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Research article

The *AGT* Gene M235T Polymorphism and Response of Power-Related Variables to Aerobic Training

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Abstract

The C allele of the M235T (rs699) polymorphism of the *AGT* gene correlates with higher levels of angiotensin II and has been associated with power and strength sport performance. The aim of the study was to investigate whether or not selected power-related variables and their response to a 12-week program of aerobic dance training are modulated by the *AGT* M235T genotype in healthy participants. Two hundred and one Polish Caucasian women aged 21 ± 1 years met the inclusion criteria and were included in the study. All women completed a 12-week program of low and high impact aerobics. Wingate peak power and total work capacity, 5 m, 10 m, and 30 m running times and jump height and jump power were determined before and after the training programme. All power-related variables improved significantly in response to aerobic dance training. We found a significant association between the M235T polymorphism and jump-based variables (squat jump (SJ) height, p = 0.005; SJ power, p = 0.015; countermovement jump height, p = 0.025; average of 10 countermovement jumps with arm swing (ACMJ) height, p = 0.001; ACMJ power, p = 0.035). Specifically, greater improvements were observed in the C allele carriers in comparison with TT homozygotes. In conclusion, aerobic dance, one of the most commonly practiced adult fitness activities in the world, provides sufficient training stimuli for augmenting the explosive strength necessary to increase vertical jump performance. The *AGT* gene M235T polymorphism seems to be not only a candidate gene variant for power/strength related phenotypes, but also a genetic marker for predicting response to training.

Key words: Training adaptation, genetic polymorphism, renin-angiotensin system, aerobic dance.

Introduction

The renin-angiotensin system (RAS) plays a key role in maintaining blood pressure homeostasis, as well as water and salt balance in the human body – significant factors associated with improvement in sport performance, athlete status and response to exercise in a variety of populations (Buxens et al., 2011; Eriksson et al., 2002). Angiotensinogen (AGT), the primary mediator of the RAS, is a globular glycoprotein produced by the liver that is cleaved by renin to yield angiotensin I (ANG I). Afterwards, angiotensin-converting enzyme (ACE) catalyses production of angiotensin II (ANG II) from ANG I, which increases blood pressure and promotes sodium retention (Eriksson et al., 2002). Additionally, ANG II is involved in inflammation, cell growth, proliferation, immune response regulation, and central neuromodulation (De Cavanagh et al., 2011; Mustafina et al., 2014).

Nowadays, the most frequently investigated genetic marker in the context of a genetic factor for athletic predisposition is ACE (angiotensin-converting enzyme gene) (Cieszczyk et al., 2009; Gayagay et al., 1998; Jastrzębski et al., 2014; Jones et al., 2016; Montgomery et al., 1998; Muniesa et al., 2010; Myerson et al., 1999; Puthucheary et al., 2011;). Furthermore, other genes involved in blood pressure regulation such as BDKRB2 (bradykinin β2 receptor gene) (Grenda et al., 2014; Saunders et al., 2006; Sawczuk et al., 2013; Williams et al., 2004; Zmijewski et al., 2016), NOS3 (nitric oxide synthase 3 gene) (Gómez-Gallego et al., 2009; Saunders et al., 2006) and AGT (angiotensinogen gene) (Buxens et al., 2011; Gomez-Gallego et al., 2009; Zarębska et al., 2013) have been previously described in the context of sport performance, athlete status and/or response to exercise.

The AGT protein is encoded by the AGT gene situated on the 1st chromosome in locus 1q42 (Corvol and Jeunemaitre, 1997). Previous studies have revealed that one of several described polymorphic sites within the gene - M235T (rs699; C/T nucleotide transition at position 4.072 in exon 2) variation is associated with different AGT levels (one of therate limiting factors affecting the synthesis of ANG II and, thus, control of blood pressure, as well as water and salt balance in the human body). Consequently, the polymorphism has recently been described in the context of sport related research (Buxens et al., 2011; Gomez-Gallego et al., 2009; Miyamoto-Mikami et al., 2016; Zarębska et al., 2013). It has been reported to modify the influence of exercise on various physical performance and health-related fitness phenotypes, e.g. blood

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pressure, cardiorespiratory endurance, and heart morphology (Alves et al., 2009; Pelliccia and Thompson, 2006; Rauramaa et al., 2002). Specifically, the C allele, which results in a replacement of threonine (T) residue with methionine (M) at amino acid 235, has been correlated with higher ANG II levels and, as a result, increased blood pressure at rest (Paillard et al., 1999) or in response to intense exercise (Rankinen et al., 2000). Moreover, at the protein level ANG II acts as a skeletal muscle growth factor which is beneficial for strength- and power-related sports (Jones and Woods, 2003).

Our scientific team have previously demonstrated significant overrepresentation of the CC genotype and the C allele among Polish power-oriented athletes compared with endurance and control subjects (Zarębska et al., 2013). We confirmed earlier studies conducted on Spanish athletes (Buxens et al., 2011; Gomez-Gallego et al., 2009) which suggested that the C allele correlated with higher levels of ANG II and might improve power and strength sport performance (Zarębska et al., 2013). A quite recent study has also demonstrated that the AGT C allele might be favourable for sprint/power athlete status in the Japanese population (Miyamoto-Mikami et al., 2016). Nevertheless, the M235T allele or genotype distribution has not been shown to be significantly different between athletes stratified by their level of performance; thus, the results obtained so far remain inconsistent (Gomez-Gallego et al., 2009; Zarębska et al., 2013). Given the role of AGT in blood pressure homeostasis and the evidence suggesting that the polymorphism may be beneficial for exercise, we aimed to investigate whether or not selected power-related variables and their response to a 12-week program of low- and high-intensity aerobic dance training would be modulated by the AGT M235T genotype in healthy participants. We have also tested the hypothesis that aerobic dance, as one of the most commonly practiced adult fitness activities in the world, may provide sufficient training stimuli for augmenting power-related phenotypes.

