

Association between psychological traits and physical performance in Kyorugi Taekwondo athletes

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Published online: March 31, 2026

Accepted for publication: March 15, 2026

DOI:10.7752/jpes.2026.03046

Abstract:

Performance in combat taekwondo depends on a complex interaction between physical and psychological factors, whose specific relationship remains not fully understood. This study examined the association between psychological characteristics related to sports performance, assessed using the CPRD questionnaire, and physical performance in *Kyorugi* taekwondo athletes. A cross-sectional correlational design was employed with 53 competitive athletes (31 males, 22 females; aged 14–25 years). Physical performance was evaluated using vertical jump tests (SJ and CMJ), a sport-specific agility test (TSAT), and a taekwondo-specific intermittent high-intensity test (TAAA). Canonical correlation analysis did not reveal a significant global multivariate relationship between psychological and physical variable sets ($\Lambda = 0.57$, $p = .39$). However, hierarchical regression models identified mean power in the TAAA as a robust predictor of fatigue index ($\beta = -0.53$, $p < .01$), explaining a substantial proportion of variance. The inclusion of psychological variables resulted in a moderate additional increase in explained variance ($\Delta R^2 = 0.08$), although this increment did not reach statistical significance ($p = .09$). Significant sex differences were observed in several physical performance variables and in stress control. The findings suggest that psychological characteristics are not globally associated with physical performance but may exert a specific and context-dependent influence, particularly under fatigue conditions. In conclusion, the ability to sustain high levels of power during intermittent efforts emerges as a key determinant of combat performance, while psychological variables may modulate the expression of physical capacities. These results support the implementation of integrated training approaches combining physical and psychological development in taekwondo athletes.

Key Words: sport psychology, intermittent performance, neuromuscular fatigue, combat sports physiology, agility performance

Introduction

Taekwondo is a martial art and Olympic sport that has become one of the most widely practiced combat sports worldwide, with over 80 million practitioners across approximately 210 countries (World Taekwondo, 2024). In its competitive *Kyorugi* (combat) modality, taekwondo is characterized as a full-contact sport where two athletes engage in combat rounds alternating high-intensity actions (kicks and punches), low-intensity actions (footwork and evasions), and brief pauses, creating a high-intensity intermittent effort pattern. This places predominant demands on oxygen-independent energy systems (the phosphagen and glycolytic pathways) (Ouergui et al., 2025). The temporal structure of a taekwondo match, consisting of three two-minute rounds with one minute of rest between them, imposes considerable physiological and psychological demands on competitors (Podrigalo et al., 2025). Success in this modality depends on a complex interaction of technical, tactical, physical, and psychological factors, where the ability to execute explosive actions repeatedly and maintain mental clarity under competitive pressure are critical determinants of sports performance (Podrigalo et al., 2025).

From the perspective of physical performance, numerous studies have documented the anthropometric characteristics and physical capacities that distinguish successful *Kyorugi* taekwondo competitors. Apollaro et al. (2024) reported significant correlations between muscle mass and body fat percentage with performance on the

Multiple Frequency Speed of Kick Test (FSKTMult), a specific test assessing the capacity to perform high-intensity kicks intermittently. Similarly, Ojeda-Aravena et al. (2023) identified that asymmetries in body composition between limbs correlate negatively with performance on specific taekwondo tests, underscoring the importance of balanced bilateral development (Ouergui et al., 2025). Lower limb power, assessed through vertical jump tests such as the squat jump (SJ) and countermovement jump (CMJ), has shown consistent associations with sport-specific high-intensity capacity, suggesting that improvements in explosive leg power may translate into a greater ability to repeat high-intensity efforts during combat (Apollaro et al., 2024; Nabilpour et al., 2023). Additionally, sport-specific agility tests like the Taekwondo-Specific Agility Test (TSAT) and high-intensity capacity tests like the Taekwondo-specific Aerobic-Anaerobic-Agility test (TAAA) have proven valid, reliable, and ecologically representative of the competitive demands of taekwondo, constituting valuable tools for evaluating and monitoring athletes' physical performance (Ojeda-Aravena et al., 2023; Samanipour et al., 2025).

Concurrently, the psychological dimension of sports performance in taekwondo and other combat sports has received considerable attention in the scientific literature. Combat sports are characterized by exposing athletes to high mental stress stemming from direct physical contact with an opponent, outcome uncertainty, constant evaluation by referees, coaches, and spectators, and the inherent risk of injury (Fernández et al., 2020; Mojtahedi et al., 2023; Predoiu et al., 2025). In this context, various psychological variables have been identified as critical factors for competitive success. Competitive anxiety, in both its cognitive component (worries and negative thoughts) and somatic component (physiological manifestations of arousal), has shown significant relationships with performance in combat sports (Fernández et al., 2020; Rossi et al., 2022). Kang and Jang (2021) demonstrated in taekwondo athletes that cognitive and somatic anxiety negatively affect self-perceived performance, while self-confidence has positive effects. Complementarily, Mojtahedi et al. (2023) reported that combat sport athletes with higher levels of mental toughness experience lower levels of cognitive and somatic anxiety and higher levels of self-confidence before competitions, which is associated with better competitive outcomes (Predoiu et al., 2025). Motivation, understood as the directional orientation and intensity of effort, has also been identified as a significant predictor of performance in combat sports (Ayranci & Aydin, 2025; Rossi et al., 2022). Remiszewska et al. (2022) found that taekwondo competitors with higher athletic achievements presented higher levels of motivation and extraversion compared to athletes of a lower competitive level. Additionally, other psychological characteristics such as stress control, emotional intelligence (Fernández et al., 2020; Nabilpour et al., 2023), concentration ability, and team cohesion (relevant in contexts of national teams or representative squads) have been associated with competitive success in martial arts and combat sports (Li et al., 2020; Rossi et al., 2022).

