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Capacidade preditiva dos saltos com agachamento profundo e *Abalakov* no desempenho do chute circular em atletas de elite de esporte de combate

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Dissertação apresentada ao Programa de Pós-Graduação em Educação Física da Universidade Federal de Juiz de Fora como requisito parcial à obtenção do título de Mestra em Educação Física. Área de concentração: Exercício e Esporte.

Orientador: Prof. Dr. Ciro José Brito

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Dedico este trabalho ao meu pai Cícero Luiz de Oliveira (in memoriam) e a minha filha Maria Luiza Rezende Fagundes.

Cinthya Luiza Rezende Oliveira Fagundes

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RESUMO GERAL

O presente estudo investigou se as variáveis do *deep squat jump* (DSJ) e do *Abalakov jump* (ABK) estão correlacionadas com o desempenho do *rear roundhouse kick* em atletas de elite de esportes de combate. Para isso, 26 atletas de elite de Taekwondo (12♀) realizaram três tentativas válidas de: (a) DSJ, (b) ABK (plataformas de força Pasco®) e (c) *roundhouse kick* (Vicon® Motion Systems). Os principais resultados indicaram que, para o DSJ, o RFD-100ms concêntrico previu independentemente a velocidade linear do pé (R^2=0,21, p=0,009), a aceleração linear do pé (R^2=0,303, p=0,003) e a aceleração angular do joelho (R^2=0,194, p=0,021). Combinada com a potência média concêntrica/BM, ela previu a aceleração angular do joelho (R^2=0,27, p=0,04). Para o membro ND, a Força de Pico de Decolagem previu independentemente a Aceleração Angular do Quadril (R^2=0,144, p=0,029), melhorando quando combinada com a Força no Pico de Força (R^2=0,315, p=0,013). Para o ABK, a força de pico excêntrica/BM previu o tempo total (R^2=0,123, p=0,039). A força de pico concêntrica/BM previu a velocidade angular do joelho (R^2=0,173, p=0,018). A Frenagem Excêntrica RFD-100ms (D) previu a Velocidade Angular do Quadril (R^2=0,135, p=0,034) e a Aceleração Angular do Quadril (R^2=0,24, p=0,006). Em conclusão, este estudo demonstrou que as variáveis DSJ e ABK preveem o desempenho do chute *roundhouse*. As principais variáveis de avaliação incluem RFD-100ms concêntrico e força de pico de decolagem do membro não dominante para DSJ, bem como RFD-100ms de frenagem excêntrica para ABK.

Palavras-chave: artes marciais, desempenho esportivo, biomecânica, análise cinemática.

ABSTRACT

The present study investigated whether deep squat jump (DSJ) and Abalakov jump (ABK) variables correlate with rear roundhouse kick performance in elite combat sport athletes. For this, 26 elite Taekwondo athletes (12♀) performed three valid attempts for: (a) DSJ, (b) ABK (Pasco® force platforms) and (c) roundhouse kick (Vicon® Motion Systems). The main results indicated that for DSJ, the Concentric RFD-100ms independently predicted Lineal Foot Velocity (R^2=0.21, p=0.009), Lineal Foot Acceleration (R^2=0.303, p=0.003), and Angular Knee Acceleration (R^2=0.194, p=0.021). Combined with Concentric Mean Power/BM, it predicted Angular Knee Acceleration (R^2=0.27, p=0.04). For the ND limb, Takeoff Peak Force independently predicted Angular Hip Acceleration (R^2=0.144, p=0.029), improving when combined with Force at Peak Force (R^2=0.315, p=0.013). For ABK, Eccentric Peak Force/BM predicted Total Time (R^2=0.123, p=0.039). Concentric Peak Force/BM predicted Angular Knee Velocity (R^2=0.173, p=0.018). Eccentric Braking RFD-100ms (D) predicted both Angular Hip Velocity (R^2=0.135, p=0.034) and Angular Hip Acceleration (R^2=0.24, p=0.006).in conclusion, this study demonstrated that DSJ and ABK variables predict roundhouse kick performance. Key assessment variables include Concentric RFD-100ms and non-dominant limb Takeoff Peak Force for DSJ, as well as Eccentric Braking RFD-100ms for ABK.

Keywords: martial arts, sport performances, biomechanics, kinematic analysis.

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1. INTRODUÇÃO GERAL

1.1 Importância do chute circular nos Esportes de Combate

O chute circular destaca-se como uma das técnicas mais eficazes e frequentes em modalidades de combate de *striking* como Taekwondo (*bandal chagi*), Kickboxing (*roundhouse kick*) caratê (*mawashi geri*) e Muay Thai (*te chiang*). Sua aplicação técnica combina alta velocidade de execução, impacto contundente e versatilidade estratégica, sendo igualmente eficaz em contextos ofensivos e defensivos (Corcoran; Climstein; Whitting; Del Vecchio, 2024; Diniz; Del Vecchio; Schaun; Oliveira *et al.*, 2021; Estevan; Álvarez; Falcó; Castillo, 2014). A eficiência desse chute relaciona-se diretamente com a força explosiva, agilidade e precisão técnica, fatores determinantes para o desempenho competitivo (De Oliveira Goulart; Corgosinho; Rodrigues; Drummond *et al.*, 2016).

A eficácia do chute circular depende de múltiplos fatores biomecânicos, incluindo a velocidade angular do quadril e joelho, a aceleração linear do pé e o tempo total de execução (Estevan; Jandacka; Falco, 2013; Gavagan; Sayers, 2017; Huang; Tang; Liu; Hamill *et al.*, 2025). A produção rápida e coordenada de força gera alto impacto em curtos intervalos temporais (Diniz; Del Vecchio; Schaun; Oliveira *et al.*, 2021). Corcoran; Climstein; Whitting E Del Vecchio (2024) identificaram esse chute como o mais veloz entre os analisados em esportes de combate, com médias superiores a 18 m/s.

A análise cinemática divide o movimento em três fases principais: (a) saída do pé, (b) máxima flexão do joelho e (c) impacto (Kim; Kwon; Yenuga; Kwon, 2010). Durante essas etapas, as articulações do quadril, joelho e tornozelo atuam sinergicamente. As variáveis mais relevantes para avaliação incluem velocidade e aceleração angular das articulações, além da velocidade linear do pé, reconhecidas como indicadores-chave de desempenho técnico (Estevan; Álvarez; Falcó; Castillo, 2014; Vagner; Cleather; Olah; Vacek *et al.*, 2023).

1.2 Capacidade de Salto como Indicador de Performance dos chutes

A força explosiva dos membros inferiores é fundamental para execução de chutes em esportes de combate (Corcoran; Climstein; Whitting; Del Vecchio, 2024), assim sendo, os testes de salto amplamente utilizados para estimar a potência de membros inferiores em lutadores de *striking* (Albuquerque; Tavares; Longo; Caldeira Mesquita *et al.*, 2021; Bercades; Pieter, 2012; Chaabène; Hachana; Franchini; Mkaouer *et al.*, 2012). Focados em avaliar a se a capacidade de salto pode determinar a eficiência do chute, alguns investigadores se propuseram a pesquisar essa possível associação e encontraram forte correlação entre potência muscular de membros inferiores e eficiência ações de ataque como o chute circular (Antonietto; Roa Gamboa; Ribeiro; Brito *et al.*, 2024; Cimadoro; Mahaffey; Babault, 2019; Paulino Oliveira; Cochrane; Motta

Drummond; Rodrigues Albuquerque *et al.*, 2018). Nesta linha, Antonietto; Roa Gamboa; Ribeiro; Brito *et al.* (2024) observaram que o salto com agachamento (SJ) e salto com contramovimento (CMJ) permitem avaliar objetivamente a produção rápida de força e potência e estão associados a performance do chute circular.

Ademais deste estudo, outros também mostraram correlações positivas entre variáveis de salto e variáveis do chute, como velocidade e tempo de execução (Albuquerque; Tavares; Longo; Caldeira Mesquita *et al.*, 2021; Chiang; Chiang; Lin; Tseng *et al.*, 2025). Albuquerque; Tavares; Longo; Caldeira Mesquita *et al.* (2021) verificaram que o desempenho no CMJ se associa à velocidade do chute em atletas de Taekwondo. Paralelamente, Chiang; Chiang; Lin; Tseng *et al.* (2025) observaram que medalhistas nessa modalidade apresentam resultados superiores em testes de salto, reforçando o valor preditivo da avaliação de potência de membros inferiores.

