Anthropometric and biomechanical predictors of competitive success in a Brazilian regional taekwondo competition

Predictores antropométricos y biomecánicos del éxito competitivo en una competición regional de taekwondo en Brasil

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Received: 01-05-26
Accepted: 16-05-26

How to cite in APA

Inostroza-Ríos, F., Sepúlveda-González, S., dos Santos, M. H., Almeida, N. R., Ferreira Costa, K., Aedo-Muñoz, E., Vieira-Souza, L. M., Pérez Contreras, J., & Brito, C. J. (2026). Anthropometric and biomechanical predictors of competitive success in a Brazilian regional taekwondo competition. *Retos, 82*, 256-267. https://doi.org/10.47197/retos.v82.119367

Abstract

Introduction: Previous research indicated that both anthropometric characteristics and vertical jump biomechanics impacted taekwondo performance. However, there were currently no predictive models for athletic success based on anthropometric characteristics or physical performance in the vertical jump.
Objective: The aim of this study was to analyze how anthropometric characteristics and physical performance in the drop jump could predict the athletic success of competitive taekwondo athletes at a regional level.
Methodology: A total of 46 athletes (28 male, 18 female) were categorized as regional champions or non-regional champions based on regional competition placement. Lower limb anthropometry and drop jump performance (30-cm height) on force plates were assessed. Bivariate logistic regressions determined the predictive power of these variables
Results: The champions showed significantly greater absolute and relative thigh length and a lower crural index compared to non-regional champions. Regional champions outperformed non-regional champions in most force and power production variables in drop jump performance. Logistic regression models identified normalized thigh length (AOR = 2.07; p = 0.003) and normalized average propulsive power (AOR = 1.38; p = 0.002) as the most robust predictors of athletic success. The latter variable exhibited the highest discriminatory power (AUC = 0.83).
Conclusions: It was demonstrated that both anthropometric characteristics and power output during drop jump performance serve as valid predictors of performance in regional taekwondo athletes. The results highlighted the importance of power output and establish the drop jump as a practical tool for talent identification and training optimization.

Keywords

Biomechanics; combat sports; drop jump; muscle strength; performance analysis.

Resumen

Introducción: Investigaciones previas indicaron que tanto las características antropométricas como la biomecánica del salto vertical influyeron en el rendimiento del taekwondo. Sin embargo, actualmente no existían modelos predictivos del éxito deportivo basados en las características antropométricas o en el rendimiento físico en el salto vertical.
Objetivo: El objetivo de este estudio fue analizar cómo las características antropométricas y el rendimiento físico en el *drop jump* podían predecir el éxito deportivo de taekwondistas competitivos a nivel regional.
Metodología: Cuarenta y seis atletas (28 hombres, 18 mujeres) fueron categorizados como campeones regionales o no campeones regionales basándose en su clasificación en la competencia regional. Se evaluaron la antropometría del tren inferior y el rendimiento en el *drop jump* (altura de 30 cm) sobre plataformas de fuerza. Se utilizaron regresiones logísticas bivariadas para determinar el poder predictivo de estas variables.
Resultados: Los campeones regionales mostraron una longitud de muslo absoluta y relativa significativamente mayor y un índice crural menor en comparación con los no campeones regionales. En el rendimiento del DJ, los campeones regionales superaron a los no campeones regionales en la mayoría de las variables de producción de fuerza y potencia. Los modelos de regresión logística identificaron la longitud del muslo normalizada (AOR = 2.07; p = 0.003) y la potencia propulsiva media normalizada (AOR = 1.38; p = 0.002) como los predictores más robustos del éxito deportivo. Esta última variable exhibió el mayor poder discriminatorio (AUC = 0.83).
Conclusiones: Se demostró que tanto las características antropométricas como la producción de potencia durante el DJ sirven como predictores válidos del rendimiento en atletas regionales de taekwondo. Los resultados destacaron la importancia de la producción de potencia y establecen al DJ como una herramienta práctica para la detección de talentos y la optimización del entrenamiento.

Palabras clave

Biomecánica; deportes de combate; salto con caída; fuerza muscular; análisis del rendimiento.

Introduction

Taekwondo stands out as a highly complex and intermittent combat sport which places significant metabolic demands on anaerobic pathways, particularly in rapid actions that require applying force in limited time intervals (Campos et al., 2012; Chiodo et al., 2011). A relevant mechanism in most sports techniques is the stretch-shortening cycle (SSC), which is characterized by the transition between eccentric and concentric muscle actions (Komi, 2003). Since offensive and defensive actions, and even movements in taekwondo, need to be performed at high speed, it is assumed that these actions have a short SSC (ground contact time <250 ms) (Komi, 2003; Turner & Jeffreys, 2010).

