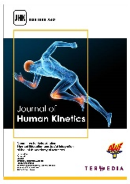

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Section IV – Psychological and Sociological Aspects of Sport and Exercise

Interaction Analysis of the *ANKK1* Gene *Taq1A rs1800497* Polymorphism and Personality Traits in a Cohort of Elite Athletes

by

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The ANKK1 TaqIA polymorphism (rs1800497) has been linked to substance dependence, possibly through reduced striatal D2 receptor density and altered dopamine signaling. Beyond addiction, dopaminergic pathways are also implicated in motivation, reward, and athletic behavior. Personality further contributes to performance, as traits influence athletes' engagement and preparation. The aim of this study was to examine: (1) the association between ANKK1 TaqIA rs1800497 and elite athletic status; (2) differences in personality traits measured by the NEO Five-Factor Inventory (NEO-FFI) between athletes and controls; and (3) interactions between the genotype, athletic status, and personality. The study included 141 competitive athletes competing nationally or internationally and 182 controls (total N = 323). Genotype analysis revealed significant differences between groups (p = 0.0439), with the C allele more frequent in athletes and the T allele in controls (p = 0.0158). Athletes scored higher on conscientiousness (p = 0.0001). Interaction analyses showed significant effects of genotype × athletic status for neuroticism (p = 0.0065), extraversion (p = 0.0403), and agreeableness (p = 0.0191). These findings not only provide a compelling rationale for further investigation into the role of ANKK1 in modulating personality traits relevant to athletic performance, but also suggest potential practical applications in the field of sports science—for example, in talent identification, a personalized training program design, and psychological support strategies aimed at optimizing athletes' performance and well-being.

Keywords: *DRD2; NEO-FFI; personality; athlete; ANKK1*

Introduction

The combined influence of genetic factors and structured training on athletic achievement has long captivated researchers. Although environmental stimuli and social influences shape phenotypic expression and personality, genetic factors strongly determine the pace of progress and the upper limits of performance (Georgiades et al., 2017). Meta-analysis indicates that deliberate practice explains only part of performance variability—approximately 26% in games, 21% in music, and 18% in sports (Macnamara et al., 2014). Twin studies indicate that genetic factors substantially contribute to athletic performance, with heritability estimates for sports-related traits typically around 50% (Yan et al., 2016). By contrast, heritability of height—a major determinant of success in certain sports—can reach approximately 80% (Neville et al., 2004).

A systematic review by Petr et al. (2018) emphasizes the role of genetic trainability,

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showing that specific gene variants contribute to individual differences in response to training stimuli.

One locus of particular interest is the *ANKK1*/*DRD2* region on chromosome 11q23.2. The *ANKK1* gene encodes a 765-amino-acid protein with ankyrin repeats and a serine/threonine kinase domain (Zhang and Zhang, 2016), and its polymorphisms are in linkage disequilibrium with variants of the adjacent *DRD2* gene (SNPedia, 2025). The *TaqIA* polymorphism (rs1800497), a C>T variant in 8th exon of *ANKK1*, results in a Glu713Lys substitution (Ghosh et al., 2013). The T allele is linked to reduced striatal D2 receptor expression (Jönsson et al., 1999; Magistrelli et al., 2021; Ritchie and Noble, 2003) and greater vulnerability to substance dependencies (Deng et al., 2015; Munafò et al., 2009; Verdejo-Garcia et al., 2015).

Beyond addiction, dopamine signaling plays a role in motivation and reward processes relevant to sports. However, findings on the relationship between dopamine-related variants and sports participation remain inconsistent (Jozkow et al., 2013; Lee et al., 2020). Human personality, conceptualized by the Five-Factor Model (FFM), comprises neuroticism, extraversion, openness, agreeableness, and conscientiousness (Allen et al., 2013; McCrae and John, 1992). Previous research has shown that low neuroticism, together with higher extraversion and conscientiousness, is associated with successful athletes' performance and well-being (Fabbricatore et al., 2023; Piepiora and Witkowski, 2020; Rhodes et al., 2002; Terracciano et al., 2013).

The aim of the present study was therefore to investigate: (1) the association between the *ANKK1 Taq1A* rs1800497 polymorphism and elite athletic status; (2) personality traits measured by the NEO Five-Factor Inventory in athletes and controls; and (3) potential interactions between the polymorphism, athletic status, and personality traits.