1.3 Biomecânica dos Testes de Salto (DSJ e ABK)

Saltos com agachamento profundo (DSJ) e o salto *Abalakov* (ABK) são empregados na avaliação de força e potência de membros inferiores em atletas (Nishiumi; Nishioka; Saito; Kurokawa *et al.*, 2023). O DSJ caracteriza-se pela ausência de contramovimento, sendo executado a partir de posição estática, o que elimina o uso do reflexo de estiramento (Vizcaya; Viana; Olmo; Acero, 2009). O ABK, por sua vez, envolve contramovimento e balanço dos braços, promovendo ação mais natural com maior engajamento da cadeia cinética (Arede; Esteves; Ferreira; Sampaio *et al.*, 2019; Ruiz; Ortega; Gutierrez; Meusel *et al.*, 2006).

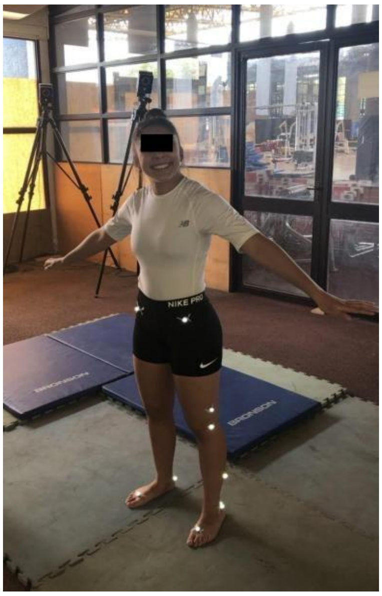
Embora sejam gestos predominantemente verticais, estes saltos demonstram capacidade de predizer performance em levantadores de peso olímpico (Nishiumi; Nishioka; Saito; Kurokawa *et al.*, 2023; Soriano; Flores; Lama-Arenales; Fernández-Del-Olmo *et al.*, 2024), jogadores de voleibol (Miguel-Ortega; Calleja-González; Mielgo-Ayuso, 2023) e basquetebol (Bazanov; Pedak; Rannama, 2019; Miguel-Ortega; Calleja-González; Mielgo-Ayuso, 2023).
Essa relação explica-se pela demanda compartilhada de produção explosiva de força, controle motor e coordenação intermuscular (Nishiumi; Nishioka; Saito; Kurokawa *et al.*, 2023; Soriano; Flores; Lama-Arenales; Fernández-Del-Olmo *et al.*, 2024). Adicionalmente, o ABK simula parcialmente a ação coordenada de tronco e membros inferiores, aproximando-se de movimentos esportivos como o bloqueio no basquetebol e voleibol (Miguel-Ortega; Calleja-González; Mielgo-Ayuso, 2025) e o DSJ se assemelha ao arranco e arremesso para levantadores olímpicos (Vizcaya; Viana; Olmo; Acero, 2009).

Em plataformas de força, estes saltos entregam diversas variáveis que podem auxiliar biomecânicos e treinadores a analisarem a performance de atletas como pico de força, taxa de desenvolvimento de força (RFD), potência média e pico, impulso, tempo até pico de força, tempo total de execução e altura de voo (Joffe; Price; Chavda; Shaw *et al.*, 2023; Pojskić; Papa; Wu; Pagaduan, 2022). Esses parâmetros são distribuídos nas fases excêntrica, concêntrica, de amortecimento e voo e a normalização por massa corporal é essencial para comparação entre biotipos distintos (Barker; Harry; Mercer, 2018; Eagles; Sayers; Bousson; Lovell, 2015; Harry; Barker; Paquette, 2020). Evidências confirmam que ambos os testes possuem alta validade e confiabilidade para avaliar qualidades neuromusculares como potência, força explosiva e rigidez muscular (Eagles; Sayers; Bousson; Lovell, 2015; Soriano; Flores; Lama-Arenales; Fernández- Del-Olmo *et al.*, 2024).

1.4 Métodos de Análise Cinemática em Esportes de Combate

A análise cinemática tridimensional tem se mostrado como uma importante ferramenta para estudo do desempenho técnico em esportes de combate (Antonietto; Roa Gamboa; Ribeiro; Brito *et al.*, 2024; Bagchi; Raizada; Thapa; Ștefănică *et al.*, 2024; Vagner; Cleather; Olah; Vacek *et al.*, 2023). Sistemas como de videofotogametria como o Vicon® são adotados pela precisão na mensuração de velocidade, aceleração e ângulos articulares durante movimentos rápidos e complexos como chutes (Merriaux; Dupuis; Boutteau; Vasseur *et al.*, 2017; Windolf; Götzen; Morlock, 2008). Este sistema utilizam marcadores refletores posicionados em pontos anatômicos estratégicos para reconstrução tridimensional fidedigna (Sers; Forrester; Moss; Ward *et al.*, 2020). A Figura 1 apresenta um modelo que exemplifica o uso dos marcadores em um atleta analisado em um estudo com judocas do centro de alto rendimento do Chile.

Figura 1. Exemplo de como devem ser inseridos os pontos reflexivos, tendo por base as recomendações de (WINDOLF; GÖTZEN; MORLOCK, 2008)



A Figura 2 exemplifica a aplicação prática de uma técnica de judô na qual é possível ver o movimento sendo registrado pelas câmeras em torno do atleta e o modelo sendo reconstruído na tela do computador.

Figura 2. A esquerda temos a tela de computador na qual o avaliador pode monitorar em tempo real o movimento. A direita o atleta avaliado aplicando a técnica, sendo capturado pelas câmeras do sistema Vicon®.

Quanto aos estudos de taekwondo, percebe-se pela revisão feita para a presente dissertação que, os protocolos prévios focaram em analisar variáveis como velocidade e aceleração linear do pé, velocidade e aceleração angular do quadril e joelho, além do tempo total de execução do chute (Antonietto; Roa Gamboa; Ribeiro; Brito *et al.*, 2024; Quintero; Arjona; Valderrama, 2025; Szczęsna; Błaszczyszyn; Pawlyta, 2021). Observam-se também estudos que se basearam em modelos biomecânicos validados, com segmentação nas fases de saída do pé, máxima flexão do joelho e impacto (Antonietto; Roa Gamboa; Ribeiro; Brito *et al.*, 2024; Kim; Kwon; Yenuga; Kwon, 2010). A correlação dessas variáveis com testes de salto demonstrou que aspectos biomecânicos do movimento podem ser indiretamente previstos, facilitando intervenções práticas no treinamento. Contudo, a análise cinemática enfrenta desafios como alto custo, necessidade de calibração constante, tempo de processamento e exigência de ambiente controlado (Fiorentino; Uva; Foglia; Bevilacqua, 2013; Torvinen; Ruotsalainen; Zhao; Cronin *et al.*, 2024). Assim, a identificação de variáveis biomecânicas passíveis de estimativa por métodos acessíveis, como testes de salto em plataformas de força, constitui contribuição relevante para práticas esportivas e científicas, nas quais treinados podem medir e monitorar grande quantidade de atletas sem necessitar de realizar alto investimento financeiro (Antonietto; Roa Gamboa; Ribeiro; Brito *et al.*, 2024; Yeung; Fu; Chua; Mok *et al.*, 2016).

2. ARTIGO CIENTÍFICO

Predictive power of Deep squat and Abalakov jump tests in roundhouse kick performance among elite striking athletes

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Short title: jump and roundhouse kick performance

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Predictive power of Deep squat and Abalakov jump tests in roundhouse kick performance among elite striking athletes

Abstract

The present study investigated whether *deep squart jump* (DSJ) and Abalakov jump (ABK) variables correlate with rear roundhouse kick performance in elite combat sport athletes. For this, 26 elite Taekwondo athletes (12♀) performed three valid attempts for: (a) DSJ, (b) ABK (Pasco® force platforms) and (c) roundhouse kick (Vicon® Motion Systems). The main results indicated that for DSJ, the Concentric RFD-100ms independently predicted Lineal Foot Velocity (R^2=0.21, p=0.009), Lineal Foot Acceleration (R^2=0.303, p=0.003), and Angular Knee Acceleration (R^2=0.194, p=0.021). Combined with Concentric Mean Power/BM, it predicted Angular Knee Acceleration (R^2=0.27, p=0.04). For the ND limb, Takeoff Peak Force independently predicted Angular Hip Acceleration (R^2=0.144, p=0.029), improving when combined with Force at Peak Force (R^2=0.315, p=0.013). For ABK, Eccentric Peak Force/BM predicted Total Time (R^2=0.123, p=0.039). Concentric Peak Force/BM predicted Angular Knee Velocity (R^2=0.173, p=0.018). Eccentric Braking RFD-100ms (D) predicted both Angular Hip Velocity (R^2=0.135, p=0.034) and Angular Hip Acceleration (R^2=0.24, p=0.006).in conclusion, this study demonstrated that DSJ and ABK variables predict roundhouse kick performance. Key assessment variables include Concentric RFD-100ms and non-dominant limb Takeoff Peak Force for DSJ, as well as Eccentric Braking RFD-100ms for ABK.