In this context, a recent study demonstrated that variables from the force-time curve of the countermovement jump (CMJ) measured with force platforms can differentiate between the performance of medal-winning and non-medal-winning taekwondo athletes, specifically maximum eccentric force and force at zero velocity (Chiang et al., 2025). However, these findings are derived from a limited sample of college athletes (n=17), which limits their generalizability to the population. In addition, from a strength classification perspective, the CMJ represents a fast maximum dynamic strength quality, and the CMJ may not adequately capture the short SSC mechanism, as its ground contact time typically exceeds 250 ms (Antonietto et al., 2024; James et al., 2023). In contrast, the drop jump (DJ) test emerges as an ecological alternative, which represents reactive strength capacity and could replicate the short SSC of technical actions in taekwondo (James et al., 2023; Komi, 2003; Weakley et al., 2024). This allows for a granular assessment of short SSC (<250 ms) mechanisms and the reactive strength index (RSI), which have been recently highlighted as critical components of athletic performance and neuromuscular adaptations in competitive taekwondo athletes (Park et al., 2025). Consequently, the DJ directly replicates the fast, high-intensity plyometric demands inherent in the defensive and offensive actions of this combat sport.

In addition to physical performance, differences have been shown between the anthropometric characteristics of taekwondo athletes based on their performance level. In particular, a low body mass index differs among taekwondo athletes with different athletic statuses (national and international level) (Can et al., 2022; Mirali et al., 2022). Complementarily, the absolute length of the tibia and femur shows significant positive correlations with peak anaerobic power and agility in well-trained athletes (Kwon & Kim, 2025). These anthropometric characteristics could give an advantage in terms of reach for kicking techniques during combat, emerging as a determining factor. However, a significant limitation in the existing literature on anthropometric and physical factors in taekwondo is its reliance on descriptive profiles or simple bivariate correlations. These methodologies fail to establish predictive frameworks that account for anatomical structures or the kinetic components of performance. Consequently, a clear gap exists in predictive models, limiting the practical application of these variables in definitive guidelines for coaches.

Furthermore, most research on elite profiles focuses on closed international Olympic cohorts, neglecting intermediate competitive levels. Researching regional-level competitors is crucial, as these athletes represent the primary source of talent during a critical transition to high performance, where coaches need accurate assessment tools to optimize development. Therefore, the aim of this study is to analyze how anthropometric characteristics and physical performance in the drop jump can predict the athletic success of competitive taekwondo athletes at a regional level. We hypothesize that specific anthropometric traits, such as longer lower limb segments and superior reactive strength performance, characterized by a higher reactive strength index and efficient force-time curve variables during the drop jump, will be significant predictors of competitive success in Taekwondo athletes. The results could contribute to the processes of identifying talent for taekwondo, recognizing performance variables for monitoring throughout the training season, and prescribing specific strength training to develop key physical qualities for taekwondo.

Method

Research approach

The study was based on a quantitative approach, with a relational scope and an observational-cross-sectional design. First, the organizing committee was contacted to request permission to collect data at the regional "X Copa Marçal Tiger" Competition. The clubs participating in the competition were subsequently contacted by email with the help of the event organizer to invite them to participate in the study and explain the evaluation procedures, risks, and benefits of their participation. The study was conducted in accordance with the Declaration of Helsinki (World Medical Association, 2013), all participants gave their written informed consent and its protocol has been previously approved by the research ethics committee of Universidade do Estado de Minas Gerais (CAAE: 82274124.6.0000.5112; Protocol: 7.108.464).

To minimize confounding effects on neuromuscular performance, physical tests were conducted between 7:00 a.m. and 11:00 a.m. The evaluation procedures were performed in the following order: (1) Anamnesis, (2) anthropometric measurement, (3) warm-up, and (4) drop jump test with force platforms. The order of the procedures was assigned with the aim of avoiding interference between the evaluations. To standardize conditions, all athletes performed a supervised 15-minute warm-up starting with 5 minutes of low-intensity running at a self-perceived intensity of 5–6 on the Borg CR-10 rate of perceived exertion (RPE) scale. This was followed by a bodyweight circuit executed in two sets (30 s work / 15 s passive rest) consisting of squats, high-frequency/low-amplitude pogo jumps, forearm planks, reverse lunges, and moderate-frequency/maximum-amplitude pogo jumps. The results of each participant in the competition were extracted from the records provided by the event's organizing committee.

