

Correlates of concentric jump metrics with directional sprint velocities and MDSA performance in university field athletes

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Abstract:

Rapid sprinting in team sports relies on concentric power for propulsion and efficient change-of-direction (COD) transitions, however traditional assessments often overlook holistic multidirectional capabilities. This study examined the correlations between concentric metrics from countermovement jump (CMJ) and drop jump (DJ) assessments and multidirectional sprint performance, including the novel multidirectional sprint area (MDSA) method. Twenty-eight university-level athletes (age: 20 ± 1 years; body mass: 68 ± 9 kg; height: 166 ± 6 cm) playing hockey and rugby participated in a correlational study. Participants completed linear sprints, deceleration, COD (45° , 90° and 135° angles bilaterally), as well as MDSA evaluations, alongside CMJ and DJ tests on force plates. Data were analysed using Pearson's and Spearman's correlations ($p < 0.05$). Significant positive correlations emerged between CMJ height, concentric mean force, peak power, vertical velocity at take-off, and the modified reactive strength index (RSI-mod) with Phase 1 and 2 sprint velocities across directions ($r = 0.390$ – 0.825 , $p < 0.05$ – 0.01) and MDSA total and segmental areas ($r = 0.450$ – 0.810 , $p < 0.05$ – 0.01). DJ height, peak power, relative peak power, peak drive-off force, and RSI were positively correlated with velocity ($r = 0.458$ – 0.778 , $p < 0.05$ – 0.01) and MDSA ($r = 0.575$ – 0.710 , $p < 0.01$), whereas the CMJ contraction time displayed negative associations ($r = -0.400$, $p < 0.05$). The associations between concentric CMJ and DJ metrics and multidirectional sprint performance indicated that elevated jump height, peak power, drive-off force, and RSI were associated with enhanced sprint velocity, with prolonged contraction times linked to reduced performance. These metrics exhibited strong positive correlations with MDSA total and directional areas, highlighting the critical role of concentric force and power in supporting holistic multidirectional sprint ability.

Key Words: - Reactive Strength Index, Stretch-Shortening Cycle, Neuromuscular Profiling, Agility Kinematics, Force-Velocity Characteristics, Horizontal Propulsion

Introduction

Rapid sprinting in athletic competitions demands high levels of mechanical power and is dependent on the ability of the muscular system to generate force quickly during shortening phases and transfer it efficiently to the support surface (Nagahara *et al.*, 2014; Freitas *et al.*, 2018). Concentric contractions, involving muscle length reduction while producing tension, form the basis for such power generation, supporting explosive propulsion and smooth transitions in multidirectional movements (Suarez-Arrones *et al.*, 2020; Thomas *et al.*, 2017). Within a variety of sports, running efforts vary from brief accelerations to extended sprints, with initial speed build-up phases prevailing due to the requirement for swift directional adjustments, wherein concentric capabilities aid in rapid impulse creation to counter resistance (Oleksy *et al.*, 2024; Jiménez-Reyes *et al.*, 2019).

While acceleration is well-documented, the negative velocity phase is often overlooked despite its frequency in match play (Harper *et al.*, 2020; Hewit *et al.*, 2011). Traditional assessments often isolate linear components, failing to capture the holistic locomotive envelope an athlete utilises during multidirectional manoeuvres (Dos'Santos *et al.*, 2021b). Modern technologies, such as laser devices, have improved the accuracy of profiling these characteristics in straight-line runs, providing an understanding of how concentric force affects speed across various orientations (Harper *et al.*, 2020; Harper *et al.*, 2022). Success in field sports is predicated on navigating chaotic environments that require rapid transitions between maximal sprinting, deceleration, and high-intensity changes of direction (COD) (Brughelli *et al.*, 2008; Gordon & Green, 2026).

Team sports demand multidirectional sprinting capabilities, typically involving rapid CODs that require a sequence of deceleration, redirection and reacceleration (Dos'Santos *et al.*, 2021a; Russell *et al.*, 2016). Decelerations are frequent in match play and, while essential for controlling momentum and enabling positional transitions, the high-impact braking phase imposes significant eccentric loading and ground reaction forces, increasing neuromuscular fatigue and injury risk, particularly to the quadriceps (Colby *et al.*, 2000; Harper *et al.*, 2022a). Critically, the functional success of the entire manoeuvre relies on an efficient stretch-shortening cycle (SSC), where optimal deceleration techniques facilitate energy transfer into the subsequent concentric drive, i.e., the action that generates propulsion in a new direction (von Lieres Und Wilkau *et al.*, 2020; Jones *et al.*, 2017).