For the systematic assessment of these psychological characteristics related to sports performance, various psychometric instruments have been developed and applied to taekwondo athletes in diverse contexts (Cardozo, Rodríguez, et al., 2025). Among these, the Cuestionario de Características Psicológicas relacionadas con el Rendimiento Deportivo (CPRD) stands out as a widely used tool in the Spanish-speaking sports context for evaluating five fundamental psychological dimensions: Stress Control (ability to manage competitive tension and anxiety), Influence of Performance Evaluation (ability to manage the impact of internal and external performance evaluation), Motivation (level of achievement orientation and sport commitment), Mental Ability (capacity for concentration, visualization, and cognitive self-regulation), and Team Cohesion (perception of integration and collaborative work with teammates and coaches). The CPRD has demonstrated adequate psychometric properties in various athletic populations (Álvarez et al., 2025). Olmedilla et al. (2021) used this instrument to assess sex differences in the psychological profile of young soccer players, identifying that males showed better scores in Stress Control and Influence of Performance Evaluation, while females obtained better scores in Team Cohesion, with moderate effect sizes. However, it is noteworthy that, despite its widespread use in other sports, the CPRD has not been systematically employed in taekwondo populations, representing an opportunity to expand knowledge about the specific psychological profile of this combat sport.

Despite a substantial body of evidence on physical and psychological characteristics associated with taekwondo performance independently, the understanding of direct relationships between both dimensions remains limited and fragmented (Ayranci & Aydin, 2025; Li et al., 2020). Some studies have begun to explore these connections, albeit with significant methodological limitations. Nabilpour et al. (2023) investigated associations between psychological skills and physical capacities in ten male Iranian elite taekwondo athletes, reporting significant correlations between social skills and relative peak power, and between mental control and relative peak power. However, this study had a very small sample size, excluded female participants, and did not utilize sport-specific taekwondo physical performance tests. More recently, Samanipour et al. (2025) examined correlations considering sex, nutritional intake, body composition, psychological skills, and performance metrics in 35 young taekwondo athletes (13 ± 1 years), reporting that in females, emotional regulation emerged as a significant predictor of FSKTMult performance, while in males, no significant psychological predictors were identified. However, this study focused on prepubertal athletes, whose physiological and psychological

characteristics differ substantially from those of adolescent and adult athletes (Li et al., 2020; Remiszewska et al., 2022), and also did not use the CPRD as the psychological assessment instrument. Consequently, while scientific literature provides solid evidence on the individual relevance of physical and psychological characteristics for *Kyorigi* taekwondo performance (Apollaro et al., 2024; Predoiu et al., 2025), there is a notable scarcity of studies that have comprehensively and systematically examined the relationships between the psychological profile, assessed using validated instruments like the CPRD (Olmedilla et al., 2021), and sport-specific taekwondo physical performance, measured through a comprehensive battery of tests including body composition, power capacities, sport-specific agility, and sport-specific endurance (Ojeda-Aravena et al., 2023; Ouerghi et al., 2025). This knowledge gap is particularly relevant because understanding these relationships could inform the design of more holistic and integrated training programs (Ayranci & Aydin, 2025), facilitate the identification of individual psychophysical strength and weakness profiles (Li et al., 2020), and guide more specific and effective psychological interventions to optimize competitive performance (Mojtahedi et al., 2023; Rossi et al., 2022). Additionally, considering the documented sex differences in both psychological and physical variables (Fernández et al., 2020; Olmedilla et al., 2021; Samanipour et al., 2025), as well as the potential influence of age and athletic experience (Remiszewska et al., 2022), it is essential to examine these relationships while considering these control variables. This would allow for the identification of specific patterns and generate more precise and applicable recommendations for different segments of the taekwondo athlete population.

Therefore, the objective of the present study was to analyze the relationship between psychological characteristics related to sports performance, assessed via the Cuestionario de Características Psicológicas relacionadas con el Rendimiento Deportivo (CPRD), and physical performance in *Kyorigi* taekwondo athletes, evaluated through a test battery. It was hypothesized that psychological skills, particularly Stress Control, Mental Ability, and Motivation, would be positively associated with indicators of sport-specific taekwondo physical performance, and that these relationships could be moderated by the athletes' sex, age, and athletic experience. The results of this study will contribute to broadening the understanding of the multidimensional nature of performance in *Kyorigi* taekwondo and will provide empirical evidence to guide the development of more comprehensive and personalized preparation programs.

Material & methods

Design

The present research employed a non-experimental, cross-sectional, correlational design aimed at examining the relationship between psychological characteristics and physical performance, while additionally considering specific demographic variables.