Methods

Ethics statement

All the procedures followed in the study were approved by the Ethics Committee of the Regional Medical Chamber in Szczecin (Approval number 09/KB/IV/2011) and were conducted ethically according to the principles of the World Medical Association Declaration of Helsinki and ethical standards in sport and exercise science research. Furthermore, the experimental procedures were conducted in accordance with the set of guiding principles for reporting the results of genetic association studies defined by the Strengthening the Reporting of Genetic Association studies (STREGA) Statement (Little et al., 2009). All participants were given a consent form and a written information sheet concerning the study, providing all pertinent information (purpose, procedures, risks, and benefits of participation). The potential participant had time to read the information sheet and the consent form. After ensuring that the participant had understood the information, every participant gave written informed consent (signed consent form) for genotyping with the understanding that it was anonymous and that the obtained results would be confidential.

Participants

Two hundred and one Polish Caucasian women aged 21 ± 1 years (range 19–24) met the inclusion criteria and were included in the study. None of these individuals had engaged in regular physical activity in the previous 6 months. They had no history of any metabolic or cardiovascular diseases. Participants were never smokers and refrained from taking any medications or supplements known to affect metabolism. All participants were students of the Academy of Physical Education and Sports in Gdansk (Poland). All of them ate their meals (breakfast, dinner and supper) in the same student cafeteria. Additionally, all of them were asked to take care of their diet (approximately 2000 kilocalories a day) for the duration of the experiment. All tests (peak power, sprint, jump) were completed both prior to and after the aerobic training program. The study was conducted during 2 years (participants were divided into two subgroups (n=109, n = 92) and each subgroup trained at the same time). For each investigated group, physiological tests were conducted every 2 days at the same hours. The rest between tests was 48 hours. The same group of participants was used in the previous studies (Zarębska et al., 2014a; 2014b).

Training phase

The training stage was preceded by a week-long familiarization stage, when the participants exercised 3 times a week for 30 minutes, at an intensity of approximately 50% of their HRmax. After the week-long familiarization stage, a12-wk aerobic training program commenced. Each training session consisted of a warm-up routine (10 minutes), the main aerobic routine (43 minutes), and stretching and breathing exercises (7 minutes). The main aerobic routine was a combination of two alternating styles—low and high impact. Low impact style comprises movements with at least one foot on the floor at all times, whereas high impact styles include running, hopping, and jumping with a variety of flight phases (De Angelis et al., 1998). Music of variable rhythm intensity (tempo) was incorporated into both styles. A 12-week program of low and high impact aerobics was divided as follows: (i) 3 weeks (9 training sessions), 60 minutes each, at approximately 50–60% of HRmax, tempo 135–140 BPM, (ii) 3 weeks (9 training sessions), 60 minutes each, at 50–60% of HRmax, tempo 135–140 BPM, (iii) 3 weeks (9 training sessions), 60 minutes with an intensity of 60%−70% of HRmax, tempo 140–152 BPM, and (iv) 3 weeks (9 training sessions), 60 minutes with an intensity of 65%−75% of HRmax, tempo 140–152 BPM. All 36 training units were administered and supervised by the same experienced aerobics tutor.

Experimental procedures

Peak power

A 30-s Wingate test (unmodified version) on a cycle ergometer (Monark Ergomedic 894 E, Monark, Sweden) was used to assess the peak power and total work in the

lower limbs of all participants. A relative load corresponding to 7.5% of the subject's body mass was applied. Before performing the test, the participants completed a 10-min warm-up, including pedalling at a frequency of 60 rotations per minute (RPM), with a relative load of 1.2 $W \cdot kg^{-1}$ and three rapid accelerations between the 7th and 10th minute. After the warm-up, the subjects performed five minutes of stretching and relaxing exercises and then started the test (Bar-Or, 1987).

Sprint test

Before the test, the participants performed a 20-min warm-up involving two 5m and 10m sprints and one 30m sprint. The sprint times were recorded by double photocells (Smart Speed electronic system, Fusion Sport, Cooper Plains, Australia) positioned at the starting (0 m) and finishing lines (5 m, 10m and 30 m) at a height of 0.7 m and 0.9 m. The subjects performed two maximal attempts for the 5, 10 and 30m distances. Only the best (the fastest) times were used in the subsequent analysis. Each participant started from a standing position, with her front foot on the starting line (0 m). The resting periods were 90s after the 5m sprint, 120s after 10m and 240s after 30m. During the tests, students performed run tests according to a random order (required by the electronic steering of photocells).

Jump test

Before the test, the participants performed a 20-min warm-up involving five vertical squat jumps. The test was comprised of two maximal countermovement jumps without arm swings and two with arm swings. The resting period between jumps was two minutes. Only the best (the highest) jumps were used in the subsequent analysis. After a 5-min break participants performed 10 maximal vertical jumps that were performed in the shortest possible time on a tensometric mat (Smart Jump Mat 120 x 120 cm - Fusion Sport, Cooper Plains, Australia). Maximum jump height, mean jump height and power, were recorded and used in the analysis. The given 'power generated during the jumps' results during the 10 jump test refer to the middle value of the height of every 10 jumps, middle generated power during each of the 10 jumps and maximal jump's height of the highest jump.

Genotyping

The buccal cells donated by the subjects were collected in Resuspension Solution (GenElute Mammalian Genomic DNA Miniprep Kit, Sigma, Germany) with the use of sterile foam-tipped applicators (Puritan, USA). DNA was extracted from the buccal cells using a GenElute Mammalian Genomic DNA Miniprep Kit (Sigma, Germany) according to the manufacturer's protocol.

Genotyping of the *AGT* M235T polymorphism (rs699, also designated as 4072T>C or c.803T>C [cDNA label], and p. M268T [protein label], depending on the position at which the numbering was started) was done using an allelic discrimination assay on a StepOne Real-Time Polymerase Chain Reaction (RT-PCR) instrument (Applied Biosystems, USA) with TaqMan probes. To distinguish between AGT M235 and T235 alleles, TaqMan Pre-Designed SNP Genotyping Assays were used (assay ID: C_1985481_20; Applied Biosystems, USA), including primers and fluorescent-labeled (FAM and VIC) MGB probes for the detection of both alleles. Pure water was used as negative control, and no visible PCR products were observed.