Efficient multidirectional movement requires high concentric strength to overcome inertia during re-acceleration (Suarez-Arrones *et al.*, 2020). Because isolated linear tests often correlate poorly with COD ability, there is a clear opportunity for a solution that quantifies the interplay of concentric power and directional velocity (Little & Williams, 2005; Gordon & Green, 2026).

In the same way that greater eccentric forces are required to effectively decelerate during COD, greater concentric forces are required to reaccelerate the body (Dos'Santos *et al.*, 2021a; Dos'Santos *et al.*, 2021b; Hader *et al.*, 2016; Havens & Sigward, 2015). This concentric phase is key to minimising energy loss and maximising reacceleration velocity, which is distinct from reactive agility and linear speed (Sheppard & Young, 2006). Therefore, the capacity for superior concentric power, measured by specific metrics such as peak power and drive-off force, is essential for maintaining multidirectional sprint proficiency, enhancing recovery from fatiguing eccentric loads, and generating the necessary mediolateral and horizontal forces, especially at sharper COD angles (Dos'Santos *et al.*, 2021a; Harper & Kiely, 2018; Morin *et al.*, 2012). Training interventions, such as plyometrics and strength exercises targeting concentric phases, can enhance COD by improving the rate of force development (RFD) and reactive strength, thereby supporting holistic multidirectional sprint performance (DeWeese & Nimphius, 2016; Falch *et al.*, 2019; Ramirez-Campillo *et al.*, 2023).

Lower-body power, assessed through vertical jump tests such as the countermovement jump (CMJ) and drop jump (DJ), serves as a surrogate for evaluating the necessary propulsive capacity and SSC efficiency for multidirectional tasks (Cahill *et al.*, 2021; Cronin & Hansen, 2005; Harper *et al.*, 2022a; Harris *et al.*, 2008; Loturco *et al.*, 2017). A CMJ assessment serves multiple purposes, including the evaluation of athletic performance and the analysis of interlimb asymmetries (Berton *et al.*, 2018). Furthermore, CMJ-derived metrics, such as jump height, power, and force, provide critical insights into the neuromuscular capacities that underpin sprint acceleration and COD performance, as these shared elements of explosive power enable athletes to generate and transfer substantial ground forces during linear and multidirectional tasks (Morin & Samozino, 2016). The CMJ evaluates explosive power via a rapid eccentric–concentric transition, providing metrics, such as jump height, peak power and the modified reactive strength index (RSI-mod), which indicates the concentric efficiency during sprint acceleration and COD re-acceleration (Anicic, *et al.*, 2023; Berton *et al.*, 2018; Claudino *et al.*, 2017; Lake *et al.*, 2018; McMahon *et al.*, 2017a). The DJ serves as a critical assessment tool for evaluating reactive strength, which is integral to explosive movements involving rapid eccentric loading followed by concentric propulsion (Young & Farrow, 2006). Similarly, the DJ emphasises the reactive strength from a drop height, yielding variables such as peak power, drive-off force and RSI, which are linked to deceleration tolerance and subsequent concentric propulsion in multidirectional sprints (McMahon *et al.*, 2017a; Harper *et al.*, 2022a). Concentric-dominant metrics from these jumps correlate with sprint velocity because they indicate propulsive efficiency and rapid force production, with higher CMJ heights and RSI associated with faster sprint times, greater accelerations, and improved COD through enhanced energy transfer and neuromuscular adaptations (Comfort *et al.*, 2014; Dos'Santos *et al.*, 2017; Healy *et al.*, 2019; Marshall & Moran, 2015; McMahon *et al.*, 2017a; Morin & Samozino, 2016; Jiménez-Reyes *et al.*, 2019; Loturco *et al.*, 2015; Loturco *et al.*, 2018; Suarez-Arrones *et al.*, 2020). However, prolonged contraction times in the CMJ may hinder performance in deceleration-inclusive tasks, as slower concentric phases limit responsiveness in multidirectional scenarios (Harper *et al.*, 2022a; Morin *et al.*, 2015).