Participants

The study included 53 taekwondo athletes aged 14 to 25 years (31 males [58.5%]: $Me = 17$ years, $IQR = 15.0 - 18.0$ years; 22 females [41.5%]: $Me = 16$ years, $IQR = 15.0 - 21.8$ years). Of these, 31 (58.5%) belonged to the junior category (ages 14 to 17) and 22 (41.5%) to the senior category (> 18 years). Experience in the sport ranged from 3 to 18 years ($Me = 7$ years, $IQR = 5.0 - 12$ years). Inclusion criteria consisted of holding an advanced or black belt rank, actively participating in official national or international competitions during the previous year, and being affiliated with a club or team. Exclusion criteria included having a beginner belt rank, presenting musculoskeletal injuries at the time of physical assessments, or being under medical treatment for any health condition.

Athletes were selected through a non-probabilistic purposive sampling method. The sample size was contextualized through an a priori power analysis conducted with GPower software version 3.1.9.7 (Test family: Correlation and regression; Statistical test: Correlation: Bivariate normal model; two-tailed; $\alpha = 0.05$; $1-\beta = 0.80$). According to Cohen's criteria, a sample of 53 athletes allows for the detection of moderate-to-high to large magnitude associations ($r \approx 0.40-0.50$), whereas detecting small-to-moderate effects would require larger samples. Consequently, the present study is oriented toward identifying relationships of practically relevant magnitude, prioritizing the interpretation of effect sizes and their confidence intervals over statistical significance, especially in exploratory multivariate analyses.

Instruments

Psychological characteristics were assessed using the Cuestionario de Características Psicológicas Relacionadas con el Rendimiento Deportivo (CPRD), developed by Gimeno et al. (2001) and validated in a Colombian population (Álvarez et al., 2025). The instrument consists of 55 items distributed across five dimensions: Stress Control, Influence of Performance Evaluation, Motivation, Mental Ability, and Team Cohesion, with a five-point Likert-type response scale. In the present study, the internal consistency of the CPRD dimensions was estimated using McDonald's omega coefficient (ω). Results showed excellent reliability for the Stress Control dimension ($\omega = 0.92$; 95% CI = 0.89–0.95) and adequate reliability for Influence of Performance Evaluation ($\omega = 0.84$; 95% CI = 0.78–0.90). In contrast, the Motivation ($\omega = 0.60$; 95% CI = 0.45–

0.74), Mental Ability ($\omega = 0.49$; 95% CI = 0.32–0.66), and Team Cohesion ($\omega = 0.65$; 95% CI = 0.52–0.78) dimensions presented low to moderate reliability values.

The variables sex, age, and years of athletic experience were considered as sociodemographic variables. Body composition variables included height, body mass, fat percentage, and muscle mass. These were assessed using the digital stadiometer InBody InLab® and the OMRON HBF-514c bioelectrical impedance scale, an instrument that has demonstrated adequate reliability in previous studies (Vázquez-Bautista et al., 2025).

Lower limb power capacities (CMJ and SJ jump tests) were assessed using the inertial sensor G-Sensor (BTS Bioengineering, Brooklyn NY), a previously validated instrument (McHugh et al., 2019). Sport-specific agility was assessed using the "Taekwondo-Specific Agility Test" (TSAT), validated by Chaabene et al. (2018), with time recorded using Microgate Witty-Gate photocells (Microgate, Italy). To evaluate the high-intensity intermittent effort capacity characteristic of *Kyorigi* taekwondo, the "Taekwondo-specific Aerobic-Anaerobic-Agility test" (TAAA) was employed (Taati et al., 2022). It should be noted that, in accordance with current exercise physiology nomenclature (Petro et al., 2025), these tests predominantly demand oxygen-independent energy systems (the phosphagen and glycolytic pathways).

Procedure

In a first stage, direct contact was established with the coaches of the participating teams, who were thoroughly informed about the study's objectives, scope, and procedures. Subsequently, informed consent and assent were provided digitally to the athletes and/or their legal guardians, as appropriate, guaranteeing the confidentiality of the information and the voluntary nature of participation.

Psychological characteristics were assessed using the CPRD questionnaire, which was administered in digital format via an electronic form (Google Forms). The instrument was administered in person, under the supervision of the researchers, who were available to clarify any doubts related to item comprehension without influencing participants' responses.

Physical assessments were conducted in person and distributed across two sessions separated by a 24-hour interval, to minimize the effects of accumulated fatigue. The first session assessed body composition variables, as well as lower limb power through jump tests (CMJ and SJ) and the sport-specific agility TSAT. The second session assessed sport-specific endurance (TAAA test).

All physical tests were performed barefoot and, in the case of agility and endurance tests, on an official taekwondo doyang (Daedo® mat, Spain), to avoid potential bias from footwear type and to enhance the ecological validity of the assessments by replicating conditions similar to competition. Before each assessment session, athletes performed a standardized warm-up under the supervision of the research team. The procedure was carried out following approval by the university's ethics committee (Act 17_10/05/2024).