Methods

Participants

The study sample consisted of 323 volunteers, including 141 competitive athletes (M = 92, 65%; F = 49, 35%; mean age = 22.7 years, SD = 6.02 years) and 182 control participants (M = 146, 80%; F = 36, 20%; mean age = 21.9 years, SD = 3.88 years).

The group of athletes comprised of individuals actively competing at the national or international level across various disciplines: karate (n = 6), judo (n = 17), boxing (n = 19), MMA (n = 31), ju-jitsu (n = 5), kickboxing (n = 8), volleyball (n = 5), handball (n = 5), ice hockey (n = 24), triathlon (n = 1), basketball (n = 4), and soccer (n = 16). All athletes had at least five years of continuous training and had participated in official sports events within the previous 12 months.

Inclusion criteria for competitive athletes were: (I) systematic training at least five times per week, (II) continuous involvement in competitive sport for a minimum of five years, and (III) participation in national or international competitions in the year prior to enrollment. Many of the athletes included in this study were multiple medalists at national or international levels. Exclusion criteria were: (I) current or recent injury preventing full training participation, (II) chronic somatic illness, (III) psychiatric disorders or substance dependence as assessed by the MINI interview, and (IV) lack of informed consent.

Prior to entering the study, all volunteers provided written informed consent. The study was approved by the Bioethics Committee for Clinical Research of the Regional Medical Society in Szczecin, Poland (protocol no. 13/KB/ VI/2016, approval date: 08 December 2016). The study was carried out at the Independent Laboratory of Behavioral Genetics and Epigenetics.

Psychometric Measures

All participants underwent a psychiatric assessment using the Mini International Neuropsychiatric Interview (MINI) and the NEO Five-Factor Personality Inventory (NEO-FFI). The MINI is a structured diagnostic tool developed to identify psychiatric disorders based on the DSM-IV and ICD-10 classification systems.

The NEO-FFI (Costa and McCrae, 2008) evaluates five core personality dimensions, each comprising six facets: openness (e.g., fantasy, aesthetics, values), extraversion (e.g., sociability, energy, emotional expressiveness), agreeableness (e.g., trust, altruism, modesty), neuroticism (e.g., anxiety, depression, impulsiveness), and conscientiousness (e.g., competence, organization, diligence).

NEO-FFI outcomes were expressed using sten scores, calibrated according to Polish adult norms. In this scale, scores of 1–2 indicate very low levels, 3–4 low, 5–6 average, 7–8 high, and 9–10 denote very high levels of a given trait.

Genotyping

Genomic DNA was extracted from peripheral venous blood using the QIAamp Blood DNA Mini Kit from QIAGEN (Hilden, Germany). The genotyping process employed real-time PCR, utilizing LightSNiP probes (TIB MOLBIOL, Berlin, Germany) in combination with the LightCycler® FastStart DNA Master HybProbe mix and the LightCycler 480 II system (Roche Diagnostics, Penzberg, Germany).

Fluorescence signals were recorded across a temperature gradient, generating melting curves that enabled genotype discrimination. For the *Taq1A* polymorphism (rs1800497) in the *ANKK1* gene, melting peaks were detected at 67.17°C for the C allele and at 58.95°C for the T allele.

The genotype distributions were evaluated for adherence to Hardy-Weinberg equilibrium using an online calculator available at https://wpcalc.com/en/equilibrium-hardy-weinberg/ (accessed: 12 December 2024).

Associations between the *ANKK1 Taq1A* (rs1800497) genotype and allele frequencies in competitive athletes compared to controls were examined using the chi-square test.

Since the distribution of NEO Five-Factor Inventory scores (neuroticism, extraversion, openness, agreeableness, and conscientiousness) deviated from normality, the non-parametric Mann-Whitney U test was applied to compare these traits between the study and control groups.

The Levene's test confirmed the homogeneity of the variance assumption ($p > 0.05$). Interactions among the rs1800497 variants, group affiliation (athletes vs. controls), and personality traits (NEO-FFI dimensions) were analyzed via multifactorial ANOVA models [NEO-FFI trait × genotype × group × (genotype × group)].