Keywords: martial arts, sport performances, biomechanics, kinematic analysis.

Poder predictivo de las pruebas de sentadilla profunda y salto Abalakov en el rendimiento de patada circular entre atletas de élite de striking

Resumen

El presente estudio investigó si las variables de salto en sentadilla profunda (DSJ) y salto Abalakov (ABK) se correlacionan con el rendimiento de la patada circular trasera en atletas de deportes de combate de élite. Para esto, 26 atletas de Taekwondo (12♀) realizaron tres intentos válidos para: (a) DSJ, (b) ABK (plataformas de fuerza Pasco®) y (c) patada circular (Vicon® Motion Systems). Los principales resultados indicaron que para DSJ, el RFD-100ms concéntrico predijo de forma independiente la velocidad lineal del pie (R^2=0,21, p=0,009), la aceleración lineal del pie (R^2=0,303, p=0,003) y la aceleración angular de la rodilla (R^2=0,194, p=0,021).

Combinado con la potencia media concéntrica/MC, predijo la aceleración angular de la rodilla (R^2=0,27, p=0,04). Para la pierna ND, la Fuerza Máxima de Despegue predijo de forma independiente la Aceleración Angular de Cadera (R^2=0,144, p=0,029), mejorando al combinarse con la Fuerza Máxima (R^2=0,315, p=0,013). Para ABK, la Fuerza Máxima Excéntrica/MC predijo el Tiempo Total (R^2=0,123, p=0,039). La Fuerza Máxima Concéntrica/MC predijo la Velocidad Angular de Rodilla (R^2=0,173, p=0,018). El Frenado Excéntrico RFD-100ms (D) predijo tanto la Velocidad Angular de Cadera (R^2=0,135, p=0,034) como la Aceleración Angular de Cadera (R^2=0,24, p=0,006). En conclusión, este estudio demostró que las variables DSJ y ABK predicen el rendimiento en la patada circular. Las variables de evaluación clave incluyen RFD-100ms concéntrico y fuerza máxima de despegue de extremidades no dominantes para DSJ, así como RFD-100ms de frenado excéntrico para ABK.

Palabras clave: artes marciales, rendimiento deportivo, biomecánica, análisis cinemático.

1. Introduction

Among the techniques common to striking combat sports, the roundhouse kick stands out as one of the most efficient and frequently employed attacks (Diniz et al., 2021; Estevan et al., 2014; Gavagan & Sayers, 2017; Moenig, 2012; Vagner et al., 2023). Its effective execution requires high levels of agility, muscular power, flexibility, and motor precision (Diniz et al., 2021). Athletes' preference for using this kick is related to its execution speed (Antonietto et al., 2024; Corcoran et al., 2024). In a review on the force and speed of kicks used by striking athletes, Corcoran et al. (2024) observed that the roundhouse kick is the fastest (18.3 m/s). From a biomechanical perspective, effective performance of this kick is characterized by a dynamic sequence that includes: (1) rapid pelvic axial rotation, (2) hip abduction and flexion, (3) explosive knee extension, and (4) accelerated displacement of the center of mass towards the target (Estevan et al., 2014; Gavagan & Sayers, 2017). Although universal, specific terminological variations exist according to the striking discipline: *Bandal Chagi* in Taekwondo (Estevan et al., 2014), *Mawashi-Geri* in Karate, *Tei Chiyang* in Muay Thai, and *Roundhouse Kick* in Kickboxing and Mixed Martial Arts, each adapted to the specific rules and objectives of their respective competitions (Diniz et al., 2021).

Due to its technical and tactical relevance, the roundhouse kick has been the subject of biomechanical studies seeking to identify the kinematic determinants associated with its performance (Diniz et al., 2021; Estevan et al., 2014; Gavagan & Sayers, 2017; T. Y. Huang et al., 2025; Miziara et al., 2019). Diniz et al. (2021) observed similarities (linear acceleration and knee velocity) and disparities (distance to the target and hip velocity) when comparing Taekwondo, Karate, and Muay Thai athletes. In a similar comparison, Gavagan and Sayers (2017) noted that Muay Thai athletes exhibit greater center of mass movement when performing the roundhouse kick compared to Karateka and Taekwondo athletes. Meanwhile, Miziara et al. (2019) analyzed the relationship between pelvic angular velocity and impact force, demonstrating that elite athletes achieve pelvic rotation peaks 23% higher than novices. T. Y. Huang et al. (2025) investigated the kinematic and kinetic demands of high-performance kicks, identifying that the synchronization between hip flexion and knee extension explains 72% of the variance in kick power.

Like the aforementioned studies, the review by Corcoran et al. (2024) emphasized the importance of kinematic analysis for the performance of striking combat athletes. Indeed, kinematic analyses are widely recognized as essential tools for optimizing sports movements in high performance (Ahmadi et al., 2009; Li et al., 2025). However, three-dimensional motion capture videophotogrammetric systems, such as Vicon®, involve high costs and are difficult to use outside laboratory environments (Fiorentino et al., 2013; Torvinen et al., 2024). Furthermore, these systems require substantial time for analysis and a high level of evaluator expertise (Torvinen et al., 2024). Given this context, it is desirable to have more accessible methods to evaluate large numbers of athletes. Recently, Antonietto et al. (2024) showed that CMJ stiffness and the rate of force development in the squat jump (SJ) are the primary variables associated with roundhouse kick performance in international-level Taekwondo athletes.

Similarly, other previous studies have used the CMJ to predict the performance of striking athletes (Albuquerque et al., 2021; Chaabène et al., 2012; Chiang et al., 2025). Chiang et al. (2025) observed that Taekwondo medalists exhibit better CMJ performance. Albuquerque et al. (2021) showed that CMJ correlates ($r=0.44$) with performance on the Frequency Kick Speed Test. Despite the widespread use of jump tests in combat sports, the vast majority of studies focus on the CMJ and SJ (Tabben et al., 2014). Few studies have used the Abalakov Jump (ABK) and the *Deep squart jump* (DSJ).

Although rarely used, the DSJ appears to be an interesting alternative for athlete testing. Two previous studies indicated this jump is a valuable tool for assessing Olympic weightlifting athletes (Soriano et al., 2024; Francisco J. Vizcaya et al., 2009). In basketball players, Bazanov et al. (2019) suggested that the DSJ not only assesses vertical jump capacity but also differentiates athletic performance levels, as athletes with better performance in this jump exhibited greater lower limb power. The ABK has been proposed as a comprehensive jump for assessing sports performance, as it not only measures the explosive force of the lower limbs through the countermovement but also incorporates a coordinated movement of the trunk and upper limbs (Ruiz et al., 2006). Previous studies have shown that ABK can be an assessment tool for soccer and basketball players (Sáez de Villarreal et al., 2015; Santos & Janeira, 2008; Vargas-Molina et al., 2022). In this regard, Vargas-Molina et al. (2022) observed significant improvements after a 10-week strength program in young basketball players, while Sáez de Villarreal et al. (2015) reported similar gains after plyometric and speed training in adolescent soccer players.

Regarding the use of these jumps in combat sports athletes, to the best of our knowledge, only the study by Cárdenas et al. (2019) applied the ABK test to wrestlers, where results indicated that Greco-Roman style athletes performed better than freestyle wrestlers. However, this study used a smartphone application (MyJump®), which limits measurement accuracy due to its indirect nature. Indeed, studies recommend using force platforms over contact mats, which are only valid for measuring jump height and flight time (Pojskić et al., 2022). Force platforms, in contrast, can measure ground reaction force (Chavda et al., 2025), peak force, and rate of force development (Joffe et al., 2023; Pojskić et al., 2022), which are important performance measures. Given this context, the present study aimed to verify whether variables measured in the DSJ and ABK are associated with rear roundhouse kick performance in elite fighters. We hypothesized that both jumps would contain variables predictive of roundhouse kick performance.

2. Materials and methods

2.1. Experimental approach

This cross-sectional study analyzed elite taekwondo athletes in a biomechanics laboratory setting. Following approval from the which the data was collected (CAAE: 82274124.6.0000.5112; protocol: 7.108.464), we obtained permission from the National Taekwondo Federation and main coaches. All assessments were completed during a single laboratory visit. The standardized testing protocol proceeded in the following sequence: (a) Anthropometry; (b) Standardized Warm-up; (c) ABK; (d) DSJ and (e) rear roundhouse kick.