Data Analysis

Data were analyzed using the RStudio programming environment. Initially, the distribution of variables was assessed using the Shapiro–Wilk test, complemented by visual inspection of histograms and Q–Q plots. Given that several variables did not meet the assumption of normality, descriptive results are expressed as median and interquartile range. The muscle mass percentage variable had a low percentage of missing values ($n = 3$), which were imputed using the sample median to preserve the sample size in all subsequent analyses. Scores for the dimensions of the CPRD were calculated by summing the items corresponding to each subscale. Subsequently, to homogenize scales, correct for differences in the number of items per dimension, and facilitate multivariate analyses, these scores were standardized into z-scores, calculated from the mean and standard deviation of the total sample. The total CPRD score was used for descriptive purposes only, while inferential analyses were conducted using the instrument's specific dimensions. As a secondary analysis, comparisons between males and females, and between sport categories (junior and senior), were performed for all study variables using the Mann-Whitney U test; effect size was provided using the rank-biserial correlation [r_{rb}].

Bivariate relationships between the psychological dimensions of the CPRD and physical performance indicators were analyzed using Spearman's rank correlation coefficients (ρ), based on the data distribution. Exploratory correlation analyses stratified by sex are presented. Furthermore, to examine the overall multivariate relationship between psychological characteristics and physical performance, an exploratory canonical correlation analysis was conducted, considering the sample size and age heterogeneity of the sample. For this analysis, standardized variables were used, and the presence of extreme outliers was controlled using univariate and multivariate procedures. Correlation analyses were initially performed on the total sample. Considering the sample size and to preserve statistical power, sex and age were included as covariates in the multivariate analyses.

Additionally, to examine the specific contribution of psychological variables to physical performance, hierarchical multiple regression models were employed. In the first block, control variables (sex, age, athletic experience) were entered; in the second block, selected physical variables; and in the third block, the standardized psychological dimensions of the CPRD. Continuous variables included in the regression models were previously standardized using Z-scores. Model adequacy was verified by assessing multicollinearity

(variance inflation factor, VIF), as well as through analysis of residual normality and homoscedasticity. To evaluate the stability of the results, sensitivity analyses were conducted by exploring alternative models through the exclusion of predictors with high VIF values. To avoid statistical redundancy and model overfitting, only those TAAA variables representing distinct physiological constructs (mean power output, fatigue, and total specific work volume) were selected, excluding derived or highly correlated indicators (Tabachnick & Fidell, 2022). Due to the sample size, the main analyses were conducted on the total sample, with sex-stratified analyses performed for exploratory purposes only. In all analyses, a statistical significance level of $p < 0.05$ was established.

Results

In the general descriptive analysis, athletes presented a median height of 167.4 cm ($IQR = 160.9$ – 172.3) and a body mass of 58.1 kg ($IQR = 52.4$ – 65.9). Regarding body composition, the fat percentage showed a median of 19.95% ($IQR = 13.3$ – 28.4), while the muscle percentage was 40.15% ($IQR = 28.9$ – 44.5). In the physical performance tests, the median values achieved were 32.5 cm ($IQR = 25.4$ – 37.8) in the SJ jump and 36.4 cm ($IQR = 27.7$ – 40.5) in the CMJ jump, with an elasticity index of 9.0% ($IQR = 4.9$ – 15.4). The median time recorded in the taekwondo-specific agility test (TSAT) was 5.25 s ($IQR = 4.92$ – 5.70). In the intermittent endurance test, participants performed a median of 79 kicks ($IQR = 74$ – 83), with a mean power of 8.5 ($IQR = 8.0$ – 9.0) and a fatigue index of 2.5 ($IQR = 1.4$ – 2.9). Finally, the psychological variables assessed with the CPRD presented medians of 48.0 ($IQR = 41$ – 57) in stress control, 28.0 ($IQR = 24$ – 31) in influence of performance evaluation, 24.0 ($IQR = 22$ – 26) in motivation, 24.0 ($IQR = 21$ – 26) in mental ability, and 16.0 ($IQR = 14$ – 18) in team cohesion, with a total score of 139.0 ($IQR = 126$ – 151). Table 1 presents the descriptive and analytical comparisons of the study variables according to the athletes' sex.

Table 1. Descriptive statistics and comparison by sex of the study variables

Variable	Sex	Median [Q1–Q3]	U (p), r _(rb)
Height (cm)*	Male	170.1 [167.5–175.9]	U = 612.0, $p < .001$, r _(rb) = 0.80
	Female	160.6 [157.1–164.7]	
Body mass (kg)	Male	59.4 [53.4–67.8]	U = 400.0, $p = .291$, r _(rb) = 0.17
	Female	57.6 [52.0–59.6]	
Body fat percentage*	Male	13.7 [8.1–17.9]	U = 7.0, $p < .001$, r _(rb) = –0.98
	Female	30.6 [25.8–34.0]	
Muscle mass percentage*	Male	43.8 [41.7–46.0]	U = 610.0, $p < .001$, r _(rb) = 0.98
	Female	28.4 [27.2–30.6]	
SJ jump (cm)*	Male	37.1 [32.5–38.8]	U = 648.0, $p < .001$, r _(rb) = 0.90
	Female	24.2 [21.1–27.9]	
CMJ jump (cm)*	Male	39.8 [36.8–43.8]	U = 650.5, $p < .001$, r _(rb) = 0.91
	Female	25.9 [23.7–30.3]	
Elasticity index	Male	8.9 [4.0–18.3]	U = 327.5, $p = .814$, r _(rb) = –0.04
	Female	11.0 [5.3–14.1]	
TSAT agility (s)*	Male	5.01 [4.83–5.33]	U = 164.0, $p = .001$, r _(rb) = –0.52
	Female	5.57 [5.28–6.16]	
Total kicks*	Male	82.0 [78.0–87.5]	U = 548.0, $p < .001$, r _(rb) = 0.61
	Female	74.5 [72.0–79.5]	
Mean power*	Male	8.9 [8.4–9.5]	U = 548.0, $p < .001$, r _(rb) = 0.61
	Female	8.1 [7.8–8.6]	
Kick fatigue index (KFI)	Male	2.4 [1.2–2.8]	U = 233.5, $p = .053$, r _(rb) = –0.32
	Female	2.7 [2.4–2.9]	
Control de estrés*	Male	49.0 [43.0–58.5]	U = 452.5, $p = .045$, r _(rb) = 0.33
	Female	43.0 [36.0–52.8]	