Statistical analysis

The software package Statistica (StatSoft, Inc., 2014, version 12) was used for data analysis. The Chi-square test was used for Hardy-Weinberg equilibrium. The response to training was tested with the pairwise Student's t-test. The association between the *AGT* M235T polymorphism and the response to training was analyzed using analysis of covariance (ANCOVA). For this purpose, a response to training was defined as the difference between post- and pre-training value, for each variable. Genotype-dependent differences in training response were adjusted for pre-training values. A p value <0.05 was considered significant.

Results

Pre-training, post-training and Δ (i.e. improvements after training) are presented in Table 1. All power-related variables (i.e. variables obtained from the peak power, sprint and jump tests) improved significantly in response to aerobic dance training.

Table 1. Power-related variables (pre- and post-training) and the training response to a 12-week program of aerobic dance. Data are means (±SD).

Variables	Pre-training	Post-training	Δ	*p*
Peak power [W/kg]	7.64 (.85)	7.74 (.75)	.10 (.57)	.015
Total work capacity [J/kg]	179 (18)	188 (16)	8.84 (11.95)	<.0001
5m sprint	1.30 (.08)	1.28 (.08)	-.02 (.06)	<.0001
10m sprint	2.23 (.15)	2.19 (.12)	-.04 (.10)	<.0001
30m sprint	5.36 (.35)	5.32 (.34)	-.04 (.19)	.002
SJ, height [cm]	24.3 (4.1)	25.4 (3.6)	1.04 (3.11)	<.0001
SJ, power [W]	33.6 (4.9)	35.7 (3.9)	2.13 (4.90)	<.0001
CMJ, height [cm]	28.3 (4.9)	29.7 (4.0)	1.37 (2.79)	<.0001
CMJ, power [W]	38.4 (4.1)	40.3 (4.5)	1.91 (3.46)	<.0001
MCMJ, height [cm]	27.2 (4.4)	28.2 (3.6)	.95 (2.99)	<.0001
MCMJ, power [W]	36.5 (3.5)	38.7 (3.5)	2.24 (3.09)	<.0001
ACMJ, height [cm]	24.9 (4.1)	25.5 (3.4)	.65 (2.64)	<.001
ACMJ, power [W]	34.6 (3.7)	35.5 (3.3)	.98 (2.99)	<.0001

SJ – squat jump: vertical jump with hands on hips; CMJ – countermovement jump: arm swing vertical jump; MCMJ - Maximum of 10 arm swing vertical jumps; ACMJ – average of 10 arm swing countermovement jumps.

Table 2. Power-related variables in response to a 12-week program of aerobic dance training with respect to *AGT* M235T genotypes. Data are means (±SD).

Variables	*AGT* M235T			*p*†
	TT (n = 57)	CT (n = 99)	CC (n = 45)	
Peak power [W/kg]	.02 (.62)	.12 (.63)	.15 (.35)	.629
Total work capacity [J/kg]	6.25 (11.38)	10.83 (12.75)	7.74 (10.20)	.557
5m sprint	-.02 (.03)	-.03 (.07)	-.02 (.06)	.767
10m sprint	-.04 (.07)	-.03 (.09)	-.06 (.13)	.169
30m sprint	-.04 (.10)	-.02 (.23)	-.08 (.15)	.109
SJ, height [cm]	.77 (1.75)	.74 (3.49)	2.06 (3.40)	.005
SJ, power [W]	1.56 (2.73)	2.11 (5.82)	2.91 (4.82)	.015
CMJ, height [cm]	1.01 (2.93)	1.22 (2.38)	2.16 (3.33)	.025
CMJ, power [W]	1.28 (2.72)	2.29 (3.25)	1.88 (4.55)	.797
MCMJ, height [cm]	.35 (3.36)	1.13 (2.45)	1.34 (3.51)	.122
MCMJ, power [W]	1.85 (2.62)	2.33 (3.02)	2.54 (3.74)	.398
ACMJ, height [cm]	.56 (3.11)	.32 (2.07)	1.48 (2.99)	.001
ACMJ, power [W]	.34 (2.47)	.95 (3.18)	1.85 (3.01)	.035

SJ – squat jump: vertical jump with hands on hips; CMJ – countermovement jump: arm swing vertical jump; MCMJ - Maximum of 10 arm swing vertical jumps; ACMJ – average of 10 arm swing countermovement jumps; Mean ± S.D.; † p adjusted for pre-training value (ANCOVA)

The *AGT* M235T genotypes (CC 22.4%, CT 49.3%, TT 28.4%) were in Hardy-Weinberg equilibrium (Chi-square = 0.03, p = 0.862). The *AGT* polymorphism was not associated with age, body mass or BMI. In Table 2, training responses stratified according to M235T genotype are listed.

We found a significant association between the M235T polymorphism and jump-based variables. Specifically, greater improvements were observed in the C allele carriers (CC and CT genotype carriers) in comparison with TT homozygotes (squat jump (SJ) height, p = 0.005; SJ power, p = 0.015; countermovement jump height, p = 0.025; average of 10 arm swing countermovement jumps (ACMJ) height, p = 0.001; ACMJ power, p = 0.035). No association was revealed with respect to sprint running times and Wingate anaerobic measures.