2.2. Participants

This cross-sectional study included elite male and female taekwondo athletes. Inclusion criteria were: (1) age ≥18 years, (2) ≥5 years of uninterrupted competitive training, (3) black belt certification, and (4) attainment of ≥ national champion status. Exclusion criteria comprised: (1) acute or chronic injuries impairing test performance, (2) technical errors during kinematic signal acquisition, or (3) voluntary withdrawal from the study. From an initial pool of 120 athletes screened, 56 met the inclusion criteria. Of these, 28 (16 male, 12 female) consented to participate. One male athlete was excluded due to errors in kinematic signal capture, resulting in a final cohort of 27 athletes (15 male, 12 female). The sample included 11 national champions, 8 South American medalists, and 8 Pan-American medalists (2022 competition cycle). Demographic and anthropometric characteristics are detailed in Table 1.

2.3. Anthropometric measures

Height and body mass were measured using a calibrated wall-mounted stadiometer (Detecto® Model 339, USA; precision ±0.1 cm) and a digital floor scale (Detecto® Model 339, USA; precision ±0.1 kg), respectively. Participants were assessed barefoot in lightweight clothing following standardized protocols (Norton, 2018). Body fat percentage was estimated via the Jackson-Pollock 7-site skinfold method, with gender-specific equations applied: (a) male: Chest, mid-axillary, triceps, subscapular, abdomen, suprailiac, and thigh sites (Jackson & Pollock, 1978) and (b) female: Triceps, suprailiac, thigh, abdominal, subscapular, chest, and mid-axillary sites (Jackson et al., 1980). All skinfold measurements were taken in triplicate using a Harpenden caliper (Baty International, UK; precision ±1 mm).

2.4. Kinematic of roundhouse kick

Kinematic measurements were conducted using a 3D motion capture system, Vicon® Vantage V5 (Vicon® Motion Systems Ltd., Oxford, UK). The setup consisted of ten synchronized optoelectronic cameras, model Vicon® V5 (maximum FPS 420; resolution 2432H x 2048V; ratio 1:1; lens 12,5mm) operating at a sampling frequency of 200Hz. Prior to data collection, the system was calibrated in accordance with manufacturer specifications, achieving sub-2mm residual error (Merriaux et al., 2017). Reflective spherical markers (14 mm diameter, deformable) were affixed bilaterally to anatomical landmarks based on the Lower Limbs Plug-in Gait biomechanical model Marker placements (VICON, 2023) included: (a) anterior and posterior superior iliac spines; (b) upper and lower thirds of the lateral thigh; (c) upper and lower thirds of the lateral shank; (d) lateral femoral epicondyle; (e) transmalleolar axis spanning the medial and lateral malleoli; (f) second metatarsal head; and (g) calcaneus. To capture and calculate kinematic variables, software VICON Nexus® 2.8 was used. This was calculated with the Direct Linear Transformation approach to three-dimensional reconstructions undertaken from images (Wood & Marshall, 1986). The coordinate data from these 16 points were smoothed using a low-pass second-order Butterworth digital filter with a 12 Hz cut-off frequency and used to define nine segments: left thigh, left shank, left foot, left toe, right thigh, right shank, right foot, right foot, right toe, and pelvis (VICON, 2023).

Following Windolf et al. (2008), the following parameters were analyzed across three rear kick phases (1st, 2nd, 3rd) and their cumulative totals: (a) Phase duration and total execution time; (b) Foot linear velocity and acceleration; (c) Hip and knee angular velocities; (d) Hip and knee angular accelerations. Total values were derived from the summation of individual phase measurements. Kick kinematics were assessed using the three-phase model by Kim et al. (2010): (a) Toe-off: Initial ground separation of the kicking foot; (b) Maximum Knee Flexion: Peak knee flexion of the kicking leg and; (c) Impact: Foot-target contact instant.

Before the measurement, all participants completed 10 warm-up kicks, including ≥2 maximal-intensity trials, prior to data collection. Athletes self-selected target distances for strikes against a standardized kick mitt. Three recorded attempts were performed with 14-second inter-trial intervals, consistent with elite competition cadence (Santos et al., 2014). Representative kinematic data from a male athlete’s rear roundhouse kick are illustrated in Figure 1.

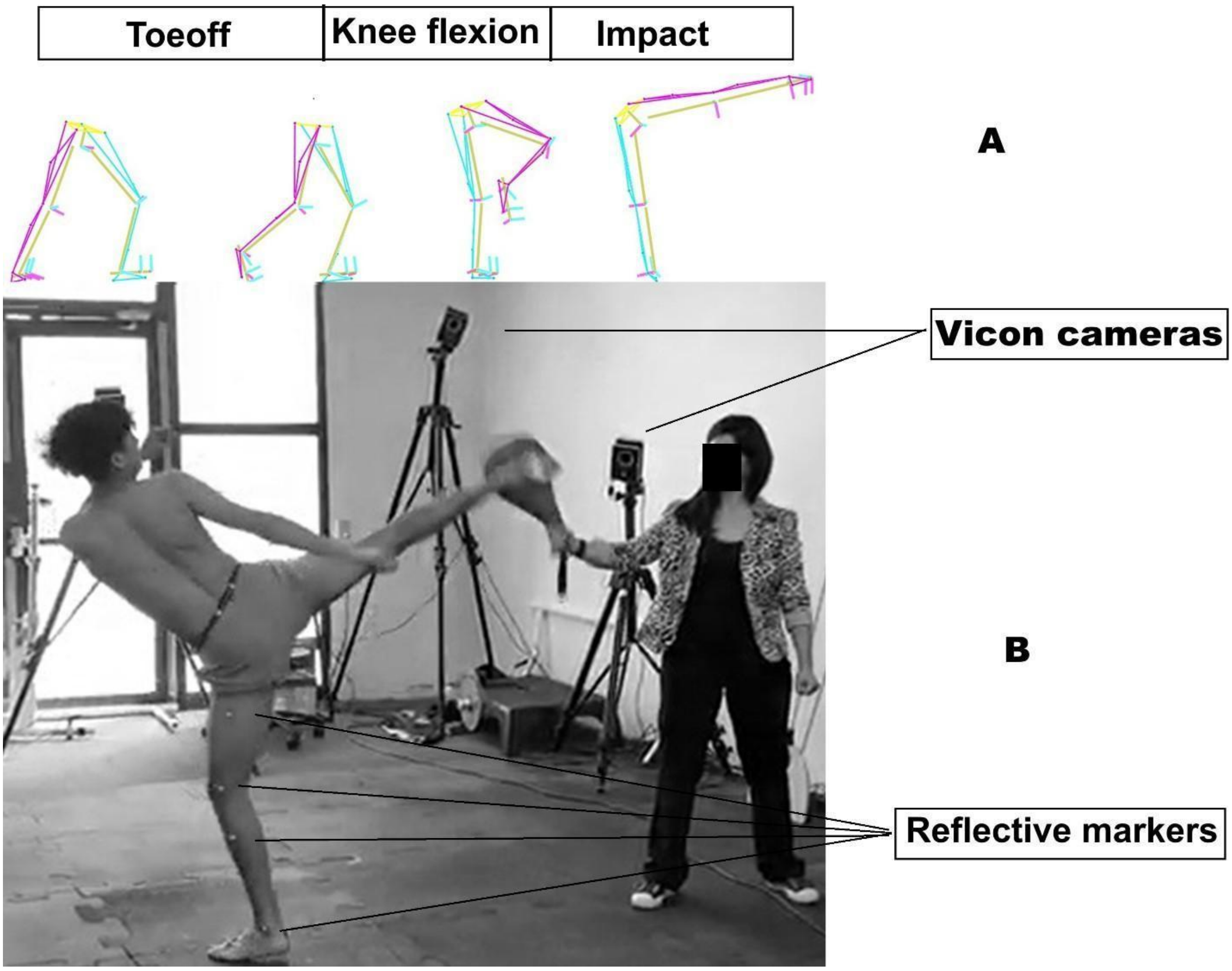

Figure 1. A. Roundhouse kick model constructed by Vicon® software divided into Toe-off, Maximum Knee Flexion and Contact. B. Example of a male kick, indicating the cameras position, sensors and mitt.

2.5. Jump tests

All participants performed the DSJ and ABK. DSJ assessment were performed according the procedures described to Francisco J Vizcaya et al. (2009), all athletes assumed a standardized starting position on two force platforms (Pasco® CI-6461, Pasco Scientific, USA), maintaining a static deep squat with knees flexed to at least 90°, feet positioned shoulder-width apart (measured via anthropometric markers), and toes aligned forward or slightly abducted (≤15°). Hands were fixed on the hips, and the trunk was held upright to minimize postural adjustments. Participants held this position motionless for 3 seconds (verified via force plate data) to ensure elimination of countermovement and pre-stretch muscle activation. Upon an auditory cue from synchronized data acquisition software Forcedecks Valperformance® (Force Decks 2.0.9.2.1.0, NMP Technologies, London, UK), participants executed a vertical jump explosively without preparatory movement (e.g., dipping or swinging arms). Force plate signals were monitored in real time to confirm the absence of countermovement (i.e., no downward displacement prior to ascent, with force trace remaining stable within ±2% body weight during the static phase). Participants were instructed to jump maximally and land back on the plate. Three trials were performed, with 2-minute rests between attempts to mitigate fatigue. Trials with detectable countermovement (via force-time curve analysis) were discarded and repeated.