All statistical procedures were carried out using STATISTICA 13 software (Tibco Software Inc., Palo Alto, CA, USA) on a Windows operating system (Microsoft Corporation, Redmond, WA, USA).

Results

Both groups exhibited *ANKK1 Taq1A* allele distributions consistent with Hardy-Weinberg equilibrium (Table 1).

A statistically significant difference was observed in the distribution of *ANKK1 Taq1A* rs1800497 genotypes between competitive athletes and control participants (C/T: 22% vs. 34%; C/C: 77% vs. 64%; T/T: 1% vs. 3%; $\chi^2 = 6.250$, $p = 0.0439$). Similarly, allele frequencies also differed significantly between the groups (C: 88% vs. 80%; T: 12% vs. 20%; $\chi^2 = 5.830$, $p = 0.0158$) (Table 2).

Table 3 presents the mean scores and standard deviations for the NEO Five-Factor Inventory traits in competitive athletes and control participants. Athletes scored significantly higher on the conscientiousness scale compared to the control group (7.08 vs. 6.10; $Z = 4.031$; $p = 0.0001$). Specifically, the frequency of the C allele was higher in athletes (87.6%) compared to controls (80.5%), whereas the T allele was more frequent in controls (19.5%) than in athletes (12.4%).

The results of the 2x3 factorial ANOVA of the NEO Five-Factor Personality Inventory traits are summarized in Table 4.

Neuroticism Scale

A significant main effect was observed for the variable of sports status (elite athlete vs. control) on neuroticism scores ($F_{1,317} = 5.45$; $p = 0.0201$; $\eta^2 = 0.017$), with statistical power estimated at 64%. Participation in competitive sports accounted for roughly 2% of the variance in neuroticism levels.

Moreover, a significant interaction emerged between the *ANKK1 Taq1A* rs1800497 genotype and group status (athlete vs. control) in relation to neuroticism ($F_{2,307} = 5.11$; $p = 0.0065$; $\eta^2 = 0.031$), with observed power reaching 82%. This interaction explained approximately 3% of the variance in neuroticism scores (Figure 1).

As presented in Table 5, the post hoc analysis revealed that athletes carrying the C/C genotype scored significantly higher in neuroticism than both controls with the C/T genotype and athletes with the T/T genotype. Athletes with the C/T genotype also showed higher neuroticism levels than those with the T/T genotype. Notably, the T/T genotype was associated with the lowest neuroticism scores among athletes when compared to controls with

C/C, C/T, or T/T variants.

Extraversion Scale

A significant main effect of the *ANKK1 Taq1A* rs1800497 genotype was identified for extraversion scores ($F_{2,317} = 3.09$; $p = 0.0465$; $\eta^2 = 0.019$), with statistical power calculated at 60%. This polymorphism accounted for approximately 2% of the variance observed in extraversion.

Furthermore, a significant interaction effect between the genotype and the group (athletes vs. controls) was observed ($F_{2,317} = 3.24$; $p = 0.0403$; $\eta^2 = 0.020$), suggesting that the relationship between the genotype and extraversion differed depending on athletic status. This interaction explained about 2% of the variance in extraversion scores, with observed power reaching 62%.

As shown in Table 5, post hoc comparisons indicated that competitive athletes with either the C/C or C/T genotypes had significantly lower extraversion scores than those with the T/T genotype. In contrast, athletes with the T/T genotype scored higher in extraversion than all control participants, regardless of the genotype (C/C, C/T, or T/T).

Agreeability Scale

A significant effect of competitive sports engagement was observed on agreeability scores ($F_{2,317} = 4.95$; $p = 0.0268$; $\eta^2 = 0.015$), with an observed statistical power of 60%. Participation in sports at the elite level accounted for approximately 1.5% of the variability in this personality trait.

Moreover, the interaction between the *ANKK1 Taq1A* rs1800497 genotype and athletic status (competitive athlete vs. control) showed a significant effect on agreeability ($F_{2,317} = 4.01$; $p = 0.0191$; $\eta^2 = 0.025$), explaining about 2.5% of the variance. The statistical power for this interaction was estimated at 71.5%.

Post hoc comparisons (Table 5) revealed that competitive athletes carrying the C/T genotype exhibited significantly higher agreeability scores than both their C/C genotype counterparts within the athletic group and control group participants with the C/T genotype.