Participants

An a priori power analysis (d=0.91, α=0.05, power=0.80) required a minimum of 20 participants per group (N=40) The estimated effect size used to determine sample size is consistent with recent biomechanical research in taekwondo. Specifically, Chiang et al. (2025) found effect sizes (Cohen's d) between 1.05 and 1.36 when comparing vertical jump parameters in college medalists versus non-medalists. With a final sample of 46 athletes, a post-hoc analysis confirmed the study was adequately powered to detect a large effect size (d≈0.84), ensuring sufficient sensitivity for between-group differences.

Participants were selected according to specific criteria. The inclusion criteria were as follows: (1) Male or female athletes; (2) active competitors in the combat modality (Kyorugi); and (3) participation in at least one official competition within the previous 12 months. Exclusion criteria included: (1) Musculoskeletal injury to the lower limbs or lumbopelvic region within the last six months; (2) withdrawal from competition due to injury or other reasons; (3) refusal to participate in the study; and (4) athletes who had not yet reached peak height velocity, as determined using the method proposed by Mirwald et al. (2002).

Following the application of these criteria, a total of 46 Taekwondo athletes (28 males and 18 females) volunteered to participate in the study. Male athletes were 19.0 ± 5.0 years old, with a height of 174.6 ± 7.4 cm and body mass of 71.4 ± 15.1 kg. Female athletes were 17.5 ± 4.3 years old, with a height of 163.9 ± 8.0 cm and body mass of 59.4 ± 13.8 kg. Furthermore, none of the participants reported engaging in intensive weight loss practices during the study period.

Procedure

Anamnesis

The anamnesis was administered using the Google Forms platform (Google LLC, Mountain View, CA, USA), with the aim of collecting contact details, sociodemographic information, characteristics of sports practice, and injury history of the participants. The following information was collected: age, sex, date of birth, years of taekwondo practice, date of the last competition in which they participated, and history of injuries to the lower extremities or lumbar-pelvic area.

Anthropometric measurements

The anthropometric measurements included body mass (kg), standing height (cm), sitting height (cm), thigh length (cm), and leg length (cm). The derived anthropometric indices comprised the cormic index (%), crural index (%), normalized thigh length (%), and normalized leg length (%).

Body mass was measured using two calibrated PASCO® force platforms (PS-2142, 1000 Hz). The participants stood still for three seconds while barefoot. The average was calculated from a 1,000-point data window to determine weight in newtons (CV <1%), converted to kg by dividing by 9.81 m/s^2.

Standing and sitting height were assessed using a professional wall-mounted stadiometer (SECA 206). The participants stood barefoot to measure standing height, with their heels, buttocks, and scapulae against the vertical plane, head in the Frankfurt plane. An anthropometric bench without a backrest was used for sitting height, with the trunk upright and knees at 90°. Both measurements were taken from the vertex to the supporting surface. Lower-limb segment lengths were measured with an anthropometric tape (CESCORF). Thigh length was measured in a seated position as the straight-line distance from the greater trochanter to the lateral femoral condyle. Leg length was measured with the leg crossed, from the medial femoral condyle joint space to the lower edge of the medial malleolus. To minimize inter-rater variability and ensure data quality, all measurements of lower limb segment lengths were performed by a single nutritionist with extensive experience and solid training in anthropometric assessment protocols, strictly adhering to standardized anatomical landmarks. Complementary anthropometric variables were calculated from these measurements (Table 1).

Table 1. Operationalization of derived anthropometric variables.

Anthropometric Variable	Calculation	Definition
Cormic index (%)	(sitting height / standing height) * 100	The proportion between the upper segment (torso-head) and total height.
Crural index (%)	(leg length / thigh length) * 100	The proportion between the length of the thigh and the leg.
Normalized thigh length (%)	(thigh length / standing height) * 100	The percentage contribution of the thigh to height.
Normalized leg length (%)	(leg length / standing height) * 100	The percentage contribution of the leg to height.

Maturity status calculation

The biological maturity of the participants was estimated using the method proposed by Mirwald et al. (2002). This validated and reliable procedure enables calculating the years from Peak Height Velocity (PHV) based on body mass (kg), standing height (cm), sitting height (cm), date of birth, and date of evaluation. Subjects were classified with the resulting value (maturity deviation) into three phases: pre-PHV (value < -1.0 year), near PHV (value between -0.99 and +0.99 years), or post-PHV (value > +1.0 year), according to established criteria (Pedley et al., 2022). Athletes in a pre-PHV and near PHV state were excluded from the analysis.

Force-time curve analysis of the drop jump

The test consisted of a bilateral jump from a standard height of 30 cm, considering the difference between the height of the jump box (35 cm) and the force platform (5 cm). Participants were instructed to: (1) drop with their feet parallel and aligned with the width of their hips; (2) jump as high as possible while minimizing ground contact time; and (3) perform a vertical jump, avoiding anterior-posterior movements (Bobbert et al., 1987; Pedley et al., 2017). Three attempts were made, with one minute of passive recovery between them, and the average of the three attempts was considered for analysis.