Traditional assessments often isolate linear sprinting, deceleration or specific COD angles, failing to provide a holistic metric for multidirectional sprint ability (Dos'Santos *et al.*, 2021b; Freitas *et al.*, 2018; Nimphius *et al.*, 2016). To address this, the multidirectional sprint area (MDSA) method integrates velocities from linear sprints, decelerations, and COD at 45°, 90° and 135° in both directions, plotting them on a radar chart to form an octagonal area representing overall sprint proficiency (Gordon & Green, 2026). The area is segmented into forward, backward, left, and right components, enabling the identification of asymmetries and directional weaknesses, but has also shown sensitivity across sporting codes, possibly reflecting concentric acceleration dominance, compared to minimal left-right differences (Gordon & Green, 2026).

This study applied the novel MDSA method (Gordon & Green, 2026). This study utilised laser radar technology to capture continuous velocity data across eight directions, which were integrated into an octagonal polygon via the shoelace algorithm to provide a single value for total sprinting proficiency (Gordon & Green, 2026). By correlating precise concentric kinetics from force plates with MDSA segmental areas, this research aimed to determine if vertical concentric power serves as a valid predictor for holistic field performance. As such, the current study examined correlations among concentric metrics, including CMJs, DJs, and MDSAs, as well as isolated sprint velocity, in university athletes. By focusing on concentric aspects, this study aimed to determine how lower-body power underpins multidirectional sprinting, thereby informing training for enhanced performance in team sports.

Material & methods

Research Design and Participants

This investigation adopted a quantitative correlational framework to investigate the links between sprinting performance metrics, encompassing those from the MDSA approach, and concentric attributes derived from vertical jumping evaluations.

A group of 28 athletes competing at the university level (age: 20 ± 1 years; body mass: 68 ± 9 kg; height: 166 ± 6 cm) was enlisted from a range of athletic backgrounds. Every participant supplied written informed consent ahead of the evaluations. This study received formal ethical approval from the institution's ethics committee (REC-1359-2022).

Data Collection

Evaluations were conducted during the athletes' active competitive period. The participant pool consisted of hockey and rugby players, including individuals of both sexes. Information was gathered on two distinct testing occasions, spaced by no less than 48 h. Conditions during testing remained uniform across sessions, and athletes donned shoes appropriate for their discipline to simulate match-like situations. Prior to each evaluation, a consistent preparation routine was implemented to maximise the athletes' preparedness. The initial session emphasised straight-line sprinting and braking capabilities, whereas the follow-up session concentrated on force-plate-based jumping protocols, namely the CMJ and DJ.

Linear Maximal Sprint Assessment

Sprint times over 15 and 30 m were recorded using a Stalker ATS II radar gun (Stalker Pro, Radar Sales Inc., Minneapolis, USA). The sprint was divided into Phase 1 (0–15 m) and Phase 2 (15–30 m), with times measured to 0.01 s. Participants started from a stationary split stance, with the front foot 30 cm behind the timing gate to prevent false triggers. They self-initiated the sprint without backward steps or rocking motions, aiming for maximal speed. Three trials were performed, separated by at least 2 min of passive recovery. The best 30 m split time was used for analysis.

Maximal Deceleration Assessment

Participants performed a 15 m maximal sprint followed by an immediate deceleration to a complete stop. The starting protocol and radar equipment matched those of the linear sprint test. After stopping, participants backpedalled to the 15 m mark to delineate the end of deceleration. Trials were invalid if the 15 m sprint time exceeded the prior maximal sprint times by more than 5%. At least 3 min of recovery was provided between trials (Harper *et al.*, 2024).

Change of Direction Assessment

The COD tests required shifting to a predefined direction after forward running. Six tests were conducted at 45°, 90°, and 135° angles to the left and right, each covering 30 m divided into two segments. The 30 m distance allowed acceleration to maximal velocity, aligning with team sport demands and enabling angular comparisons (Haugen *et al.*, 2019). Segment times were recorded using Fusion Smartspeed timing gates (Fusion Sports, Colorado, USA). Starting procedures matched the linear sprint and deceleration tests, using a stationary split stance. Participants sprinted 15 m linearly, then changed direction to a marker 15 m away, decelerating for the turn and re-accelerating through the final gate. Three trials per direction were completed, with at least a 3 min recovery. The fastest 15 m time per participant was used for analysis.