Discussion

The main finding of the present study was that the response to a 12-week program of high and low impact aerobic dance training is modulated by the M235T *AGT* genotype. Specifically, as far as jumping performance is concerned, training adaptations of the CC homozygotes were significantly superior to TT homozygotes. In addition, the majority of the jump-based variables (SJ power, CMJ height and power, ACMJ power) responded to a training routine in a C allele dose-dependent manner, with intermediate and maximum response seen in CT heterozygotes and CC homozygotes, respectively. Gomez-Gallego et al. (2009) found an overrepresentation of the CC genotype among top-level sprinters, throwers and jumpers compared with elite endurance athletes. Similar results were previously reported by our team (Zarębska et al., 2013) – the CC excess was found among the athletes competing in disciplines with high demands not only for power, (e.g. sprinters or jumpers) but strength as well (powerlifters and weightlifters). Furthermore, Miyamoto-Mikami et al. (2016) have shown that Japanese sprint and power athletes exhibit an excess of the CC/CT genotypes compared to controls. Thus, our results provide further evidence that the *AGT* gene M235T polymorphism can be considered as a genetic determinant of power and strength-related phenotypes. However, it is also worth noting that individual responses differed quite substantially across M235T genotypes, with some CC individuals exhibiting worse training response in jumping performance than TT homozygotes. This clearly indicates that other factors, both genetic (hundreds of genetic variants influencing physical performance and related traits) and non-genetic (e.g. protein intake, motivation, technique, baseline training status, etc.) are involved in determining the response to training (Wang et al., 2016).

Exercise genetics and genomics investigators most often focus on unravelling the genetic architecture of numerous fitness-related phenotypes (Ahmetov et al., 2016; Wang et al., 2016; Wolfarth et al., 2014). Despite existing evidence suggesting that differences in trainability may be genetically determined (Hamel et al., 1986; Jones et al., 2016; Prud'homme et al., 1984; Rankinen et al., 2012; Simoneau et al., 1986), fewer studies have looked into genetic determinants of individual differences in response to regular training programs (Pitsiladis et al., 2016). In spite of its popularity, particularly among women (Zaletel et al., 2013; Williford et al., 1989), aerobic dance has rarely been chosen as the training regimen. Indeed, only about 40 studies were published between 2000 and 2011 that investigated the training effects of different forms of contemporary aerobics (Zaletel et al., 2013). Moreover, these were usually conducted in older populations, as some authors suggested that a response to aerobic dance exercises may be more easily achieved in older individuals than among younger ones (Zaletel et al., 2013). In our group of young females, all measured variables improved significantly in response to training stimuli. In previous studies, the improvement of muscular strength related characteristics were reported (Iwata et al., 2006; Kraemer et al., 2001; Kin-Isler and Kosar, 2006; Mori et al., 2006). Two of these studies were conducted in older adults (Iwata et al., 2006; Mori et al., 2006), consequently, widely accepted tests of muscular power in legs (eg. vertical jumps) could not be carried out. However, using an isotonic dynamometer (Mori et al., 2006) or 30-second chair stand test (Iwata et al., 2006) an improve-

ment of the lower extremity muscle strength in response to contemporary aerobics was demonstrated. In a group of college-aged women (comparable to our cohort), Kin-Isler and Kosar (2006) found a significant improvement in anaerobic power of vertical jump in response to a 10 week step aerobics training program. Thus, our results and previous studies suggest that contemporary aerobics programs, including high and low impact aerobic dance provide sufficient stimuli for muscular adaptation changes leading to improvement in power and strength abilities. This is a valuable observation as aerobic dance exercise has traditionally been implemented in order to achieve cardiovascular benefits as well as changes in body composition (e.g. BMI) (Williford et al., 1989).

Among the many determinants of muscular power (Sargeant, 2007; Reid and Fielding, 2012), at least three seem to be influenced by ANG II (known as a skeletal muscle growth factor): muscle hypertrophy, activation of fast-twitch type II fibers, and the canalization of sympathetic transmission (Jones and Woods, 2003). The angiotensinogen level is a rate-limiting step in the generation rate of ANG II (Corvol et al., 1997). Therefore, as the M235T genotype-dependent differences in plasma angiotensinogen level have consistently been found (Danser and Schunkert, 2000), the ANG II properties mentioned above may also be critical in considering muscular adaptation to training stimuli with respect to the M235T genotype. One might speculate that the C allele, which has been correlated with higher ANG II levels, is favourable for jumping performance (explosive power). This is not surprising since several genetic (*ACE* D and rs11091046 A allele of the angiotensin II type 2 receptor gene) and biochemical (circulating angiotensin converting enzyme activity) markers have been recently reported to be associated with increased proportion of fast-twitch muscle fibres, strength, power and ability to be a power/strength-oriented athlete (Ahmetov et al., 2012; 2016; Folland et al., 2000; Gayagay et al., 1998; Jones and Woods, 2003; Ma et al., 2013; Mustafina et al., 2014; Williams et al., 2005; Zhang et al., 2003).

Many genetic factors, including the genes encoding the main components of renin angiotensin system, have been associated with both muscular power/strength related phenotypes as well as the adaptation of corresponding skeletal muscle characteristics to training loads. For example, the D allele of the I/D *ACE* polymorphism has not only been associated with strength and power-oriented performance (Puthucheary et al., 2011), but an enhanced response to resistance training as well (Folland et al., 2000; Giaccaglia et al., 2008; Jones et al., 2016). However, Charbonneau et al. (2008) found no *ACE* associations for muscle strength and volume adaptations despite significant baseline differences. Another commonly tested genetic variant in athletes, the *ACTN3* R577X variant, has been associated with both muscle size, muscle strength (Ma et al., 2013) as well as adaptation to exercise (Clarkson et al., 2005). So far, the association between AGT polymorphisms and training response has been reported with respect to change in blood pressure (Delmonico et al., 2005; Rankinen et al., 2000), vascular response (Dias et al., 2009), and left ventricular hypertrophy (Karjalainen et al., 1999). On the other hand, Bae et al. (2007) did not find any relationship between the M235T polymorphism and blood pressure, maximum rate of oxygen consumption, or metabolic parameter changes in response to endurance training.