The force applied against the ground was measured using two Pasco® biaxial force platforms (PS-2142, Roseville, CA, USA). Signals were acquired using CAPSTONE® software version 2.9.4. (Pasco, Roseville, CA, USA) with a sampling frequency of 1000 hertz and imported into an electronic spreadsheet. They were then imported and processed in an Excel spreadsheet (Microsoft 365®, v.2505) programmed for force-time curve analysis (Pedley et al., 2022), including baseline correction, signal filtering, and automatic identification of key events (initial contact, takeoff) (Pedley et al., 2022). The biomechanical variables analyzed included jump height (cm), contact time (s), braking phase duration (s), and propulsive phase duration (s), flight time (s), Reactive Strength Index (arbitrary units), peak center of mass (CoM) displacement (cm), takeoff velocity (m/s), normalized force at peak CoM (Center of Mass)displacement (N/kg), normalized propulsive peak (N/kg), normalized braking peak (N/kg), time to propulsive peak (s), time to braking peak (s), net impulse (N·s), mean propulsive velocity (m/s), mean braking velocity (m/s), mean normalized propulsive power (W/kg), mean normalized braking power (W/kg) and normalized vertical stiffness (N/m/kg).

Athletic performance

The Kyorugi competitions were held in an octagonal combat area with a diameter of eight meters. The athletes wore the regulation uniform and protective equipment and competed in three rounds of two minutes each, interspersed with one-minute breaks. The legitimacy of the competition results was ensured by the electronic scoring system. This system consisted of sensor-equipped chest protectors and foot protectors, which automatically recorded valid hits. The championship results were recorded to assess athletic performance (Brito et al., 2024). Athletes were categorized into the 'regional champions' group if they had achieved a gold medal (1st place) in events grouped by their respective competition categories. Athletes who participated in the same events but did not achieve podium positions were assigned to the ' non-regional champions' group.

Data analysis

Data distribution was assessed using the Shapiro-Wilk test and visual histograms. Results are presented as mean ± standard deviation, as well as median, first quartile, and fourth quartile where applicable. An alpha of 0.05 was set for all analyses, complemented by 95% confidence intervals where relevant. All statistics were performed using JASP (v0.19.4).

A Chi-square test was employed to compare the distribution of male and female athletes across performance groups, verifying sample homogeneity and minimizing the risk of initial selection bias.

Differences between regional champions and non-regional champions were analyzed. After testing homogeneity of variance (Levene's test), the appropriate contrast test (independent samples t-test, Welch's t-test, or Mann-Whitney U) was applied. Corresponding effect sizes (Cohen's d, Glass's delta, or biserial rank correlation) were calculated (Ahad & Yahaya, 2014; Dancey et al., 2012). The following classifications are considered for Cohen's d and Glass's delta: small effect (≥0.20 and <0.50), medium effect (≥0.50 and <0.80), large effect (≥0.80 and <1.30), and very large effect (≥1.30). In turn, the following classifications were considered to quantify the biserial rank correlation: small (≥0.10 and <0.30), medium (≥0.30 and <0.50), and large (≥0.50) (Middlemis Maher et al., 2013).

Next, variables with "large" or greater differences between groups based on athletic performance were selected for the bivariate logistic regression analysis. To isolate the independent effect of anthropometric and biomechanical variables on competitive success, biological sex was included as a control factor in all models, allowing for the calculation of Adjusted Odds Ratios (AOR) with 95% Confidence Intervals (CI). This adjustment was implemented to account for potential confounding effects associated with natural sex-based morphological dimorphism, ensuring the predictive capacity of the variables was consistent across the cohort. The model was assessed via maximum likelihood (χ^2), Nagelkerke's R^2, odds ratios, and Wald tests (Hosmer et al., 2013). Discriminatory power was evaluated using AUC, sensitivity, and specificity, with AUC interpreted as: unacceptable (<0.7), acceptable (0.7-0.8), good (0.8-0.9), or excellent (≥0.9) (Hosmer et al., 2013).

Results

Comparison analysis results

Regional champions showed significantly greater thigh length (46.8 ± 4.2 cm vs. 43.6 ± 3.0 cm; p = 0.005; d = -0.87), greater normalized thigh length (27.5 ± 2.2% vs. 25.6 ± 1.8%; p = 0.003; d = -0.92), and a lower crural index (80.8 ± 6.7% vs. 87.6 ± 7.2%; p = 0.002; d = 0.97) compared to non-regional champions. In addition, regional champions outperform non-regional champions in most force and power production variables in DJ performance. Normalized mean propulsive power shows the largest difference between groups (30.7 ± 4.7 W/kg vs. 24.9 ± 4.0 W/kg; p < 0.001; d = -1.33), followed by the reactive strength index and propulsive and braking velocity variables (Table 2).