Performance evaluation influence	Male	28.0 [24.5–32.5]	U = 383.0, $p = .453$, $r_{rb} = 0.12$
	Female	27.5 [24.3–30.0]	
Motivation	Male	24.0 [22.5–26.0]	U = 336.5, $p = .942$, $r_{rb} = -0.01$
	Female	24.0 [22.0–26.8]	
Mental skills	Male	24.0 [21.5–26.0]	U = 387.5, $p = .403$, $r_{rb} = 0.14$
	Female	23.0 [21.3–25.8]	
Team cohesion	Male	16.0 [14.0–18.0]	U = 287.0, $p = .330$, $r_{rb} = -0.16$
	Female	17.0 [14.0–19.0]	
CPRD Total Score	Male	144.0 [128.5–156.0]	—
	Female	138.5 [119.0–147.8]	

Note. Data are expressed as median and interquartile range [Q1–Q3]. Comparisons between sexes were performed using the Mann–Whitney U test. Effect size was estimated using the rank-biserial correlation (r_{rb}). * = variable where significant differences were found ($p < .05$).

Given the wide age range and the inherent differences in the maturation process, descriptive results are also presented separately by sport category for exploratory purposes. Significant differences were found only in body mass, elasticity index, and agility test variables ($p < .05$). The complete results of this secondary analysis can be found in the supplementary material (Supplementary Table S1).

Bivariate Correlation Between Psychological Characteristics and Physical Performance

Given the high number of bivariate associations evaluated and in accordance with the study's objective, the manuscript presents only the correlations between the psychological dimensions of the CPRD and physical performance indicators (Table 2). The complete correlation matrix is included as supplementary material (Supplementary Table S2).

Table 2. Spearman correlations between psychological dimensions (CPRD) and physical performance

Dimensions (CPRD)	SJ	CMJ	Elasticity index	TSAT agility (s)	Total kicks	Mean power	KFI
Stress control	$\rho = 0.210$ ($p = .130$)	$\rho = 0.237$ ($p = .088$)	$\rho = 0.070$ ($p = .620$)	$\rho = -0.142$ ($p = .311$)	$\rho = 0.248$ ($p = .073$)	$\rho = 0.248$ ($p = .073$)	$\rho = -0.249$ ($p = .072$)
Performance evaluation influence	$\rho = 0.122$ ($p = .385$)	$\rho = 0.152$ ($p = .276$)	$\rho = 0.075$ ($p = .592$)	$\rho = -0.116$ ($p = .407$)	$\rho = 0.147$ ($p = .293$)	$\rho = 0.147$ ($p = .293$)	$\rho = -0.202$ ($p = .147$)
Motivation	$\rho = 0.065$ ($p = .644$)	$\rho = 0.046$ ($p = .742$)	$\rho = 0.285$ ($p = .039$)	$\rho = 0.186$ ($p = .182$)	$\rho = -0.047$ ($p = .737$)	$\rho = -0.047$ ($p = .737$)	$\rho = 0.272$ ($p = .048$)
Mental skills	$\rho = 0.078$ ($p = .579$)	$\rho = 0.064$ ($p = .648$)	$\rho = -0.013$ ($p = .924$)	$\rho = -0.107$ ($p = .448$)	$\rho = 0.121$ ($p = .387$)	$\rho = 0.121$ ($p = .387$)	$\rho = -0.041$ ($p = .773$)
Team cohesion	$\rho = 0.109$ ($p = .437$)	$\rho = -0.114$ ($p = .416$)	$\rho = 0.031$ ($p = .828$)	$\rho = 0.086$ ($p = .541$)	$\rho = -0.027$ ($p = .850$)	$\rho = -0.027$ ($p = .850$)	$\rho = 0.057$ ($p = .684$)

Note. ρ = Spearman's coefficient. Lower values in TSAT indicate better performance.