Multidirectional Sprint Area (MDSA)

The MDSA system appraises an athlete's overall directional sprinting competence by extracting speed data from eight distinct evaluations: a straight-line dash, acceleration–deceleration assessment (ADA), and COD activities at 45°, 90° and 135° on both sides. Speeds were noted at the 15 and 30 m thresholds, alongside the complete cessation position in the deceleration phase. These figures were mapped as points on a radar diagram, yielding a polygonal figure whose interior area represented the athlete's cumulative sprinting ability. Speed was quantified as displacement per unit time, with outcomes divided into forward, backward, left and right orientations to provide an integrated assessment mechanism for directional sprinting efficiency (Gordon & Green, 2026).

Jump Assessments

For the CMJ, competitors stood atop VALD ForceDecks platforms with palms on their waist and lower limbs spaced at shoulder distance. A stationary period of 2–3 s preceded the action. Guidance stressed an erect posture, immovable hands, forward-facing eyes, a bend at the knees of approximately 90° and an explosive upward propulsion (Lake *et al.*, 2018). In the DJ, athletes descended from a height of 40 cm onto the platforms and promptly performed a peak vertical bound before returning to the surface (Harper *et al.*, 2022a). Both jumping variants were performed in triplicate, with 45-s inactive pauses, and the best outcome was preserved for review (Suarez-Arrones *et al.*, 2020).

Statistical Analysis

The normality of the distributions was appraised using Shapiro-Wilk procedures, indicating a blend of normal and skewed patterns across the measures. Accordingly, descriptive statistics for the group were presented as average values. Inter-variable correlations (Pearson's and Spearman's) were determined to outline the scope of the connections among the metrics. All analyses were performed using IBM SPSS software (version 30), adopting a threshold for significance of $p < 0.05$.

Results

The descriptive statistics for the 28 university athletes are presented in Tables 1–3, with Table 1 summarising the multi-directional sprint tests over 30 m, Table 2 providing means and standard deviations for the MDSA tests, and Table 3 detailing means and standard deviations for the CMJ and DJ tests.

Table 1. Summary statistics of 28 athletes participating in multi-directional sprint tests over 30m

	Mean $\pm$ SD	
	Phase 1	Phase 2
Velocity 30m Sprint	5.13 $\pm$ 1.04	7.4 $\pm$ 0.8
Velocity 45 R	5.09 $\pm$ 0.73	6.59 $\pm$ 1.04
Velocity 90 R	4.82 $\pm$ 0.72	5.57 $\pm$ 1.31
Velocity 135 R	4.65 $\pm$ 0.45	4.62 $\pm$ 0.8
Velocity Deceleration	4.43 $\pm$ 0.53	2.98 $\pm$ 0.98
Velocity 135 L	4.49 $\pm$ 0.48	4.6 $\pm$ 0.8
Velocity 90 L	4.82 $\pm$ 0.62	6.01 $\pm$ 1.16
Velocity 45 L	4.96 $\pm$ 0.65	6.82 $\pm$ 0.97

Table 2. Results (means and standard deviations) for MDSA Tests

	Mean $\pm$ SD
MDSA Area Total	92.65 $\pm$ 24.96
MDSA Area Fwd	63.57 $\pm$ 16.52
MDSA Area Bwd	29.08 $\pm$ 8.81
MDSA Area Left	45.14 $\pm$ 13.96
MDSA Area Right	47.51 $\pm$ 11.96
MDSA Area Fwd %	68.85 $\pm$ 2.54
MDSA Area Bwd %	31.15 $\pm$ 2.54
MDSA Area Left %	48.36 $\pm$ 4.02
MDSA Area Right %	51.64 $\pm$ 4.02