Table 1. Hardy-Weinberg's equilibrium in competitive athletes and the control group.

Hardy-Weinberg Equilibrium and Ascertainment Bias		Observed (Expected)	Allele frequency	χ^2 (*p-value*)
ANKK1 Taq1A rs1800497				
Competitive athletes n = 141	C/T	31 (30.7)	p (C) = 0.88 q (T) = 0.12	0.018 (0.8940)
	C/C	108 (108.1)		
	T/T	2 (2.2)		
Controls n = 182	C/T	61 (57.2)	p (C) = 0.80 q (T) = 0.20	0.825 (0.3636)
	C/C	116 (117.9)		
	T/T	5 (6.9)		

n: number of subjects, p: statistical significance χ^2 *test*

Table 2. The frequency of the *ANKK1 Taq1A* rs1800497 alleles and genotypes in competitive athletes and control individuals.

ANKK1 Taq1A rs1800497					
	Genotypes			Alleles	
	C/T n (%)	C/C n (%)	T/T n (%)	C n (%)	T n (%)
Competitive athletes n = 141	31 (21.99%)	108 (76.60%)	2 (1.42%)	247 (87.59%)	35 (12.41%)
Controls n = 182	61 (33.52%)	116 (63.74%)	5 (2.75%)	293 (80.49%)	71 (19.51%)
χ^2 (*p*-value)		6.250 (0.0439)*		5.830 (0.0158)*	

*n: number of subjects, * statistically significant differences*

Table 3. The NEO Five-Factor Inventory trait scores in competitive athletes and control individuals.

NEO Five-Factor Inventory	Competitive athletes M ± SD (n = 141)	Controls M ± SD (n = 182)	Z	(*p-value*)
neuroticism scale	4.86 ± 2.15	4.48 ± 1.96	1.296	0.1951
extraversion scale	6.49 ± 1.85	6.63 ± 1.77	−0.8259	0.4088
openness scale	4.84 ± 2.35	4.54 ± 1.62	1.0890	0.2761
agreeability scale	5.96 ± 3.94	5.77 ± 1.94	−0.1147	0.9087
conscientiousness scale	7.08 ± 2.07	6.10 ± 2.10	4.0314	0.0001*

*p: statistical significance with Mann-Whitney U-test; n: number of subjects; M ± SD: mean ± standard deviation; * statistically significant differences*

Table 4. The ANOVA results examining the effects of elite athlete’s status, the *ANKK1 Taq1A* rs1800497 genotype, and their interaction on NEO Five-Factor Inventory personality traits.