ABK were performed with the same force platform and software acquisition, according the methods followed by Arede et al. (2019). For this, all athletes began in a standing position with an upright posture (neutral spinal alignment), their feet shoulder-width apart, and arms extended along the body. The countermovement phase involved self-selected knee and hip flexion (with unrestricted angles) to generate reactive force, followed by a synchronized backward arm swing and an explosive forward-and-upward arm motion during extension. During propulsion, full extension of the ankles, knees, and hips was achieved at takeoff, accompanied by maximal arm acceleration overhead to enhance vertical momentum. In the aerial phase, the legs remained fully extended after takeoff to minimize aerodynamic resistance, while the torso stabilized in a neutral position to avoid detrimental rotations. Three trials were performed, with 2-minute rests between attempts, jumps lacking arm-leg synchronization, incomplete joint extension, or imbalance during landing were discarded. Figure 2 illustrates the ABK and DS jump phases.

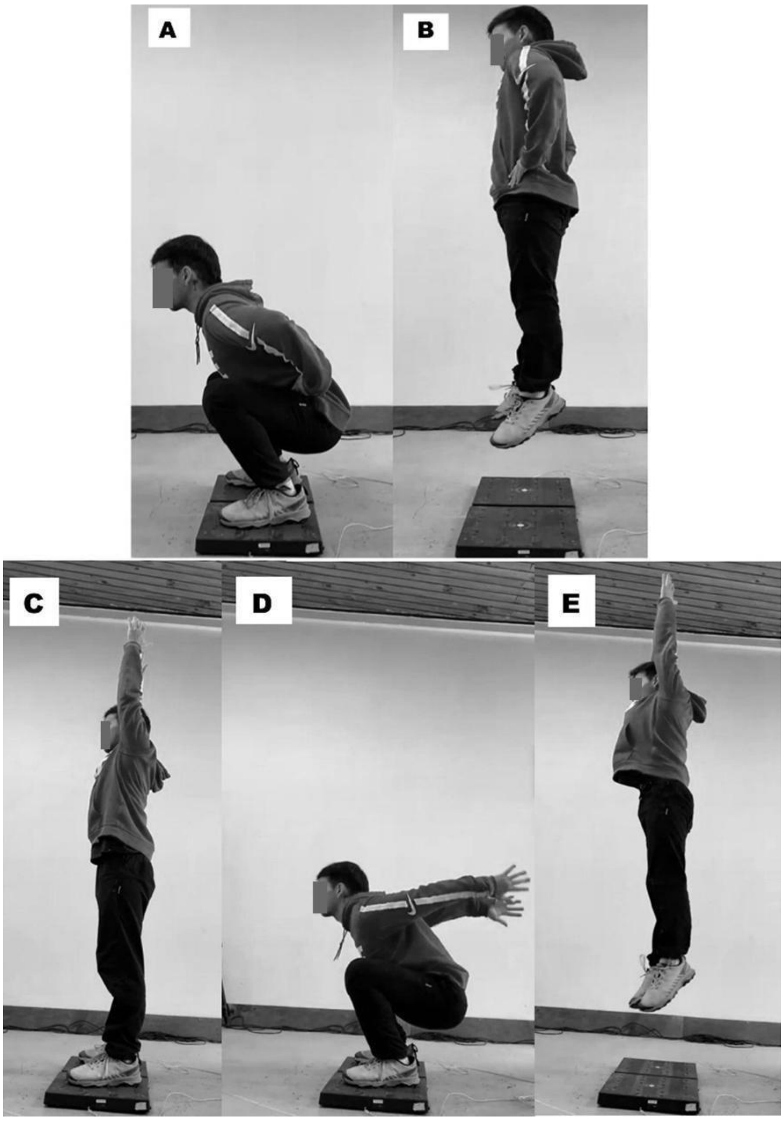

Figure 2. Deep squat jump start (A) and final position (B). Abalakov start (C), countermovement (E) and final position (E).

2.6. Statistical analysis

The Shapiro-Wilk test was employed to assess data normality. One-way ANOVA was used to compare differences in anthropometric measures (Table 1), DSJ, ABK, and kinematic measures across sex-based groups (men, women). Assumptions of homogeneity of variance (Levene's test) and normality were verified. Where variances were unequal, Welch's ANOVA was applied. Post hoc comparisons used Tukey's HSD (equal variances) or Games-Howell tests (unequal variances). Effect sizes and 95% confidence intervals were reported. A hierarchical linear regression (stepwise method) evaluated the predictive power of jumps for kinematic outcomes. Adjusted R^2 values and Akaike Information Criterion were reported to balance model fit and parsimony. To mitigate overfitting from stepwise selection, results were cross-validated using a 70:30 training-test split or k-fold cross-validation (k = 5). All analyses were performed using IBM SPSS Statistics (version 25.0), with $p \leq 0.05$.

3. Results

Table 1 showed the anthropometric measures of the participants and performance of sit-and-reach test.

Table 1. Anthropometric characteristics of participants and the performance of sit-and-reach test.

Measure	Male	female	Total
Age (years)	20.8±3.0	22.6±3.8	21.6±3.4
Experience (years)	11.4±3.1	12.1±2.3	11.7±2.8
Body mass (kg)	68.6±8.5[a]	55.2±4.4	62.9±9.7
Body fat (%)	4.7±1.9[a]	14.9±3.0	9.1±5.6
Height (m)	1.8±0.1[a]	1.6±0.1	1.7±0.1
Side domain	12 R and 4 L	11 R and 1 L	23 R and 5 L
Length of the lower right limb (cm)	100.8±5.0[a]	93.6±4.2	97.9±5.9
Length of left lower limb (cm)	100.5±4.9[a]	93.5±3.6	97.5±5.6
Right knee bone diameter (cm)	9.9±0.3[a]	9.2±0.4	9.6±0.5
Left knee bone diameter (cm)	10.±0.3[a]	9.1±0.4	9.6±0.6
Right ankle bone diameter (cm)	7.3±0.6[a]	6.7±0.4	7.0±0.6
Left ankle bone diameter (cm)	7.4±0.4[a]	6.5±0.4	7.0±0.6

Data present by mean ± standard deviation. R – right lower limb domain. L – left lower limb domain. [a] p≤0.004 vs. female.

Table 1 showed group means and for male, female, and the total participants. No significant differences were observed in age ($F = 0.931$, $p = 0.401$) or experience ($F = 0.186$, $p = 0.831$) across groups. However, significant differences were observed between male and female in all other measures. Despite these differences, men’s means aligned with the total sample averages for lower limb length (right: $F = 6.186$, $p = 0.004$; left: $F = 6.675$, $p = 0.003$), knee diameter (left: $F = 12.479$; right: $F = 9.996$, $p \leq 0.001$ for both comparison), ankle diameter (left: $F = 4.177$, $p = 0.021$; right: $F = 8.844$, $p \leq 0.001$), body mass ($F = 8.529$, $p = 0.001$), height ($F = 10.104$, $p \leq 0.001$), and fat percentage ($F = 18.448$, $p \leq 0.001$). Table 2 presents the DSJ results.

Table 2. Results of deep squat jump variables by the athletes.

Measure	Male	Female	Total
Concentric Mean Power / BM [W/kg]	15.8±2.5	16.5±3.1	16.1±2.7
Concentric Peak Velocity [ms]	2.5±0.3	2.6±0.3	2.5±0.3
Concentric RFD / BM [N/s/kg]	22.5±9.1	24.6±8.1	23.4±8.6
Concentric RFD-100ms / BM [N/s/kg]	51.7±6.2[a]	62.9±5.0	56.5±8.0
Contraction Time [ms]	545.48±64.9	518.6±71.9	534.1±68.1
Flight Time [ms]	478.8±54.5	507.7±38.5	491.1±49.6
Jump Height (Flight Time) [cm]	28.5±6.5	31.8±4.8	29.9±6.0
Peak Power / BM [W/kg]	41.3±6.7	46.2±6.9	43.4±7.1
Peak Takeoff Acceleration [m/s²]	8.8±1.1 [a]	10.3±1.4	9.4±1.4
Take off Peak Force / BM (N/Kg)	18.6±1.1 [a]	20.1±1.4	19.3±1.4
Vertical Velocity at Takeoff [m/s]	2.3±0.3	2.5±0.3	2.4±0.3
Concentric RFD (ND) [N/s]	748.3±278.3	817.4±321.5	777.9±293.8
Concentric RFD (D) [N/s]	698.3±248.5	774.4±267.9	730.9±255.0
Concentric RFD - 100ms (ND) [N/s]	1,327.3±573.7	955.0±399.6	1,167.7±532.1
Concentric RFD - 100ms (D) [N/s]	1,349.4±561.0	989.5±443.4	1,195.2±536.5
Force at Peak Power (ND) [N]	603.7±127.7	630.5±107.6	615.2±118.1
Force at Peak Power (D) [N]	589.4±117.2	625.1±104.5	604.7±111.4
Takeoff Peak Force (ND) [N]	589.4±117.2	625.1±104.5	634.1±122.9
Takeoff Peak Force (D) [N]	611.9±121.2	649.0±106.1	627.8±114.4

Note: Data present by mean ± standard deviation. RFD – rating of force development. BM – body mass. D – dominant lower limb. ND – non-dominant lower limb.