In the current study, the M235T genotype was associated with an improvement in single squat and countermovement jump height as well as the average height of 10 countermovement jumps. No association was observed with respect to Wingate peak power and sprint running time improvements. Previously, Wingate anaerobic power and field tests (jump and sprint-based field tests) have been shown to correlate well with each other, and the Wingate measures were proposed as predictors of sprinting ability (Kasabalis et al., 2005; Patton and Duggan, 1987; Shalfawi et al., 2011; Tharp et al., 1985; Wisloff, 2004). In line with these observations, we found that at baseline, the Wingate peak power correlated well with all sprint (negative correlation, Pearson r coefficient ranged from -0.39 to -0.61) and jump variables (positive correlation, Pearson r coefficient ranged from 0.24 to 0.63, data not shown). Although similar correlations were observed between post-training measures, these relationships did not hold true for pre-post differences (data not shown). It means that despite the significant training effects for all measured variables at the whole group level (Table 1), probably due to the specificity of the training program, the extent to which some individuals improved their jumping abilities was not the same for sprint running times. Interestingly, in some studies the relationship between muscular strength measures and sprinting performance could not be proven (Baker and Nance, 1999; Cronin and Hansen, 2005).

Conclusion

Aerobic dance, one of the most commonly practiced adult fitness activities in the world (Williford et al., 1989) provides sufficient training stimuli for augmenting the explosive strength necessary to increase vertical jump performance. In addition, to the best of our knowledge, our study is the first report of an association between the *AGT* M235T polymorphism and a change in power-related phenotypes in response to a training regimen. Therefore, the *AGT* gene M235T polymorphism seems to be not only a candidate gene variation for power/strength related phenotypes, but also a genetic marker for predicting response to training.

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References

Ahmetov, I.I., Egorova, E.S., Gabdrakhmanova, L.J. and Fedotovskaya, O.N. (2016) Genes and Athletic Performance: An Update. *Medicine and Sport Science* **61**, 41-54.

Ahmetov, I.I., Vinogradova, O.L. and Williams, A.G. (2012) Gene polymorphisms and fiber-type composition of human skeletal muscle. *International Journal of Sport Nutrition and Exercise Metabolism* **22**, 292-303.

Alves, G.B., Oliveira, E.M., Alves, C.R., Rached, H.R.S., Mota, G.F.A., Pereira, A.C., Rondon, M.U., Hashimoto, N.Y., Azevedo, L.F., Krieger, J.E. and Negrão, C.E. (2009) Influence of angiotensinogen and angiotensin-converting enzyme polymorphisms on cardiac hypertrophy and improvement on maximal aerobic capacity caused by exercise training. *European Journal of Cardiovascular Prevention and Rehabilitation* **16,** 487-492.

Bae, J.S., Kang, B.Y., Lee, K.O. and Lee, S.T. (2007) Genetic variation in the renin-angiotensin system and response to endurance training. *Medical Principles and Practice* **16**, 142-146.

Baker, D. and Nance, S. (1999) The relation between running speed and measures of strength and power in professional rugby league players. *The Journal of Strength and Conditioning Research* **13**, 224-229.

Bar-Or, O. (1987) The Wingate anaerobic test. An update on methodology, reliability and validity. *Sports Medicine* **4**, 381-394.

Buxens, A., Ruiz, J.R., Arteta, D., Artieda, M., Santiago, C., González-Freire, M., Martínez, A., Tejedor, D., Lao, J.I., Gómez-Gallego, F. and Lucia, A. (2011) Can we predict top-level sports performance in power vs endurance events? A genetic approach. *Scandinavian Journal of Medicine and Science in Sports* **21**, 570-579.

Charbonneau, D.E., Hanson, E.D., Ludlow, A.T., Delmonico, M.J., Hurley, B.F. and Roth, S.M. (2008) ACE genotype and the muscle hypertrophic and strength responses to strength training. *Medicine and Science in Sports and Exercise* **40**, 677-683.

Cieszczyk, P., Krupecki, K., Maciejewska, A. and Sawczuk, M. (2009) The Angiotensin Converting Enzyme Gene I / D Polymorphism in Polish Rowers. *International Journal* of *Sports Medicine* **30**, 624-627.

Clarkson, P.M., Devaney, J.M., Gordish-Dressman, H., Thompson, P.D., Hubal, M.J., Urso, M., Price, T.B., Angelopoulos, T.J., Gordon, P.M., Moyna, N.M., Pescatello, L.S., Visich, P.S., Zoeller, R.F., Seip, R.L. and Hoffman, E.P. (2005) ACTN3 genotype is associated with increases in muscle strength in response to resistance training in women. *Journal of Applied Physiology* **99**, 154-163.

Corvol, P. and Jeunemaitre, X. (1997) Molecular genetics of human hypertension: role of angiotensinogen. *Endocrine Reviews* **18**, 662-677.

Corvol, P., Soubrier, F. and Jeunemaitre, X. (1997) Molecular genetics of the renin-angiotensin-aldosterone system in human hypertension. *Pathologie Biologie (Paris)* **45**, 229-239.

Cronin, J.B. and Hansen, K.T. (2005) Strength and power predictors of sports speed. *The Journal of Strength and Conditioning Research* **19**, 349-357.

Danser, A.H. and Schunkert, H. (2000) Renin-angiotensin system gene polymorphisms: potential mechanisms for their association with cardiovascular diseases. *European Journal of Pharmacology* **410**, 303-316.

De Angelis, M., Vinciguerra, G., Gasbarri, A. and Pacitti, C. (1998) Oxygen uptake, heart rate and blood lactate concentration during a normal training session of an aerobic dance class. *European Journal of Applied Physiology* **78**, 121-127.

De Cavanagh, E.M. V., Inserra, F. and Ferder, L. (2011) Angiotensin II blockade: a strategy to slow ageing by protecting mitochondria? *Cardiovascular Research* **89**, 31-40.