NEO Five-Factor Inventory	Group	*ANKK1 Tag1A* rs1800497			Factor	ANOVA		
		C/T n = 92 M ± SD	C/C n = 224 M ± SD	T/T n = 7 M ± SD		F (*p-value*)	η^2	Power (alpha = 0,05)
neuroticism scale	Competitive athletes n = 141	4.71 ± 2.10	4.97 ± 2.12	1.00 ± -**	Intercept	$F_{1,317} = 207.23$ ($p < 0.0001$)*	0.395	1.000
					PA /Control	$F_{1,317} = 5.45$ ($p = 0.0201$)*	0.017	0.644
					(*AN*)	$F_{2,317} = 1.28$ ($p = 0.2799$)	0.008	0.277
	Controls n = 182	4.33 ± 1.80	4.49 ± 2.02	6.00 ± 2.00	PA /Control x (*AN*)	$F_{2,307} = 5.11$ ($p = 0.0065$)*	0.031	0.821
extraversion scale	Competitive athletes n = 141	6.23 ± 1.61	6.50 ± 1.87	10.00 ± -**	Intercept	$F_{1,317} = 745.79$ ($p < 0.0001$)*	745.80	1.000
					PA /Control	$F_{1,317} = 2.70$ ($p = 0.1012$)	0.008	0.374
					(*AN*)	$F_{2,317} = 3.09$ ($p = 00.0465$)*	0.019	0.595
	Controls n = 182	6.82 ± 1.81	6.52 ± 1.79	6.80 ± 0.84	PA /Control x (*AN*)	$F_{2,317} = 3.24$ ($p = 0.0403$)*	0.020	0.616
openness scale	Competitive athletes n = 141	5.03 ± 3.62	4.75 ± 1.87	6.50 ± 0.71	Intercept	$F_{1,317} = 279.28$ ($p < 0.0001$)*	0.468	1.000
					PA /Control	$F_{1,317} = 4.55$ ($p = 0.0337$)	0.014	0.566
					(*AN*)	$F_{2,317} = 0.46$ ($p = 0.6316$)	0.003	0.125
	Controls n = 182	4.69 ± 1.79	4.51 ± 1.52	3.40 ± 1.14	PA /Control x (*AN*)	$F_{2,317} = 1.46$ ($p = 0.2331$)	0.009	0.312
agreeability scale	Competitive athletes n = 141	6.97 ± 7.26	5.60 ± 2.19	9.50 ± 0.71	Intercept	$F_{1,317} = 219.24$ ($p < 0.0001$)*	0.409	1.000
					PA /Control	$F_{1,317} = 4.95$ ($p = 0.0268$)*	0.015	0.602
					(*AN*)	$F_{2,317} = 1.50$ ($p = 0.2251$)	0.009	0.318
	Controls n = 182	5.60 ± 1.91	5.90 ± 1.97	4.80 ± 1.48	PA /Control x (*AN*)	$F_{2,317} = 4.01$ ($p = 0.0191$)*	0.025	0.715
conscientiousness scale	Competitive athletes n = 141	7.00 ± 2.33	7.07 ± 2.00	8.50 ± 2.12	Intercept	$F_{1,317} = 479.62$ ($p < 0.0001$)*	0.604	1.000
					PA /Control	$F_{1,317} = 7.18$ ($p = 0.0077$)*	0.022	0.762
					(*AN*)	$F_{2,317} = 0.09$ ($p = 0.9139$)	0.001	0.064
	Controls n = 182	6.13 ± 2.08	6.12 ± 2.09	5.40 ± 3.05	PA /Control x (*AN*)	$F_{2,317} = 0.76$ ($p = 0.4674$)	0.005	0.179

** significant result; M ± SD: mean ± standard deviation, n: number of subjects, p: statistical significance, ** only one subject, AN: ANKK1 genotype*

Table 5. The Least Significant Difference (LSD) post hoc analysis for interactions between athletic status, *ANKK1 Taq1A* rs1800497 genotypes, and scores on the neuroticism, extraversion, and agreeability scales.

neuroticism scale

	M = 4.71 {1}	M = 4.97 {2}	M = 1.00 {3}	M = 4.33 {4}	M = 4.49 {5}	M = 6.00 {6}
Competitive athletes C/T {1}		0.5247	0.0125*	0.3929	0.5940	0.1867
Competitive athletes C/C {2}			0.0063*	0.0476*	0.0765	0.2677
Competitive athletes T/T {3}				0.0227*	0.0161*	0.0034*
Controls C/T {4}					0.6097	0.0766
Controls C/C {5}						0.1036
Controls T/T {6}						

extraversion scale

	M = 6.23 {1}	M = 6.50 {2}	M = 10.00 {3}	M = 6.82 {4}	M = 6.53 {5}	M = 6.80 {6}
Competitive athletes C/T {1}		0.4535	0.0042*	0.1342	0.4085	0.5069
Competitive athletes C/C {2}			0.0066*	0.2665	0.9142	0.7148
Competitive athletes T/T {3}				0.0141*	0.0070*	0.0337*
Controls C/T {4}					0.3010	0.9812
Controls C/C {5}						0.7380
Controls T/T {6}						

agreeability scale

	M = 6.97 {1}	M = 5.60 {2}	M = 9.50 {3}	M = 5.61 {4}	M = 5.90 {5}	M = 4.80 {6}
Competitive athletes C/T {1}		0.0242*	0.2418	0.0379*	0.0744	0.1296
Competitive athletes C/C {2}			0.0659	0.9921	0.4571	0.5541
Competitive athletes T/T {3}				0.0681	0.0888	0.0586
Controls C/T {4}					0.5361	0.5584
Controls C/C {5}						0.4179
Controls T/T {6}						