According Table 2 for Concentric RFD-100ms/BM (F = 8.905; p ≤ 0.001; post hoc: p ≤ 0.001 male vs. female, p = 0.027 total vs. female), Peak Takeoff Acceleration (F = 4.012; p = 0.024; post hoc: p = 0.018 male vs. female), and Takeoff Peak Force/BM (F = 4.054; p = 0.023; post hoc: p = 0.017 male vs. female). Table 3 presents the results for ABK.

Table 3. Results of Abalakov jump by the athletes.

Measure	Male	Female	Total
CMJ Stiffness [N/m]	4,422.1±2,246.4	3,208.2±675.5	3,901.8±1,834.0
Concentric Duration [ms]	343.2±34.1	327.3±50.0	336.4±41.6
Concentric Peak Force / BM [N/kg]	23.1±1.3	23.1±1.4	23.1±1.3
Concentric Peak Velocity [m/s]	2.7±0.3	2.6±0.3	2.7±0.3
Eccentric Braking RFD / BM [N/s/kg]	53.7±14.6	48.8±9.0	51.6±12.5
Eccentric Braking RFD-100ms / BM [N/s/kg]	39.6±12.9	46.3±20.7	42.4±16.7
Eccentric Deceleration RFD / BM [N/s/Kg]	57.6±23.8	50.3±14.6	54.5±24.4
Eccentric Duration [ms]	554.4±70.5	621.0±120.9	538.0±99.2
Eccentric Peak Force / BM [N/kg]	21.1±2.6	21.6±2.5	21.3±2.5
Flight Time [ms]	513.8±53.0	548.5±45.3	528.7±52.0
Jump Height (flight time) [cm]	32.7±6.7	37.1±6.2	34.6±6.8

Peak Power / BM [W/kg]	50.9±8.9	51.0±6.0	51.0±7.7
Vertical Velocity at Takeoff [m/s]	2.6±0.3	2.5±0.3	2.6±0.3
CMJ Left-Limb Stiffness [N/m]	2,229.4±1.153.9	1,604.8±236.7	1,961.7±940.8
CMJ Right-Limb Stiffness [N/m]	2,210.8±1,098.8	1,613.8±338.1	1,954.9±898.8
Concentric Peak Force (ND) [N]	765.3±176.0	740.4±139.6	754.6±159.0
Concentric Peak Force (D) [N]	761.1±165.5	728.3±142.4	747.0±154.1
Eccentric Braking RFD (ND) [N/s]	1,685.4±512.6	1,532.1±477.3	1,619.7±494.8
Eccentric Braking RFD (D) [N/s]	1,850.8±707.9	1,518.8±322.7	1,708.5±590.6
Eccentric Braking RFD-100ms (ND) [N/s]	1,981.1±458.6	1,349.5±590.2	1,263.0±514.4
Eccentric Braking RFD-100ms (D) [N/s]	1,495.8±588.2	1,415.0±822.1	1,461.2±685.0
Takeoff Peak Force (ND) [N]	767.1±175.1	750.3±140.5	759.9±158.6
Takeoff Peak Force (D) [N]	765.4±165.6	739.3±134.7	754.2±151.0

Data present by mean ± standard deviation. RFD – rating of force development. BM – body mass. D – dominant lower limb. ND – non-dominant lower limb. [a] $p \leq 0.044$ vs. female.

Regarding the means observed in Table 3, there were no significant differences when comparing men, women and the total sample ($p > 0.05$). Table 4 showed the results of the kinematic analysis of rear roundhouse kick performed by the athletes.

Table 4. Roundhouse kick kinematic analysis separated by sex and phases.

Measure	Male	Female	Total
Time 1st phase (s)	0.119±0.035	0.143±0.031	0.129±0.035
Time 2nd phase (s)	0.129±0.019	0.133±0.013	0.131±0.017
Time 3rd phase (s)	0.095±0.01	0.096±0.01	0.096±0.01
Total time (s)	0.343±0.04	0.373±0.048	0.356±0.046
Foot linear speed 1st phase (m/s)	2.2±0.7	2.0±0.4	2.1±0.6
Foot linear speed 2nd phase (m/s)	9.8±1.2	9.4±1.3	9.6±1.3
Foot linear speed 3rd phase (m/s)	13.3±1.4	12.2±1.8	12.8±1.7
Total Foot linear speed (m/s)	25.4±2.5	23.5±2.8	24.6±2.7
Knee angular speed 1st phase (g/s)	654.3±141.3	676.7±123.9	663.9±131.0
Knee angular speed 2nd phase (g/s)	970.3±300.0	861.3±169.4	923.6±254.4
Knee angular speed 3rd phase (g/s)	1,764.1±352.6	1,686.6±230.3	1,730.9±303.6
Total Knee angular speed (g/s)	3,388.7±657.8	3,224.5±338.5	3,318.4±542.1
Hip angular speed 1st phase (g/s)	258.1±60.7	271.8±112.2	263.9±85.0

Hip angular speed 2^{nd} phase (g/s)	481.6±95.6	440.6±89.7	464.1±93.7
Hip angular speed 3^{rd} phase (g/s)	626.0±170.6	603.1±223.8	616.2±191.6
Total Hip angular speed (g/s)	1,365.7±187.0	1,315.5±344.3	1,334.2±261.5
Foot acceleration 1^{st} phase (m/s2)	71.7±24.2	59.4±11.6	66.6±20.4
Foot acceleration 2^{nd} phase (m/s2)	132.7±34.3	120.5±37.0	127.5±35.4
Foot acceleration 3^{rd} phase (m/s2)	366.2±82.0	308.0±67.8	341.3±80.4
Total Foot acceleration (m/s2)	570.7±114.5	488.0±87.0	535.2±110.0
Knee acceleration 1^{st} phase (m/s2)	12,011.0±2,127.8	12,648.7±3,232.9	12,284.3±2,622.3
Knee acceleration 2^{nd} phase (m/s2)	23,028.2±11,000.3	17,845.5±5,097.8	20,031.4±8,390.5
Knee acceleration 3^{rd} phase (m/s2)	41,394.2±19,577.2	41,159.7±12,291.2	41,629.4±16,233.3
Total Knee acceleration (m/s2)	77,020.9±29,575.6	71,653.8±16,167.0	74,720.7±24,489.9
Hip acceleration 1^{st} phase (m/s2)	7,127.7±1,527.9	8,463.3±3,498.4	7,700.1±2,610.3
Hip acceleration 2^{nd} phase (m/s2)	6,622.8±1,792.7	6,143.5±1,490.4	6,417.4±1,657.9
Hip acceleration 3^{rd} phase (m/s2)	25,286.1±15,869.8	25,930.2±10,477.7	25.562.1±13,585.9
Total Hip acceleration (m/s2)	39,036.6±17,111.4	40,057.2±13,184.1	39,679.7±15,159.1

There were no significant differences ($p>0.05$) between the kinematic variables. The results for linear regression analyses between the variables of DSJ and ABK and the roundhouse kick performance are presented in Table 5. For DSJ, Concentric RFD-100ms independently predicted Lineal Foot Velocity ($R^2 = 0.21$, $p = 0.009$), Lineal Foot Acceleration ($R^2 = 0.303$, $p = 0.003$), and Angular Knee Acceleration ($R^2 = 0.194$, $p = 0.021$). Concentric RFD-100ms combined with Concentric Mean Power/B also predicted Angular Knee Acceleration ($R^2 = 0.27$, $p = 0.04$). For the ND lower limb, Takeoff Peak Force independently predicted Angular Hip Acceleration ($R^2 = 0.144$, $p = 0.029$), while combined with Force at Peak Force ($R^2 = 0.315$, $p = 0.013$). Already for ABK, Eccentric Peak Force/BM predicted Total Time ($R^2 = 0.123$, $p = 0.039$). Concentric Peak Force/BM predicted Angular Knee Velocity ($R^2 = 0.173$, $p = 0.018$). Eccentric Braking RFD-100ms (D) predicted both Angular Hip Velocity ($R^2 = 0.135$, $p = 0.034$) and Angular Hip Acceleration ($R^2 = 0.24$, $p = 0.006$).