Table 2. Anthropometric and biomechanics differences based on sporting performance.

Variables	Non-regional champions (n=26)	Regional champions (n=20)				
	M±SD Md (Q1, Q3)	M±SD Md (Q1, Q3)	Statistic	p	Effect size [95% CI]	Interpretation
Anthropometric						
Standing height (cm)	170.6±10.3	170.2±7.8	0.12 STT	0.898	0.03 [-0.54, 0.62]	Not significant
Sitting height (cm)	89.7±5.5	89.6±4.1	0.07 STT	0.943	0.02 [-0.56, 0.60]	Not significant
Cormic index (%)	52.6±1.3	52.7±1.9	-0.14 STT	0.890	-0.04 [-0.62, 0.54]	Not significant
Thigh length (cm)	43.6±3.0	46.8±4.2	-2.92 STT	0.005	-0.87 [-1.47, -0.25]	Large
Leg length (cm)	38.2±2.7	37.5±2.2	0.56 STT	0.577	0.16 [-0.41, 0.75]	Not significant
Crural index (%)	87.6±7.2	80.8±6.7	3.26 STT	0.002	0.97 [0.35, 1.58]	Large
Normalized thigh length (%)	25.6±1.8	27.5±2.2	-3.11 STT	0.003	-0.92 [-1.53, -0.30]	Large
Normalized leg length (%)	22.3±0.9	22.1±0.8	0.93 STT	0.354	0.27 [-0.30, 0.86]	Not significant
Drop jump performance						
Jump height (cm)	19.3±3.8	21.7±3.1	-2.28STT	0.027	-0.67 [-1.27, -0.075]	Medium
Contact time (s)	0.31 (0.27, 0.60)	0.25 (0.23, 0.30)	382MWU	0.007	-0.46 [-0.69, -0.16]	Medium
Braking phase duration (s)	0.17 (0.15, 0.18)	0.14 (0.11, 0.16)	415MWU	<0.001	-0.59 [-0.77, -0.33]	Large
Propulsive phase duration (s)	0.148±0.045	0.123±0.035	2.04STT	0.047	0.60 [0.008, 1.20]	Medium
Flight time (s)	0.40 (0.38, 0.47)	0.44 (0.40, 0.48)	196.5MWU	0.163	0.24 [-0.09, 0.53]	Not significant
Reactive strength index (AU)	0.60 (0.52, 0.72)	0.81 (0.71, 1.04)	90MWU	<0.001	0.65 [0.41, 0.80]	Large
Peak CoM displacement (cm)	17.5 (21.1, 13.7)	16.1 (19.9, 13.2)	289MWU	0.531	-0.11 [-0.42, 0.22]	Not significant
Normalized force at Peak CoM Displacement (N/kg)	30.9±6.1	39.7±8.7	-3.83WTT	<0.001	-1.0 [-1.66, -0.33]	Large
Normalized propulsive peak (N/kg)	31.6±6.3	40.3±8.8	-3.71WTT	<0.001	-0.98 [-1.63, -0.31]	Large
Normalized braking peak (N/kg)	36.6 (33.5, 48.3)	43.6 (36.2, 50.9)	189MWU	0.119	0.27 [-0.06, 0.55]	Not significant
Time of propulsive peak (s)	0.16 (0.13, 0.22)	0.13 (0.10, 0.16)	364MWU	0.022	-0.40 [-0.64, -0.08]	Medium
Time of braking peak (s)	0.065±0.028	0.073±0.028	-0.96STT	0.339	-0.28 [-0.87, 0.30]	Not significant
Mean propulsive velocity (m/s)	1.37±0.12	1.48±0.10	-3.22STT	0.002	-0.95 [-1.57, -0.33]	Large
Mean braking velocity (m/s)	1.23±0.16	1.39±0.16	-3.54STT	<0.001	-1.05 [-1.67, -0.42]	Large
Mean normalized propulsive power (W/kg)	24.9±4.0	30.7±4.7	-4.47STT	<0.001	-1.33 [-1.97, -0.67]	Very large
Mean normalized braking power (W/kg)	25.9±4.6	32.2±6.2	-3.95STT	<0.001	-1.17 [-1.80, -0.53]	Large
Net impulse (N.s)	269±67	257±53	0.65STT	0.516	0.19 [-0.39, 0.778]	Not significant
Takeoff velocity (m/s)	1.93±0.19	2.05±0.15	-2.38STT	0.021	-0.71 [-1.30, -0.10]	Medium
Normalized vertical stiffness (N/m/kg)	206 (177, 415)	293 (225, 374)	211MWU	0.286	0.18 [-0.14, 0.48]	Not significant