Additionally, correlational analyses stratified by sex were performed for exploratory purposes (Supplementary Tables S3 and S4). In males, moderate to high magnitude associations were observed between anthropometric and physical performance variables, particularly between height, body mass, and jump indicators (SJ and CMJ), specific agility (TSAT), and kick volume and mean power. Furthermore, in this group, associations were identified between some psychological variables, such as Stress Control and Influence of Performance Evaluation, as well as relationships between Stress Control and Mental Ability. In females, associations were mainly concentrated between body composition variables and physical performance, with relationships between muscle mass percentage and jump indicators being notable. Additionally, in this group, associations were observed between age and psychological variables such as Stress Control, Influence of Performance Evaluation, and Mental Ability, as well as between these psychological dimensions. Overall, the

stratified analyses suggest partially differentiated association patterns according to sex; however, these results should be interpreted with caution and are presented for exploratory purposes only.

Multivariate Relationship Between Psychological Profile and Physical Performance

The canonical correlation analysis did not reveal a statistically significant multivariate relationship between the set of psychological variables and the set of physical variables. The first canonical function presented a moderate correlation ($R_c = 0.58$); however, the global contrast using Wilks' Lambda did not reach statistical significance ($\Lambda = 0.57$, $\chi^2(25) = 26.43$, $p = .39$). The subsequent canonical functions were also not statistically significant ($p > .05$), so no stable multivariate linear relationship was identified between both sets of variables in the analyzed sample (Table 3 and Figure 1).

Table 3. Results of the canonical correlation analysis between psychological dimensions (CPRD) and physical performance variables in taekwondo athletes.

Function	Rc	Rc2	Wilks Lambda	Chi2	gl	p
1	0.58	0.33	0.57	26.43	25	.38
2	0.31	0.09	0.85	7.67	16	.96
3	0.19	0.04	0.94	3.12	9	.96
4	0.17	0.03	0.97	1.41	4	.84
5	0.04	0.00	1.00	0.07	1	.79

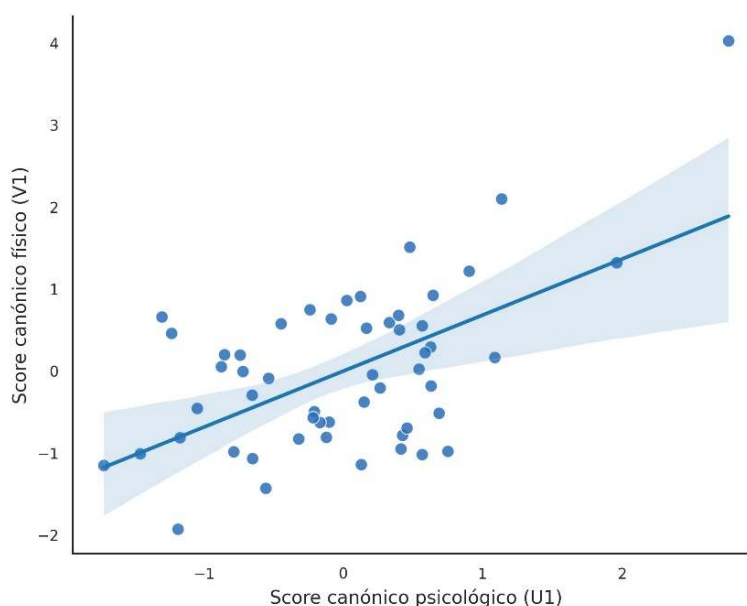


Figure 1. Scatter plot of psychological (U1) and physical (V1) canonical scores for the first canonical function.

Hierarchical Multiple Regression on the Specific Fatigue Index (KFI)

Hierarchical multiple regression models were constructed using the kick fatigue index (KFI) as the dependent variable, with the aim of examining the incremental contribution of physical and psychological variables, while controlling for relevant sociodemographic variables.

In Model 1, which included sex and age as control variables, the explained variance was low and did not reach statistical significance ($R^2 = 0.07$, $p > .05$). The incorporation of physical variables in Model 2 produced a significant increase in the explained variance ($\Delta R^2 \approx 0.35$, $p < .001$), reaching a total R^2 of approximately 0.41. Finally, the addition of the selected psychological dimensions in Model 3 generated an additional increase of moderate magnitude in the explained variance ($\Delta R^2 \approx 0.08$), reaching a total R^2 close to 0.49; however, this increase did not reach the conventional threshold of statistical significance ($p \approx .09$).

In the final model, sport-specific mean power in taekwondo emerged as the most robust predictor of the fatigue index ($\beta \approx -0.53$, $p < .01$), indicating that higher levels of mean power are associated with a lower performance drop during the specific test. The remaining predictors showed effects of smaller magnitude or were non-significant (Table 4).

Table 4. Hierarchical multiple regression models for the kick fatigue index (KFI)

Model	Predictors Included	R ²	Adjusted R ²	ΔR ²	F Change	p Change
Model 1	Age (z)	0.067	0.030	—	—	.177
Model 2	Age (z) + Muscle mass percentage (z) + CMJ (z) + TSAT (z) + Mean power TAAA (z)	0.415	0.338	0.348	6.83	< .001
Model 3	Age (z) + Physical Variables (Model 2) + Stress Control (z) + Motivation (z) + Mental Ability (z)	0.494	0.388	0.079	2.24	.097

Sensitivity Analysis and Stratification by Sex

To evaluate model stability and minimize potential collinearity effects, sensitivity analyses were performed by excluding predictors with high variance inflation factor (VIF) values. The exclusion of the sex variable and muscle mass percentage substantially reduced VIF values (max. VIF $\approx$ 1.80), without altering the direction or magnitude of the effect of mean power on the fatigue index, which remained negative and statistically significant in all model variants.