Table 5. Linear regression for Deep squat and Abalakov jumps to predict the rear roundhouse kick performance.

Deep Squat Jump
Lineal foot velocity

Model		NSC		SC	T	Sig.	95%CI expected for B	
		B	Error	Beta			Upper limit	Lower limit
1	Constant	21.6	1.1		18.8	≤0.001	19.2	23.9
	Concentric RFD 100ms	0.003	0.001	0.49	2.8	0.009	0.001	0.004
Lineal foot acceleration								
1	Constant	397.9	43.7		9.1	≤0.001	308.0	488.0
	Concentric RFD 100ms	0.1	0.03	0.6	3.3	0.003	0.04	0.2
Angular knee acceleration								
1	(Constante)	50,184.7	10,452.2		4.8	≤0.001	28,657.9	71,711.5
	Concentric RFD 100ms	20.6	8.4	0.4	2.5	0.021	3.3	37.8
2	(Constant)	100,087	10,452.2		4.0	0.001	48,489.1	151,685.1
	Concentric RFD 100ms	34.0	10.0	0.7	3.4	0.02	13.4	54.6
	Concentric Mean Power / BM	-4,044.7	1,865.7	-0.5	-2.2	0.04	-7,895.3	-194.1
Total foot linear acceleration								
1	Constant	6,041.8	14,554.9		0.4	0.692	-23,934.7	36,018.2
	Takeoff Peak Force (ND)	52.0	22.4	0.4	2.3	0.029	5.8	98.2
2	Constant	14,146.9	13,363.8		1.1	0.3	-13,434.6	41,728.4
	Takeoff Peak Force (ND)	782.6	272.3	6.3	2.9	0.008	220.7	1,344.5
	Force at Peak Force (ND)	-765.5	284.5	-5.9	-2.7	0.013	-1,352.6	-178.4
Abalakov Jump								
Total time								
1	Constant	0.2	0.07		2.8	0.01	0.05	0.4
	Eccentric Peak Force/BM	0.007	0.003	0.4	2.2	0.04	0.0	0.01
Angular knee velocity								
1	Constant	7,388.8	1,616.7		4.6	≤0.001	4,059.1	10,718.5
	Concentric Peak Force/BM	-177.9	70.0	-0.5	-2.5	0.018	-322.2	-33.7
Angular hip velocity								
1	Constant	1,108.8	110.5		10.0	≤0.001	881.4	1,366.3
	Eccentric Braking RFD-100ms (D)	0.2	0.07	0.4	2.3	0.034	0.013	0.3
Hip angular acceleration								
1	Constant	22,415.2	6,089.8		3.7	0.001	9,873.0	34,957.3
	Eccentric Braking RFD-100ms (D)	11.4	3.8	0.5	3.0	0.006	3.7	19.2

Note: NSC – Non-standardized coefficient; SC – Standardized coefficient.

4. Discussion

3D motion capture systems, such as Vicon®, offer several advantages over 2D analysis, particularly in applications requiring a deeper understanding of human movement dynamics and biomechanics (Skalski et al., 2025; Windolf et al., 2008). One of the main advantages of 3D systems is the ability to capture movements in a more realistic and accurate way, since they provide a three-dimensional visualization that reflects the complexity of interactions in space (Merriaux et al., 2017; Szczęsna et al., 2021; Windolf et al., 2008). However, these systems require laboratory settings (Fiorentino et al., 2013) and entail high costs (Torvinen et al., 2024), hindering widespread implementation (Yeung et al., 2016). In this context, valid indirect methods enabling coaches to assess, monitor, and predict sports performance relative to technical execution in motion capture systems like Vicon® are valuable (Antonietto et al., 2024; Yan et al., 2021; Yeung et al., 2016). Accordingly, the present study analyzed the predictive capacity of an explosive jump (DSJ) and a countermovement jump (ABK) on rear roundhouse kick performance. The main results showed that for the DSJ, Concentric RFD-100ms and Takeoff Peak Force of the non-dominant lower limb were the primary predictors of kick performance. For the ABK, the Eccentric Braking RFD-100ms variable of the dominant lower limb was the main predictor for this kick in high-performance combat athletes. To the best of our knowledge, this is the first study to conduct this type of prediction using DSJ and ABK jumps for a kicking technique. Recently, our research group performed a similar comparison using CMJ and DJ jumps (Antonietto et al., 2024).

Similar to the present protocol, previous studies have also analyzed relationships between the roundhouse kick and biomechanical variables (Bercades & Pieter, 2012; de Oliveira Goulart et al., 2016; Estevan et al., 2013). In Taekwondo athletes, Estevan et al. (2013) demonstrated significant correlations ($r = 0.89$, $p < 0.01$) between vertical force peak during the kick and execution time measured via 2D kinematic. Meanwhile, de Oliveira Goulart et al. (2016) reported a strong correlation between CMJ and roundhouse kick performance in Taekwondo athletes; however, this jump showed limited predictive capacity for the kick. Unlike previous studies, our protocol introduces the novel aspect of using a force platform to measure jump performance, which offers advantages over contact mats (Bagchi et al., 2024; Plakoutsis et al., 2023), combined with 3D motion capture to quantify roundhouse kick performance, allowing for multi-joint and multidirectional analysis (Antonietto et al., 2024; Szczęsna et al., 2021).

Furthermore, we are unaware of any studies applying the DSJ and ABK to striking combat athletes. As Francisco J. Vizcaya et al. (2009) note, many athletic movements are performed without a countermovement, positioning the DSJ as a valuable assessment tool. However, this jump is more commonly applied as a training exercise than an evaluative measure (Soriano et al., 2024; Francisco J. Vizcaya et al., 2009). Soriano et al. (2024) demonstrated that the DSJ strongly predicts performance in Olympic weightlifters (68.1%) due to its biomechanical similarity to the snatch and clean and jerk. Although the specific striking technique in our study differs biomechanically from the DSJ; two variables of this jump may still predict factors associated with roundhouse kick performance. Our results identified Concentric RFD-100ms and Takeoff Peak Force in the non-dominant lower limb as the primary predictors of roundhouse kick performance. Concentric RFD-100ms was the main predictor of foot acceleration and velocity. This latest variable has been shown higher values in the roundhouse kick compared to other kick techniques such as the front kick in high-level athletes [3], which also explains its high eligibility in taekwondo competitions (Avakian et al., 2021), emphasizing the importance of this findings on Concentric RFD-100ms as a predictor of athletic performance. In relation to this measure, a study involving physically active College students linked this variable to explosive force production (Mirkov et al., 2004). Indeed, the DSJ; initiated from a static squat position without countermovement; qualifies as an explosive ballistic movement (Soriano et al., 2024). In line with our results, prior researches highlight the critical role of supporting lower limb in generating velocity and power during roundhouse kicks (R. Huang et al., 2025; Robalino et al., 2025; Vagner et al., 2023). Notably, athletes in our study executed kicks exclusively with their dominant leg; future protocols should compare outcomes when using the non-dominant lower limb.

The ABK test not only assesses explosiveness but also harnesses the elastic energy stored in the tendons and requires coordination between the trunk and upper limbs (Lago-Peñas et al., 2011; Miguel-Ortega et al., 2023; Ruiz et al., 2006). Its application as an athlete assessment tool benefits from incorporating the arm-swing motion, which resembles technical movements in basketball and volleyball (Miguel-Ortega et al., 2023, 2025). Unlike the DSJ, the primary performance predictor for the ABK is associated with the kicking limb, where Excentric

Braking RFD-100ms emerges as the key predictor of hip acceleration and velocity during the roundhouse kick, an indicator linked to lower-limb explosive strength (Merino-Muñoz et al., 2020). Supporting this relationship, systematic reviews indicate that eccentric forces during the CMJ (as measured by RFD-100ms) are associated with the reactive strength index (Nishiumi et al., 2023). Therefore, athletes with better Excentric Braking RFD-100ms performance are expected to exhibit superior reactive force during kick performance. This correlation aligns with studies directly linking excentric braking to countermovement performance (Krzyszkowski et al., 2022; Nishiumi et al., 2023). Krzyszkowski et al. (2022) suggest that strategies to enhance the Excentric Braking RFD-100ms may improve athletic performance.