Delmonico, M.J., Ferrell, R.E., Meerasahib, A., Martel, G.F., Roth, S.M., Kostek, M.C. and Hurley, B.F. (2005) Blood pressure response to strength training may be influenced by angiotensinogen A-20C and angiotensin II type I receptor A1166C genotypes in older men and women. *Journal of the American Geriatrics Society* **53**, 204-210.

Dias, R.G., Alvim, R.O., Rene, C.R., Alves, G.B., Pereira, A.C., Krieger, J.E. and Negrao, C.E. (2009) Physical training does not influence vasodilatation responses in individuals with M235T AGT and I/D ECA gene polymorphisms. *The FASEB Journal* **23**, 955.

Eriksson, U., Danilczyk, U. and Penninger, J.M. (2002) Just the beginning: novel functions for angiotensin-converting enzymes. *Current Biology* **12**, 745-752.

Folland, J., Leach, B., Little, T., Hawker, K., Myerson, S., Montgomery, H. and Jones, D. (2000) Angiotensin-converting enzyme genotype affects the response of human skeletal muscle to functional overload. *Experimental Physiology* **85**, 575-579.

Gayagay, G., Yu, B., Hambly, B., Boston, T., Hahn, A., Celermajer, D.S. and Trent R.J. (1998) Elite endurance athletes and the ACE I allele--the role of genes in athletic performance. *Human Genetics* **103**, 48-50.

Giaccaglia, V., Nicklas, B., Kritchevsky, S., Mychalecky, J., Messier, S., Bleecker, E. and Pahor, M. (2008) Interaction between angiotensin converting enzyme insertion/deletion genotype and exercise training on knee extensor strength in older individuals. *International Journal of Sports Medicine* **29**, 40-44.

Gomez-Gallego, F., Santiago, C., González-Freire, M., Yvert, T., Muniesa, C.A., Serratosa, L., Altmäe, S., Ruiz, J.R. and Lucia, A. (2009) The C allele of the AGT Met235Thr polymorphism is associated with power sports performance. *Applied Physiology, Nutrition,* and *Metabolism* **34**, 1108-1111.

Gómez-Gallego, F., Ruiz, J.R., Buxens, A., Artieda, M., Arteta, D., Santiago, C., Rodrıguez-Romo, G., Lao, J.I. and Lucia, A. (2009) The -786 T/C polymorphism of the NOS3 gene is associated with elite performance in power sports. *European Journal of Applied Physiology* **107**, 565-569.

Grenda, A., Leońska-Duniec, A., Cięszczyk, P. and Żmijewski, P. (2014) BDKRB2 gene -9/+9 polymorphism and swimming performance. *Biology of Sport* **31**, 109-113.

Hamel, P., Simoneau, J.A., Lortie, G., Boulay, M.R. and Bouchard C. (1986) Heredity and muscle adaptation to endurance training. *Medicine and Science in Sports and Exercise* **18**, 690–696.

Iwata, T., Ishii, K., Kishimoto, N., Sakuma, I. and Tanaka, H. (2006) The Effect of Bench Stepping Exercise at Nursing Home in Snowy Area. *International Journal of Sport and Health Science* **4**, 577-582.

Jastrzębski, Z., Leońska-Duniec, A., Kolbowicz, M. and Tomiak, T. (2014) The *angiotensin converting enzyme gene* I/*D polymorphism* in *Polish rowers. Central European Journal of Sport Sciences and Medicine* **5**, 77-82.

Jones, A. and Woods, D.R. (2003) Skeletal muscle RAS and exercise performance. *The International Journal of Biochemistry and Cell Biology* **35**, 855-866.

Jones, N., Kiely, J., Suraci, B., Collins, D.J., de Lorenzo, D., Pickering, C. and Grimaldi, K.A. (2016) A genetic-based algorithm for personalized resistance training. *Biology of Sport* **33**, 117-126.

Karjalainen, J., Kujala, U.M., Stolt, A., Mäntysaari, M., Viitasalo, M., Kainulainen, K. and Kontula, K. (1999) Angiotensinogen gene M235T polymorphism predicts left ventricular hypertrophy in endurance athletes. *Journal of the American College of Cardiology* **34**, 494-499.

Kasabalis, A., Douda, H. and Tokmakidis, S.P. (2005) Relationship between anaerobic power and jumping of selected male volleyball players of different ages. *Perceptual and Motor Skills* **100**, 607-614.

Kin-Isler, A. and Kosar, S.N. (2006) Effect of step aerobics training on anaerobic performance of men and women. *The Journal of Strength and Conditioning Research* **20**, 366-371.

Kraemer, W.J., Keuning, M., Ratamess, N.A., Volek, J.S., McCormick, M., Bush, J.A., Nindl, B.C., Gordon, S.E., Mazzetti, S.A., Newton, R.U., Gomez, A.L., Wickham, R.B., Rubin, M.R. and Häkkinen, K. (2001) Resistance training combined with bench-step aerobics enhances women's health profile. *Medicine and Science in Sports and Exercise* **33**, 259-269.

Little, J., Higgins, J.P.T., Ioannidis, J.P.A., Moher, D., Gagnon, F., von Elm, E., Khoury, M.J., Cohen, B., Davey-Smith, G., Grimshaw, J., Scheet, P., Gwinn, M., Williamson, R.E., Zou, G.Y., Hutchings, K., Johnson, C.Y., Tait, V., Wiens, M., Golding, J., van Duijn, C., McLaughlin, J., Paterson, A., Wells, G., Fortier, I., Freedman, M., Zecevic, M., King, R., Infante-Rivard, C., Stewart, A. and Birkett, N. (2009) STrengthening the REporting of Genetic Association Studies (STREGA)— An Extension of the STROBE Statement. *PLOS Medicine* **6,** e1000022, 0151-0163.

Ma, F., Yang, Y., Li, X., Zhou, F., Gao, C., Li, M. and Gao, L. (2013) The association of sport performance with ACE and ACTN3 genetic polymorphisms: a systematic review and meta-analysis. *PLoS One* **8**, e54685.