** statistically significant differences; M: mean*

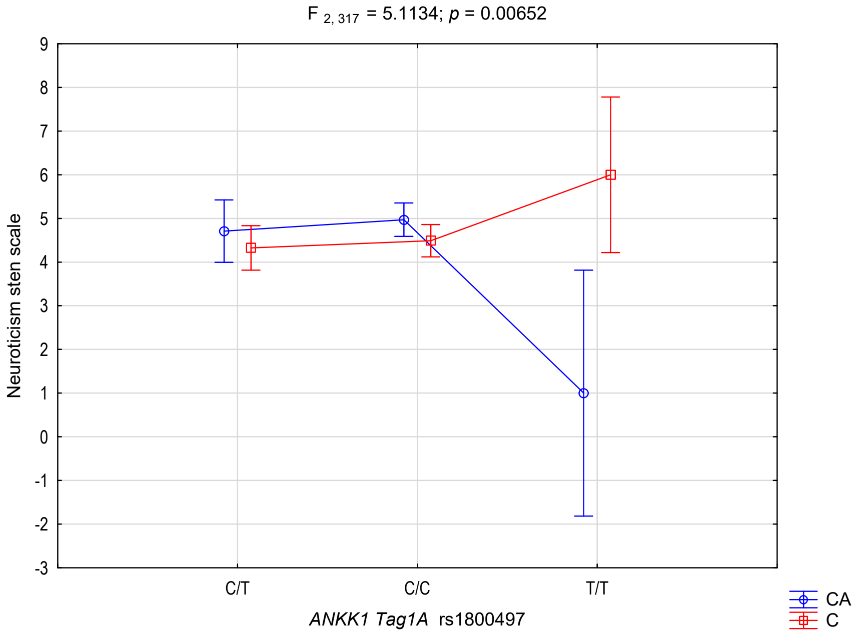

Figure 1. Interaction between competitive athletes (CA), controls (C), *ANKK1 Taq1A* rs1800497 and the neuroticism scale.

Discussion

This study aimed to explore three key objectives: (1) the association between the *ANKK1 Taq1A* rs1800497 polymorphism and elite athletic status; (2) differences in personality traits between competitive athletes and controls; and (3) interaction effects of the genotype, personality, and engagement in sport. Our findings offer new insights into how specific genotypic configurations may contribute to distinct personality profiles and psychological readiness in elite athletes, with potential implications for training personalization, psychological support, and talent development.

The genotypic distribution of *ANKK1 Taq1A* differed significantly between athletes and controls. The C/C genotype and the C allele were more prevalent in the group of competitive athletes, whereas carriers of the T allele (C/T and T/T) were more common in controls. These findings are consistent with earlier research indicating that the A1 (T) allele may be associated with reduced dopaminergic efficiency, lower reinforcement from exercise, and increased vulnerability to addictive behaviors, particularly in women (Lee et al., 2020). Notably, however, male carriers of the T allele have been shown to demonstrate sustained engagement in sport, suggesting sex-specific reward mechanisms that could make physical activity more "addictive" in this group (Lee et al., 2020). From a practical perspective, this supports the notion that training programs and motivation strategies may benefit from being tailored not only by the personality profile, but also by genetic susceptibility to reward sensitivity.

While rs1800497 was not directly associated with performance metrics in previous research (Bayraktar et al., 2023), our results indicate its importance in shaping personality traits that influence athletic engagement and mental preparation. Personality-related characteristics, together with the broader talent development environment, are known to influence athletes' long-term commitment and progression in sport (Zhang and Wei, 2025). Athletes in our study exhibited significantly higher conscientiousness scores than controls—a trait strongly associated with discipline, reliability, and goal-directed behavior (Fabbricatore et al., 2023; Piepiora and Witkowski, 2020). In high-performance settings, this may translate into more structured training routines, better compliance with coaching directives, and long-term career sustainability.

More importantly, significant interactions emerged among the genotype, personality traits, and athletic status:

Neuroticism: among athletes, the C/C genotype was associated with elevated neuroticism scores, while the T/T genotype was linked to markedly lower levels of neuroticism. This may indicate that individuals with the C/C genotype, despite having favorable dopaminergic reinforcement profiles, could be more emotionally reactive or stress-sensitive under performance pressure. For coaches and sport psychologists, this implies a need for targeted mental resilience training or stress inoculation programs for C/C athletes to mitigate burnout or performance anxiety. In contrast, athletes with the T/T genotype may demonstrate greater emotional stability and psychological detachment during high-stakes competitions.