M: Mean; SD: Standard deviation; Md: Median; Q1: First Quartile; Q3: Third Quartile.; STT: Student's t-test contrast and effect size calculated by Cohen's d; WTT: Welch's t-test contrast and effect size calculated by Glass's Delta; MWU: Mann-Whitney U contrast and effect size calculated by rank-biserial correlation.

Logistic regression results

Table 3 presents the logistic regression results adjusted for biological sex. Preliminary Chi-square analysis confirmed a homogeneous distribution of male and female athletes across the performance groups (p = 0.916), minimizing the risk of initial selection bias. When biological sex was introduced as a control covariate, all sex-adjusted models outperformed the null model, and the analyzed variables made a significant contribution to their respective models.

Of the models using anthropometric variables, normalized thigh length (%) emerged as the strongest positive predictor after controlling for sex, with a substantial increase in its adjusted odds ratio to 2.07 (p = 0.003). This indicates that the probability of becoming a regional champion increase by 107% for every 1% increase in this metric, regardless of the athlete's sex. Furthermore, a statistically significant suppression effect was observed with respect to the crural index; the predictive accuracy of the model improved, revealing an inverse relationship (AOR = 0.825) where a lower crural index is associated with a higher competitive level. Meanwhile, sex as a control did not alter the predictive capacity of thigh length (AOR = 1.29; p = 0.013).

Regarding the models based on drop jump performance, the introduction of biological sex as a control covariate did not alter their significance or predictive strength, confirming them as universal predictors of competitive success independent of sex. The model with the best adjusted odds ratio remained mean normalized propulsive power (AOR = 1.38; p = 0.002), in which each 1 W/kg increase enhances the probability of being a regional champion by 38%. A one-unit increase in the models of the mean normalized braking power, normalized force at peak CoM displacement, or normalized propulsive peak variables increases the probability of becoming a regional champion by 25%, 19%, and 18%, respectively. However, models based on the reactive strength index, braking phase duration, mean braking velocity, and mean propulsive velocity were identified as unstable due to high standard errors (>2) and extremely wide confidence intervals for the AORs.

Acceptable AUC values were obtained regarding the discriminatory capacity of anthropometric variable models (0.71 to 0.79). For models based on drop jump performance, the mean normalized braking power and mean normalized propulsive power variables show good AUC values (0.80 and 0.83, respectively), and the normalized propulsive peak and normalized force at peak CoM displacement show acceptable AUC values (0.78 to 0.79).

Table 3. Bivariate logistic regression models of anthropometric variables and drop jump performance, adjusted for sex.

Variables	Coefficients			Model		Behavior metrics		
	AOR	LL	UL	ΔX^2	Nagelkerke's R^2	AUC	Sensitivity	Specificity
Anthropometric								
Thigh length (cm)	1.29*	1.06	1.58	8.17†	0.22	0.71	0.60	0.85
Crural index (%)	0.82	0.72	0.93	2.77	0.31	0.79	0.60	0.80
Normalized thigh length (%)	2.07**	1.28	3.34	12.94†	0.33	0.77	0.60	0.84
Drop jump performance								
Braking phase duration (s)	3.364×10^{-17}**	0.00	0.00	12.40‡	0.32	0.80	0.60	0.85
Reactive strength index (AU)	609**	9.27	39,993	14.86‡	0.37	0.83	0.60	0.81
Normalized force at peak CoM displacement (N/kg)	1.19***	1.06	1.33	14.28‡	0.36	0.78	0.55	0.89
Normalized propulsive peak (N/kg)	1.18**	1.05	1.31	13.34‡	0.34	0.79	0.65	0.89
Mean propulsive velocity (m/s)	8383**	12.02	5,848,164	9.72†	0.26	0.75	0.60	0.73
Mean braking velocity (m/s)	992**	8.63	113,913	11.38†	0.29	0.76	0.55	0.73
Mean normalized propulsive power (W/kg)	1.38**	1.13	1.68	16.96‡	0.41	0.83	0.70	0.81
Mean normalized braking power (W/kg)	1.25***	1.08	1.45	13.78‡	0.35	0.80	0.55	0.80

ΔX^2: Chi-squared change; AOR: Adjusted Odds Ratio; LL: Lower Limit of the 95%; UL: Upper Limit of the 95%; CoM: center of mass; Asterisks indicate significance of the Wald test for individual coefficients, *: p< 0.05, **: p< 0.01, ***: p< 0.001. Daggers indicate significance of the overall model fit, †: p< 0.01; ‡: p< 0.001; The crural index model yielded a p-value of 0.096.