Miyamoto-Mikami, E., Murakami, H., Tsuchie, H., Takahashi, H., Ohiwa, N., Miyachi, M., Kawahara, T. and Fuku, N. (2016) Lack of association between genotype score and sprint/power performance in the Japanese population. *Journal of Science and Medicine in Sport* pii: S1440-2440(16)30110-4

Montgomery, H.E., Marshall, R., Hemingway, H., Myerson, S., Clark-

son, P., Dollery, C., Hayward, M., Holliman, D.E., Jubb, M., World, M., Thomas, E.L., Brynes, A.E., Saeed, N., Barnard, M., Bell, J.D., Prasad, K., Rayson, M., Talmud, P.J. and Humphries, S.E. (1998) Human gene for physical performance. *Nature* **393,** 221-222.

Mori, Y., Ayabe, M., Yahiro, T., Tobina, T., Kiyonaga, A., Shindo, M., Yamada, T. and Tanaka, H. (2006) The Effects of Home-based Bench Step Exercise on Aerobic Capacity, Lower Extremity Power and Static Balance in Older Adults. *International Journal of Sport and Health Science* **4**, 570-576.

Muniesa, C.A., González-Freire, M., Santiago, C., Lao, J.I., Buxens, A., Rubio, J.C., Martín, M.A., Arenas, J., Gomez-Gallego, F. and Lucia, A. (2010) World-class performance in lightweight rowing: is it genetically influenced? A comparison with cyclists, runners and non-athletes. *British Journal of Sports Medicine* **44**, 898-901.

Mustafina, L.J., Naumov, V.A., Cieszczyk, P., Popov, D.V., Lyubaeva, E.V., Kostryukova, E.S., Fedotovskaya, O.N., Druzhevskaya, A.M., Astratenkova, I.V., Glotov, A.S., Alexeev, D.G., Mustafina, M.M., Egorova, E.S., Maciejewska-Karłowska, A., Larin, A.K., Generozov, E.V., Nurullin, R.E., Jastrzębski, Z., Kulemin, N.A., Ospanova, E.A., Pavlenko, A.V., Sawczuk, M., Akimov, E.B., Danilushkina, A.A., Zmijewski, P., Vinogradova, O.L., Govorun, V.M., and Ahmetov, I.I. (2014) AGTR2 gene polymorphism is associated with muscle fibre composition, athletic status and aerobic performance. *Experimental Physiology* **99**, 1042-1052.

Myerson, S., Hemingway, H., Budget, R., Martin, J., Humphries, S. and Montgomery, H. (1999) Human angiotensin I-converting enzyme gene and endurance performance. *Journal* of *Applied Physiology* **87**, 1313-1316.

Paillard, F., Chansel, D, Brand, E., Benetos, A., Thomas, F., Czekalski, S., Ardaillou, R. and Soubrier, F. (1999) Genotype-phenotype relationships for the renin-angiotensin-aldosterone system in a normal population. *Hypertension* **34**, 423–429.

Patton, J.F. and Duggan, A. (1987) An evaluation of tests of anaerobic power. *Aviation, Space, and Environmental Medicine* **58**, 237-242.

Pelliccia, A. and Thompson, P.D. (2006) The genetics of left ventricular remodeling in competitive athletes. *Journal of Cardiovascular Medicine (Hagerstown)* **7**, 267–270.

Pitsiladis, Y.P., Tanaka, M., Eynon, N., Bouchard, C., North, K.N., Williams, A.G., Collins, M., Moran, C.N., Britton, S.L., Fuku, N., Ashley, E.A., Klissouras, V., Lucia, A., Ahmetov, I.I., de Geus, E., Alsayrafi, M. and Athlome Project Consortium. (2016) Athlome Project Consortium: a concerted effort to discover genomic and other "omic" markers of athletic performance. *Physiological Genomics* **48**, 183-190.

Prud'homme, D., Bouchard, C., Leblanc, C., Landry, F. and Fontaine, E. (1984) Sensitivity of maximal aerobic power to training is genotype-dependent. *Medicine and Science in Sports and Exercise* **16**, 489-493.

Puthucheary, Z., Skipworth, J.R.A., Rawal, J., Loosemore, M., Van Someren, K. and Montgomery, H.E. (2011) The ACE gene and human performance: 12 years on. *Sports Medicine* **41**, 433-448.

Rankinen, T., Gagnon, J., Perusse, L., Chagnon, Y.C., Rice, T., Leon, A.S., Skinner, J.S., Wilmore, J.H., Rao, D.C. and Bouchard, C. (2000) AGT M235T and ACE ID polymorphisms and exercise blood pressure in the HERITAGE Family Study. *American Journal of Physiology - Heart and Circulatory Physiology* **279**, H368- H374.

Rankinen, T., Sung, Y.J., Sarzynski, M.A., Rice, T.K., Rao, D.C. and Bouchard, C. (2012) Heritability of submaximal exercise heart rate response to exercise training is accounted for by nine SNPs. *Journal of Applied Physiology* **112**, 892-897.

Rankinen, T., Wolfarth, B., Simoneau, J.A., Maier-Lenz, D., Rauramaa, R., Rivera, M.A., Boulay, M.R., Chagnon, Y.C., Pérusse, L., Keul, J. and Bouchard, C. (2000) No association between the angiotensin-converting enzyme ID polymorphism and elite endurance athlete status. *Journal of Applied Physiology* **88**, 1571-1575.

Rauramaa, R., Kuhanen, R., Lakka, T.A., Väisänen, S.B., Halonen, P., Alén, M., Rankinen, T. and Bouchard, C. (2002) Physical exercise and blood pressure with reference to the angiotensinogen M235T polymorphism. *Physiological Genomics* **10**, 71-77.

Reid, K.F. and Fielding, R.A. (2012) Skeletal muscle power: a critical determinant of physical functioning in older adults. *Exercise and Sport Sciences Reviews* **40**, 4-12.

Sargeant, A.J. (2007) Structural and functional determinants of human muscle power. *Experimental Physiology* **92**, 323–331.