Additionally, analyses stratified by sex were performed. In both groups, a negative association was observed between mean power and the fatigue index. However, the effect reached statistical significance only in the male group ($p < .01$), while in the female group it showed a similar trend without reaching statistical significance, likely due to the smaller sample size and lower statistical power.

Diagnostic analyses indicated that the assumptions of residual normality and homoscedasticity were adequately met in the final models (see Figure S1, supplementary material).

Discussion

The present study aimed to analyze the relationship between psychological characteristics related to sports performance, assessed using the CPRD, and physical performance in *Kyorugi* taekwondo athletes. The main finding indicates that, although a significant global multivariate relationship between the sets of psychological and physical variables was not identified, mean power in the TAAA test emerges as the most robust predictor of fatigue resistance during high-intensity intermittent efforts, while psychological variables contribute a moderate additional contribution. These results suggest that the influence of psychological characteristics on physical performance may manifest in a specific manner on certain indicators, rather than as a uniform linear pattern, which is consistent with contemporary approaches in sport psychology that emphasize the contextual and task-dependent nature of the relationships between psychological variables and competitive performance (Ayranci & Aydin, 2025; Predoiu et al., 2025).

The absence of statistical significance in the canonical correlation analysis ($\Lambda = 0.57, p = 0.39$) can be explained by considering the heterogeneity of the analyzed sample, which included athletes from junior and senior categories with a wide age range (14-25 years) and different trajectories of biological and psychological development. From a methodological perspective, it is important to note that non-significance in a global multivariate analysis like CCA does not preclude the existence of specific and robust associations between individual variables from both sets, which are better captured by bivariate or regression analyses (Tabachnick & Fidell, 2022). This was precisely the case in our study, where hierarchical regression revealed the key predictive role of mean power.

Previous research has documented that psychological characteristics and their relationship with performance show substantial variations depending on biological maturation and athletic experience (Li et al., 2020; Remiszewska et al., 2022). Specifically, Remiszewska et al. (2022) identified significant differences in neuroticism between junior and senior taekwondo athletes, while Samanipour et al. (2025) reported differentiated patterns of performance prediction according to sex in young athletes. Additionally, from a methodological perspective, canonical analysis assumes linear relationships between sets of variables, an assumption that may not fully conform to the nature of psychophysical interactions, which can be non-linear, mediated by third variables, or dependent on the specific competitive context (Aditya et al., 2024; Mojtahedi et al., 2023).

The mean power developed during the TAAA test constitutes the most significant predictor of the fatigue index, indicating that athletes with higher levels of sustained power experience a smaller performance drop as the intermittent effort progresses. This finding is consistent with previous literature, as Apollaro et al. (2024) reported significant correlations between performance in vertical jump tests and the total number of kicks in the FSKTmult, while Ojeda-Aravena et al. (2023) found that body composition, particularly fat-free mass, correlates negatively with the kick decrement index. From a physiological perspective, the temporal structure of

a taekwondo match imposes substantial demands on oxygen-independent energy systems (the phosphagen and glycolytic pathways) (Ouergui et al., 2025; Podrigalo et al., 2025). Therefore, athletes with a greater capacity to generate and sustain power likely possess neuromuscular and metabolic adaptations that allow them to better tolerate the accumulation of fatigue, maintaining technical quality during decisive moments of combat.

Although psychological variables did not reach the conventional threshold of statistical significance in the final model, the moderate increase in explained variance suggests a complementary effect on performance. This pattern is consistent with conceptions proposing that psychological characteristics influence performance in an indirect or modulatory manner (Gimeno et al., 2007). In judokas, Gimeno et al. (2007) identified that stress control differentiated successful from non-successful athletes, and Mojtahedi et al. (2023) reported that mental toughness is associated with lower anxiety and higher pre-competitive self-confidence. Specifically, Samanipour et al. (2025) found that emotional regulation predicted performance on the FSKTmult exclusively in females, suggesting that the role of psychological variables could be particularly relevant in certain subgroups or under specific demand conditions. Therefore, characteristics such as stress control and mental ability could facilitate the maintenance of concentration and tolerance to the discomfort associated with neuromuscular fatigue during maximal efforts (Aditya et al., 2024; Ayranci & Aydin, 2025).

Comparative analyses revealed significant sex differences in multiple physical performance indicators, with large effect sizes (r , r_b) between 0.52 and 0.91), consistent with previous literature on dimorphisms in body composition and physical capacities in taekwondo athletes (Apollaro et al., 2024; Cardozo, Salcedo-Gómez, et al., 2025; Ojeda-Aravena et al., 2023). In contrast, differences in the psychological dimensions of the CPRD were more limited, with Stress Control being the only significant one, a pattern consistent with previous studies: Olmedilla et al. (2021) reported greater Stress Control in male soccer players with moderate effect sizes, and Quintero-Ovalle et al. (2023) identified better stress control in male Colombian athletes. These differences could be explained by sociocultural factors and sports socialization, considering that women tend to perceive stressful situations as less controllable (Fernández et al., 2020; Olmedilla et al., 2021). However, the absence of differences in the other dimensions indicates that the general psychological profile is relatively similar between sexes, consistent with Samanipour et al. (2025) who found no differences in emotional intelligence or mental toughness in young elite taekwondo athletes.