Extraversion: athletes with the T/T genotype also showed the highest extraversion scores, surpassing both their C/C and C/T peers and all control genotypes. This suggests that T/T individuals may possess enhanced sociability, assertiveness, and responsiveness to external stimuli—traits beneficial in team-based or interactive sport environments. Coaches may consider positioning T/T athletes in leadership or communicative roles, where emotional expression, enthusiasm, and interpersonal coordination are key.

Agreeableness: athletes with the C/T genotype scored higher in agreeableness than both C/C athletes and C/T controls. Agreeableness is linked to cooperation, trust, and group harmony—attributes essential in team sports requiring interpersonal synergy. These athletes may respond particularly well to cooperative training formats, shared goal-setting, and conflict-sensitive coaching approaches.

These results reinforce the concept of genetically modulated personality profiles, with sport engagement further amplifying or attenuating trait expression. Environmental and developmental contexts, including the quality of the talent development environment and psychosocial influences such as the coaching style or family support, may further shape athletes' commitment, resilience, and long-term engagement in sport (Zhang and Wei, 2025; Vega-Díaz and González-García, 2025). Gene-environment interactions, particularly in the context of high-performance training, appear to shape not only the psychological characteristics of athletes, but potentially their receptivity to specific coaching styles and motivational strategies. For instance, athletes predisposed to higher neuroticism (e.g., C/C genotype) may require structured feedback, cognitive reframing, and emotional coaching, while those with higher extraversion (e.g., T/T genotype) may thrive in dynamic, externally rewarding environments.

The broader literature supports this interpretation. While high conscientiousness and low neuroticism consistently correlate with better athletic outcomes (Fabbricatore et al., 2023), individual profiles vary by sport discipline, team vs. individual formats, and the athlete's level (Piepiora and Witkowski, 2020). Our findings are in line with studies suggesting that elite athletes—especially those competing at the international level—tend to exhibit lower neuroticism, higher extraversion, and greater conscientiousness than their non-elite or recreational counterparts (Piepiora, 2024). These personality configurations likely facilitate optimal stress regulation, mental focus, and interpersonal coordination.

The observed personality differences should be interpreted in light of three limitations. First, the lack of sex-stratified analysis may have obscured genotype-by-sex interactions, particularly relevant for traits like neuroticism and reward sensitivity. Second, the inclusion of athletes from various sport disciplines introduces heterogeneity, although this reflects real-world athlete diversity. Finally, the exclusive inclusion of Caucasian participants limits generalizability. Future studies should expand to multi-ethnic and sex-balanced cohorts to validate and refine these genotype-trait associations.

Moreover, as this study employed a

candidate-gene approach, it does not account for the broader polygenic architecture of sports performance and personality traits. Future investigations should therefore incorporate polygenic scores and whole-genome analyses to provide a more comprehensive understanding of the genetic basis of these complex phenotypes.

Conclusions

The present study demonstrates that the *ANKK1 Taq1A* rs1800497 polymorphism is significantly associated with both elite athletic status and the expression of specific personality traits relevant to sport performance. The higher frequency of the C/C genotype and the C allele among athletes suggests a potential genetic contribution to behaviors underpinning long-term engagement in high-level sports. However, this genotype was also linked to elevated neuroticism, highlighting a possible vulnerability to stress reactivity in demanding competitive environments. These findings may guide individualized psychological interventions aimed at enhancing emotional regulation and resilience, particularly for C/C carriers in elite sport contexts.

Conversely, the T/T genotype—despite its lower prevalence—was associated with higher extraversion scores in athletes, indicating potential benefits for interpersonal functioning, team cohesion, and externally driven motivation. Athletes with the C/T genotype showed elevated agreeableness, suggesting enhanced cooperative potential—valuable in team dynamics and conflict resolution.

Together, these interactions underscore the utility of integrating genetic and psychological profiling in athlete's development programs. The nuanced influence of the *ANKK1* rs1800497 polymorphism on personality traits suggests that genotype-informed coaching strategies could enhance mental preparation, training adherence, and interpersonal effectiveness. Future research should validate these associations in larger, more diverse cohorts and further investigate the biological pathways linking *ANKK1* to dopaminergic regulation of personality traits.

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