Discussion

The aim of this study was to investigate whether anthropometric characteristics or performance in the drop jump (DJ) can predict athletic performance in competitive taekwondo athletes at the regional level. The results indicated that, within the context of this regional cohort, successful athletes exhibited a distinct anthropometric and biomechanical profile compared to non-regional champions. While these findings provide valuable benchmarks, the results should be interpreted with caution when extrapolating to other levels of competence. Specifically, regional champions had greater thigh length, both absolute and normalized, and a lower crural index. Additionally, regional champions demonstrated superior physical capacity in the DJ, particularly in the mean normalized propulsive and braking power. A logistic regression analysis corroborated the predictive power of these variables, with mean normalized propulsive power being the indicator which best explains the variance (Nagelkerke's R^2 = 0.41) and demonstrating good discriminatory power (AUC = 0.83), while normalized thigh length stands out as the variable that most increases the probability of becoming a champion (OR = 2.07). Taken together, these findings indicate that both anthropometric variables and those derived from the force-time curve of the drop jump act as valid predictors of performance in taekwondo at the regional level.

Structural advantages: The role of lower limb proportions in regional competition

The length of body segments has been consistently highlighted as a determining factor in combat sports involving kicks, such as taekwondo (Can et al., 2022; Mirali et al., 2022). The present results indicate that regional champions have both greater absolute and normalized thigh length. Longer lower limbs, especially thighs, increase the effective reach of kicks, allowing athletes to score or maintain a safe distance more efficiently (Kwon & Kim, 2025). This finding is supported by recent studies reporting a positive correlation between relative femur length and performance in explosive jump tests, which are relevant to technical movements in taekwondo (Kwon & Kim, 2025). In addition, it has been observed that international-level athletes have significantly greater iliospinal height and lateral tibial height compared to national athletes, reinforcing the importance of specific segmental lengths for competitive performance (Mirali et al., 2022).

The finding of a lower crural index in regional champions is particularly relevant. A low crural index implies that the length of the thigh is proportionally greater than that of the leg. From a mechanical perspective, a low crural index could optimize the moment of inertia and angular velocity of the limb during kicking motion (Ölmez et al., 2022). This could translate into greater impact speed, and therefore greater striking power, which is crucial for the electronic scoring system (Jia et al., 2024). This result complements previous studies that have identified low crural index as a performance differentiator, suggesting that the distribution of segment length within the lower limb is as important as total length (Can et al., 2022; Mirali et al., 2022).

Notably, whereas the existing literature on elite Olympic cohorts frequently identifies absolute height as a primary determinant of competitive success (Can et al., 2022; Scamardella et al., 2025), the present study observed no significant differences in standing height among regional taekwondo athletes ($p = 0.898$). This lack of variance indicates that at the regional tier, absolute stature may not be the principal performance differentiator; instead, specific limb length proportions appear to confer a crucial mechanical advantage. Consequently, anthropometric profiling at this competitive level should extend beyond absolute height to emphasize athletes exhibiting optimal lower limb proportions.

Notably, the predictive value of relative thigh length maintained statistical significance after adjusting for biological sex within the logistic regression models. These results suggest that this favorable distal segment ratio confers a distinct mechanical advantage regarding attacking efficiency and tactical reach in taekwondo. This structural advantage appears to hold true for both male and female cohorts, suggesting that these findings are likely not just a byproduct of the biological differences in height and limb length typically observed between sexes.

Biomechanical determinants: Propulsive power and kinetic efficiency in the short SSC

The results reveal that regional champions exhibit superior performance, highlighting the variables which showed predictive stability. Specifically, it was observed that mean normalized propulsive power, mean normalized braking power, normalized force at peak CoM displacement and normalized propulsive peak were significantly higher in regional champions.

When comparing our results with the literature, the importance of strength production in taekwondo is consistent. Studies on elite female athletes identified that alactic anaerobic power and jumping ability were higher in the successful group (Markovic et al., 2005). Likewise, research on young talents reported significant correlations between relative power to body mass generated in a squat jump (SJ; $r = 0.90$) and a CMJ ($r = 0.777$) with long-term competitive performance (Moreira et al., 2014). This study extends these findings to a short SSC jump action, identifying mean normalized propulsive power as the most robust and stable predictor for this regional cohort.