Exploratory stratified analyses suggested partially differentiated association patterns according to sex: in females, associations were observed between age and psychological variables (Stress Control, Influence of Performance Evaluation, Mental Ability), while in males associations were concentrated between anthropometric variables and physical performance. Although these results require cautious interpretation given their exploratory nature, they suggest that the mechanisms of influence of psychological characteristics on performance may differ between sexes, consistent with Samanipour et al. (2025) who identified differentiated predictors according to sex: body mass and calcium intake in males, versus emotional regulation as an additional predictor in females. From a theoretical perspective, these findings support ecological conceptions of sports performance that emphasize the dynamic interdependence between psychological, physiological, and contextual factors (Li et al., 2020; Predoiu et al., 2025), and reinforce the conceptualization of *Kyorigi* taekwondo as a high-intensity intermittent sport, with predominant demands on oxygen-independent energy systems (Apollaro et al., 2024; Ouergui et al., 2025).

Limitations and other future directions

The present study has limitations that must be considered: the sample size ($n = 53$), although comparable to previous studies in combat sports (Apollaro et al., 2024; Nabilpour et al., 2023; Samanipour et al., 2025), limits statistical power to detect small magnitude associations, particularly in multivariate and stratified analyses; the cross-sectional design prevents establishing causal relationships between variables; the use of self-report measures (CPRD) could introduce social desirability bias; the inclusion of athletes from different categories may have increased sample heterogeneity; the moderate to low reliability of some CPRD dimensions (Motivation: $\omega = 0.60$; Mental Ability: $\omega = 0.49$) might have limited the detection of significant associations, consistent with previous reports (Álvarez et al., 2025; Quintero-Ovalle et al., 2023); and the absence of real competitive performance indicators limits the ecological validity of the findings.

Future studies should consider longitudinal designs to examine the joint evolution of psychological and physical variables throughout the competitive season and their relationship with sports outcomes; larger and more homogeneous samples in terms of competitive category; mediation and moderation analytical techniques to clarify the mechanisms of influence; controlled trials evaluating the effect of psychological training interventions on objective performance indicators; multi-group structural equation models to formally examine differences according to sex or category; and the integration of psychophysiological measures (heart rate variability, cortisol) providing complementary information on underlying mechanisms.

Practical Implications

The findings reinforce the relevance of integrating training strategies aimed at developing sustained high-intensity power, through HIIT protocols and plyometric exercises that improve the ability to maintain

power output under fatigue. The inclusion of specific tests like the TAAA in assessment batteries allows for obtaining ecologically valid information about sport-specific fatigue tolerance. Although psychological variables did not show a statistically significant independent contribution, the moderate increase in explained variance suggests that mental skills training programs focused on stress control and attentional regulation could enhance the expression of physical potential during competition. The identified differences in Stress Control suggest the pertinence of adapting psychological interventions considering the specific needs of each group, adopting individualized approaches based on the systematic assessment of physical and psychological characteristics.

Conclusions

This study provides relevant evidence on the interaction between psychological and physical variables in Kyorugi taekwondo athletes, addressing an existing gap in the literature through an integrative approach using sport-specific assessments. The findings indicate the absence of a significant global multivariate relationship between psychological profiles assessed through the CPRD and physical performance. However, specific associations of practical relevance were identified, particularly highlighting mean power output in the TAAA test as the strongest predictor of fatigue resistance during high-intensity intermittent efforts. This result reinforces the central role of neuromuscular and metabolic capacities in sustaining performance during combat. Although psychological variables did not reach statistical significance in the final regression model, their moderate contribution to explained variance suggests a modulatory role in physical performance, especially under high-demand conditions. This supports contemporary theoretical frameworks proposing that psychological factors influence performance in an indirect, context-dependent manner.

From an applied perspective, these findings suggest that training programs should prioritize the development of sustained high-intensity power while simultaneously incorporating psychological interventions focused on stress regulation and attentional control. Additionally, the observed sex differences highlight the importance of individualized training strategies. Overall, this study contributes to a more comprehensive understanding of the multifactorial nature of performance in combat sports and provides a foundation for future research employing longitudinal designs and more advanced multivariate analytical approaches.

Acknowledgments: Acknowledgments to the clubs, teams, coaches, and athletes who participated in this project. Special thanks to the Bogotá Taekwondo League, the HAN KOOK Club (Cajicá branch), and the IKIGAI Club.

Funding: This research was funded by the Fundación Universitaria del Área Andina (Applied Research Call 2023-2024).

Conflict of Interest: The authors MCF, MAGA, and LVMB receive honoraria as taekwondo coaches for regional and national representative teams. The other authors declare no conflict of interest.

Declaration of generative AI and AI-assisted technologies in the writing process: During the preparation of this work, the author did not use any generative artificial intelligence tools or AI-assisted technologies. The manuscript was entirely written by the authors, who takes full responsibility for the content.

Supplementary Material: Available at <https://figshare.com/s/fafd9f9d542add95a26a>

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