Saunders, C.J., Xenophontos, S.L., Cariolou, M.A., Anastassiades, L.C., Noakes, T.D. and Collins, M. (2006) The bradykinin beta 2 receptor (BDKRB2) and endothelial nitric oxide synthase 3 (NOS3) genes and endurance performance during Ironman Triathlons. *Human Molecular Genetics* **15**, 979-987.

Sawczuk, M., Timshina, Y.I., Astratenkova, I.V., Maciejewska-Karlowska, A., Leońska-Duniec, A., Ficek, K., Mustafina, L.J., Cięszczyk, P., Klocek, T. and Ahmetov, I.I. (2013) The -9/+9 polymorphism of the bradykinin receptor Beta 2 gene and athlete status: a study involving two European cohorts. *Human Biology* **85**, 741-756.

Shalfawi, S.A.I., Sabbah, A., Kailani, G., Tønnessen, E. and Enoksen, E. (2011) The relationship between running speed and measures of vertical jump in professional basketball players: a field-test approach. *The Journal of Strength and Conditioning Research* **25**, 3088-3092.

Simoneau, J.A., Lortie, G., Boulay, M.R., Marcotte, M., Thibault, M.C. and Bouchard, C. (1986) Inheritance of human skeletal muscle and anaerobic capacity adaptation to high-intensity intermittent training. *International Journal of Sports Medicine* **7**, 167-171.

Tharp, G.D., Newhouse, R.K., Uffelman, L., Thorland, W.G. and Johnson, G.O. (1985) Comparison of sprint and run times with performance on the wingate anaerobic test. *Research Quarterly for Exercise and Sport* **56**, 73-76.

Wang, G., Tanaka, M., Eynon, N., North, K.N., Williams, A.G,. Collins, M., Moran, C.N., Britton, S.L., Fuku, N., Ashley, E.A., Klissouras, V., Lucia, A., Ahmetov, I.I., de Geus, E., Alsayrafi, M. and Pitsiladis, Y.P. (2016) The Future of Genomic Research in Athletic Performance and Adaptation to Training. *Medicine and Sport Science* **61**, 55-67.

Williams, A.G., Day, S.H., Folland, J.P., Gohlke, P., Dhamrait, S. and Montgomery, H.E. (2005) Circulating angiotensin converting enzyme activity is correlated with muscle strength. *Medicine and Science in Sports and Exercise* **37**, 944-948.

Williams, A.G., Dhamrait, S.S., Wootton, P.T.E., Day, S.H., Hawe, E., Payne, J.R., Myerson, S.G., World, M., Budgett, R., Humphries, S.E. and Montgomery, H.E. (2004) Bradykinin receptor gene variant and human physical performance. *Journal* of *Applied Physiology* **96**, 938-942.

Williford, H.N., Scharff-Olson, M. and Blessing, D.L. (1989) The physiological effects of aerobic dance. A review. *Sports Medicine* **8**, 335-345.

Wisloff, U. (2004) Strong correlation of maximal squat strength with sprint performance and vertical jump height in elite soccer players. *British Journal of Sports Medicine* **38**, 285-288.

Wolfarth, B., Rankinen, T., Hagberg, J.M., Loos, R.J.F., Pérusse, L., Roth, S.M., Sarzynski, M.A. and Bouchard, C. (2014) Advances in exercise, fitness, and performance genomics in 2013. *Medicine and science in sports and exercise* **46**, 851-859.

Zaletel, P., Gabrilo, G. and Perić, M. (2013) The training effects of dance aerobics: A review with an emphasis on the perspectives of investigations. *Collegium Antropologicum* **37**, 125-130.

Zarebska, A., Jastrzebski, Z., Cieszczyk, P., Leonska-Duniec, A., Kotarska, K., Kaczmarczyk, M., Sawczuk, M. and Maciejewska-Karlowska, A. (2014a) The Pro12Ala Polymorphism of the Peroxisome Proliferator-Activated Receptor Gamma Gene Modifies the Association of Physical Activity and Body Mass Changes in Polish Women. *PPAR Research* **2014**, 373782.

Zarebska, A., Jastrzebski, Z., Kaczmarczyk, M., Ficek, K., Maciejewska-Karlowska, A., Sawczuk, M., Leońska-Duniec, A., Krol, P., Cieszczyk, P., Zmijewski, P. and Eynon, N. (2014b) The GSTP1 c.313A>G polymorphism modulates the cardiorespiratory response to aerobic training. *Biology of Sport* **31**, 261-266.

Zarębska, A., Sawczyn, S., Kaczmarczyk, M., Ficek, K., Maciejewska-Karłowska, A., Sawczuk, M., Leońska-Duniec, A., Eider, J., Grenda, A. and Cięszczyk, P. (2013) Association of rs699 (M235T) polymorphism in the AGT gene with power but not endurance athlete status. *The Journal of Strength and Conditioning Research* **27**, 2898-2903.

Zhang, B, Tanaka, H., Shono, N., Miura, S., Kiyonaga, A., Shindo, M. and Saku, K. (2003) The I allele of the angiotensin-converting enzyme gene is associated with an increased percentage of slow-twitch type I fibers in human skeletal muscle. *Clinical Genetics* **63**, 139-144.

Zmijewski, P., Grenda, A., Leońska-Duniec, A., Ahmetov, I., Orysiak, J. and Cięszczyk, P. (2016) Effect of *BDKRB2* Gene -9/+9 Polymorphism on Training Improvements in Competitive Swimmers. *The Journal of Strength and Conditioning Research* **30**, 665-671.

Key points

- Aerobic dance provides sufficient training stimuli for the improvement of explosive power.
- The *AGT* gene M235T polymorphism is associated with individual variation in the change of power-related phenotypes in response to aerobic dance training.
- The C allele carriers of the *AGT* gene M235T polymorphism show greater improvements of jump-based variables in comparison with TT homozygotes.

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