic profile of a gymnast can give the trainers a new useful tool to plan individual training regimens to more specifically improve his metabolic (i.e., anaerobic lactic and alactic system) or muscular component (i.e., pure muscle strength).

The results obtained in this study are currently driving Italian Gymnastic Federation coaches in planning new specific individual training programs on the basis of each athlete's genotype. The planning of individual training regimens based on the polygenic profile of each single athlete will be highly recommended to improve the sport performances.

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