The present results align with the findings of Chiang et al. (2025), who identified relative force at zero velocity as a differentiator between medal-winning and non-medal-winning taekwondo athletes. Within the evaluated cohort, the normalized force at peak CoM displacement, which represents the transition point between the braking and propulsive phases, successfully differentiated regional champions. Both variables reflect the athlete's ability to arrest downward movement and rapidly initiate upward propulsion (McMahon et al., 2018; Pedley et al., 2023). The superiority of regional champions in these metrics reinforces the premise that competitive success relies on high force production during the braking-to-propulsion transition, which could be fundamental for efficiently executing actions involving changes of direction or immediate counterattack techniques during combat.

While previous research by Chiang et al. (2025) demonstrated that peak eccentric force during a CMJ successfully differentiates medalists, our DJ models yielded limited predictive capacity for the eccentric phase. This divergence likely stems from the varying biomechanical demands associated with the fast stretch-shortening cycle (Komi, 2003). As a result, eccentric variables, including braking phase duration, mean braking velocity, and the reactive force index, demonstrated profound statistical instability and wide confidence intervals. The inherent mechanical volatility of the short SSC largely explains this instability (Pedley et al., 2022), which exacerbates the risk of model overfitting and constrains the robustness of eccentric metrics compared to those derived from the propulsion phase.

Limitations and future projections

An inherent limitation of this study is its design, which prevents establishing direct causality between the predictors and athletic performance. Although significant differences were identified, it cannot be determined whether training or natural selection is responsible for these characteristics. Furthermore, the sample was limited to a regional competition, which could restrict generalizing the findings to higher-level athletes.

The regression models for the reactive strength index and braking phase metrics displayed statistical instability, evidenced by high standard errors and wide confidence intervals. This methodological phenomenon is typically associated with a near-complete separation of data or the high dispersion of these specific biomechanical metrics relative to the sample size. Consequently, these metrics lack sufficient robustness to serve as isolated predictors. Their predictive value must be interpreted with caution, as competitive taekwondo performance involves complex, multifactorial interactions that cannot be reduced to single biomechanical variables.

The lack of intra-rater reliability data represents a limitation inherent to the study's field setting. Nevertheless, we addressed this by employing a single, highly experienced nutritionist for all evaluations, thereby adhering to strict standardized protocols to ensure data reliability and minimize measurement error.

Looking ahead to future research, longitudinal studies are suggested to analyze the evolution of anthropometric and physical variables across different training seasons (preparatory, competitive, and transition periods). Furthermore, integrating technical-tactical and psychological factors into the predictive model could not only significantly improve its accuracy, but also help clarify the relative importance of each of these elements. Finally, it is pertinent to investigate the relevance of these variables at various competition levels to determine whether they represent cross-cutting determinants at the state, national, and international levels.

Practical applications

This study offers key contributions to talent selection, performance monitoring, and training prescription in taekwondo. First, anthropometric variables such as thigh length and crural index can serve as early screening tools in talent identification, as athletes with a longer thigh and lower crural index possess a structural advantage that cannot be developed through training alone.

Additionally, variables with strong predictive capacity, particularly those derived from the DJ force-time curve, should be monitored throughout the season, especially near competitions. Normalized mean propulsive power in particular stands out as the most robust predictor of physical performance and a critical variable to track.

Finally, coaches are encouraged to incorporate exercises which engage the SSC, especially those involving low contact time and high-speed eccentric-concentric actions. Plyometric exercises like DJ variations with controlled drop heights and an emphasis on minimal contact time are recommended.

Conclusions

This study showed that greater thigh length, as well as greater power during the drop jump (DJ), can serve as predictors of competitive success in regional taekwondo athletes. These findings highlight the importance of both anatomical advantages and high-speed force generation, making the DJ a valuable ecological test for talent identification and training optimization in regional-level taekwondo.

Acknowledgements

The authors would like to express their sincere gratitude to the organizing committee of the X Copa Marçal Tiger for their invaluable support and for granting permission to conduct data collection during the event. We also extend our thanks to the participating clubs, coaches, and athletes for their cooperation and commitment to this research.

Financing

Felipe Inostroza-Ríos received a scholarship from the Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG) (PAPG Grant: # 13464; Agreement: 5.12/2022). Sebastián Sepúlveda González received a scholarship from the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) –Brazil (Project no. 014) of the Postgraduate Program in Physical Education – Master's Degree.

Artificial intelligence usage statement

We hereby declare that the AI-based tool "Consensus" was used during the literature review phase. This application was used exclusively to optimize the process of searching for, exploring, and locating scientific articles related to the subject of study. In addition, all references provided by this platform underwent rigorous manual review and verification to confirm their relevance, scientific rigor, and suitability for the research.

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