Similar to previous studies, our results also does not support jump height as an indicator of lower-limb explosive strength (Antonietto et al., 2024; Merino-Muñoz et al., 2020; Soriano et al., 2024), a result contrasting with other studies on striking athletes (Roschel et al., 2009; Spigolon et al., 2018). However, it is important to highlight that these studies did not use force platforms. In this sense, we also reinforce that contact mats and other indirect methods should be disregarded in favor of force platforms, which provide a high number of variables (Antonietto et al., 2024; Joffe et al., 2023) and are more reliable as measurement instruments (Chavda et al., 2025; Joffe et al., 2023; Soriano et al., 2024). The results of the present study should be analyzed considering the limitations of the applied methodology. Only elite Taekwondo athletes were evaluated; previous studies have shown small biomechanical differences when the roundhouse kick is performed by athletes from other striking combat sports (Corcoran et al., 2024; Diniz et al., 2021; Gavagan & Sayers, 2017). The analyzed data refers exclusively to the rear lower limb.

5. Conclusion

Based on the established aims, applied methods, and obtained results, the present study demonstrated that variables from DSJ and ABK predict roundhouse kick performance. When evaluating athletes, the main variables to be observed are Concentric RFD-100ms and Takeoff Peak Force of the non-dominant lower limb for DSJ, and Eccentric Braking RFD-100ms for ABK.

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3. CONCLUSÃO GERAL

A presente dissertação analisou a possível relação entre variáveis biomecânicas derivadas dos saltos DSJ e ABK com o desempenho do chute circular em atletas de elite de Taekwondo. Os resultados indicaram que ambos os testes exibem poder preditivo relevante para distintos parâmetros cinemáticos do chute, com contribuições específicas: o DSJ associou-se predominantemente a variáveis de força explosiva dos membros inferiores, em especial a RFD concêntrica em 100ms e a força de pico na perna não-dominante, enquanto o ABK demonstrou correlação com a força de frenagem excêntrica, influenciando diretamente a aceleração e velocidade angular do quadril durante o movimento. Tais achados reafirmam a relevância dos testes de salto como instrumentos válidos e aplicáveis à avaliação e monitoramento do desempenho técnico em esportes de combate.

A aplicação prática desta abordagem viabiliza a identificação, por treinadores e profissionais, de atributos neuromusculares críticos para a execução de chutes de maior potência e eficiência, fomentando o desenvolvimento de programas de treinamento personalizados e cientificamente embasados. Adicionalmente, a integração de plataformas de força e sistemas de captura em 3D propiciam uma análise mais acurada e abrangente dos gestos técnicos, aprofundando a compreensão da biomecânica subjacente. Conclui-se, portanto, que a sinergia entre testes de salto e análise cinemática configura-se como uma estratégia eficaz para a otimização do desempenho esportivo em modalidades de striking, como o Taekwondo. Recomenda-se que estudos futuros investiguem a aplicação desses métodos em diferentes contextos e populações, abrangendo atletas de outras artes marciais, bem como análises comparativas do chute entre pernas dominante e não dominante, visando delinear com maior precisão os fatores determinantes da performance em gestos técnicos complexos.

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PARECER DO COMITÊ DE ÉTICA

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PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Predição de desempenho em técnicas de esportes de combate por meio de testes físicos: uma análise a partir da biomecânica esportiva

Pesquisador: Lucio Marques Vieira Souza

Área Temática:

Versão: 2

CAAE: 82274124.6.0000.5112

Instituição Proponente: UEMG - Unidade de Passos

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 7.272.986

Apresentação do Projeto:

Apresentação do Projeto: As informações elencadas nos campos "Apresentação do Projeto", "Objetivo da Pesquisa" e "Avaliação dos Riscos e Benefícios" foram retiradas do arquivo Informações Básicas da Pesquisa, (PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_ "Predição de desempenho em técnicas de esportes de combate por meio de testes físicos: uma análise a partir da biomecânica esportiva", gerado na Plataforma Brasil em 25/10/2024 - Versão 2 - Número do Parecer: 7.108.464

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RESUMO: Existem estudos anteriores em biomecânica já realizados no judô; porém, nenhum deles analisou as técnicas mais utilizadas em competição em modelo 3D. Após a análise dos dados a serem mensurados neste estudo, o principal avanço científico que esperamos é a utilização de testes físicos mais indiretos que possam prever o desempenho em uma técnica deste esporte de combate. Como o acesso aos sistemas de captura de movimento é limitado e o equipamento não é portátil, acreditamos que existe uma correlação entre medições mais acessíveis (ou seja, testes de salto) e a potência realizada pela aplicação direta da técnica, seremos capazes de fornecer treinadores com indicadores indiretos que podem ajudar a classificar e qualificar os lutadores de judô, estabelecer estratégias de treinamento e detectar pontos a melhorar.

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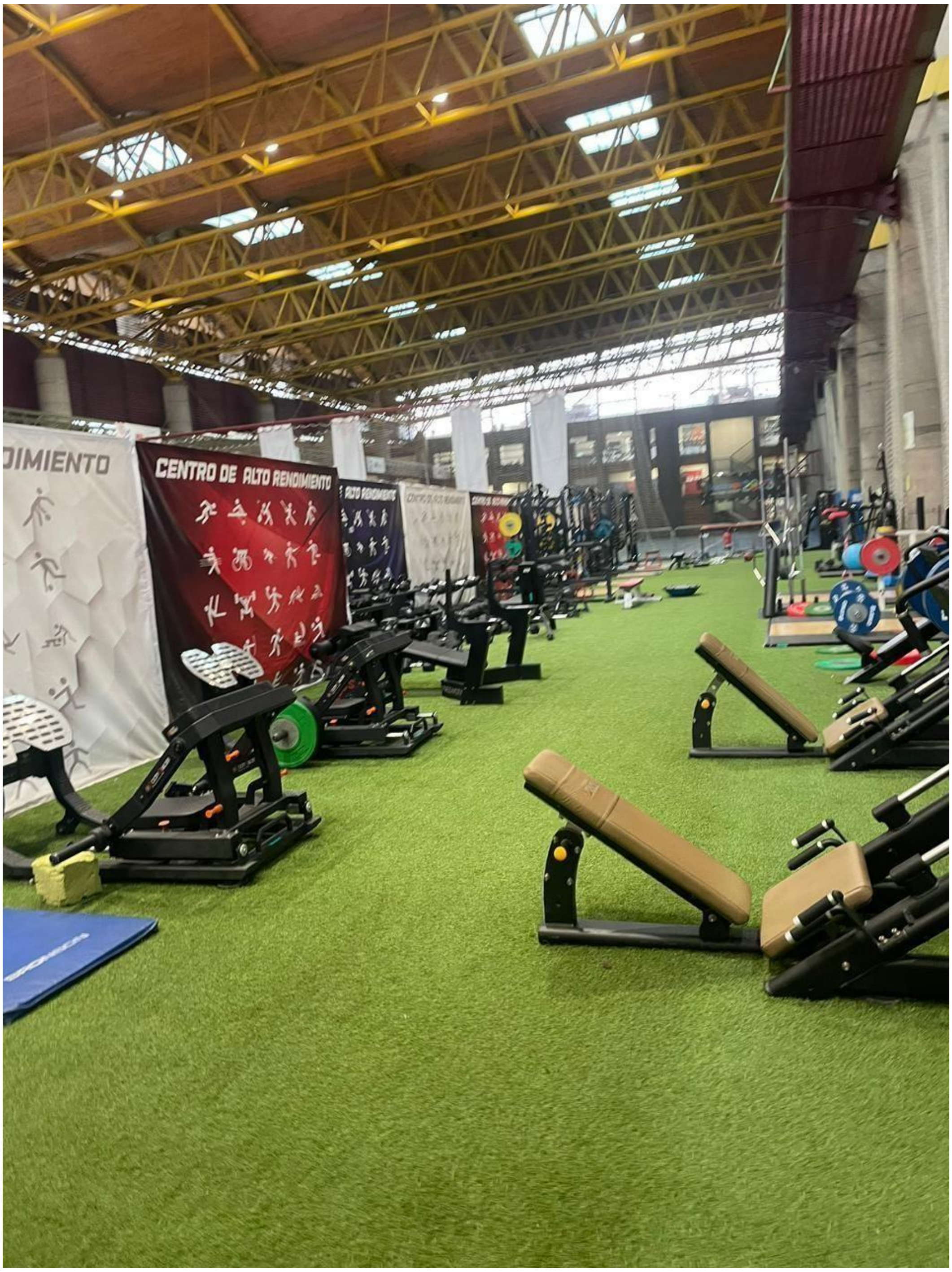
CENTRO DE ALTO RENDIMENTO – CAR (SANTIAGO – CHILE)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