Table 3. Results (means and standard deviations) for CMJ and DJ Tests

	Mean $\pm$ SD
CMJ Jump Height [cm]	30.09 $\pm$ 8.89
CMJ RSI-modified [m/s]	0.37 $\pm$ 0.15
CMJ Contraction Time [ms]	876.54 $\pm$ 193.63
CMJ Contraction Time:Eccentric Duration [%]	152.82 $\pm$ 16.32
CMJ Concentric Mean Force [N]	1231.25 $\pm$ 288.24
CMJ Peak Power [W]	3114.04 $\pm$ 992.066
CMJ Vertical Velocity at Take-off [m/s]	2.40 $\pm$ 0.36
DJ Jump Height [cm]	29.72 $\pm$ 8.02
DJ Peak Power [W]	8787.46 $\pm$ 7181.1
DJ Relative Peak Power [W]	134.57 $\pm$ 117.73
DJ Eccentric:Concentric Mean Force Ratio [%]	115.22 $\pm$ 16
DJ Relative Eccentric:Concentric Mean Force Ratio [%]	1.79 $\pm$ 0.36
DJ Peak Drive-Off Force [N]	1817.61 $\pm$ 486.75
DJ Relative Peak Drive-Off Force [N]	27.49 $\pm$ 4.67
DJ RSI	1.1 $\pm$ 0.34
DJ Drop Landing RFD [N/s]	68496.07 $\pm$ 33832.28

Correlations with Sprint Velocity

Significant negative correlations were observed between CMJ height and Phase 1 sprint times across most directions, including the 30 m linear sprint ($r = -0.570$, $p < 0.01$), 45° right ($r = -0.447$, $p < 0.05$), 90° right ($r = -0.515$, $p < 0.01$), 135° right ($r = -0.583$, $p < 0.01$), deceleration ($r = -0.427$, $p < 0.05$), 135° left ($r = -0.650$, $p < 0.01$), 90° left ($r = -0.498$, $p < 0.01$), and 45° left ($r = -0.499$, $p < 0.01$). Similar patterns were noted for Phase 2

sprint times, with stronger associations including the 30 m linear sprint ($r = -0.825$, $p < 0.01$), 45° right ($r = -0.719$, $p < 0.01$), 90° right ($r = -0.744$, $p < 0.01$), and 135° right ($r = -0.757$, $p < 0.01$).

Positive correlations were found between CMJ height and Phase 1 velocity, including the 30 m linear sprint ($r = 0.591$, $p < 0.01$), 45° right ($r = 0.540$, $p < 0.01$), 90° right ($r = 0.656$, $p < 0.01$), and 135° right ($r = 0.647$, $p < 0.01$). For Phase 2 velocity, significant positive correlations were observed with the 30 m linear sprint, 45° right, 90° right, and 135° right (Table 4). Positive correlations were also found between CMJ concentric mean force and Phase 1 velocity across most directions, including the 30 m linear sprint, 45° right, 90° right, 135° right, 135° left, 90° left, and 45° left (Table 4).

For Phase 2 velocity, significant positive correlations were observed between CMJ concentric mean force and the 30 m linear sprint ($r = 0.515$, $p < 0.01$), 45° right ($r = 0.593$, $p < 0.01$), 90° right ($r = 0.623$, $p < 0.01$), 135° right ($r = 0.612$, $p < 0.01$), 135° left ($r = 0.615$, $p < 0.01$), 90° left ($r = 0.620$, $p < 0.01$), and 45° left ($r = 0.434$, $p < 0.05$). Positive correlations were found between CMJ peak power and Phase 1 velocity across most directions, including the 30 m linear sprint, 45° right, 90° right, 135° right, 135° left, 90° left, and 45° left (Table 4). For Phase 2 velocity, significant positive correlations were observed between CMJ peak power and the 30 m linear sprint ($r = 0.653$, $p < 0.01$), 45° right ($r = 0.753$, $p < 0.01$), 90° right ($r = 0.811$, $p < 0.01$), 135° right ($r = 0.777$, $p < 0.01$), 135° left ($r = 0.728$, $p < 0.01$), 90° left ($r = 0.662$, $p < 0.01$), and 45° left ($r = 0.518$, $p < 0.01$). Positive correlations were found between CMJ vertical velocity at take-off and Phase 1 velocity across most directions, including the 30 m linear sprint, 45° right, 90° right, 135° right, 135° left, 90° left, and 45° left (Table 4). For Phase 2 velocity, significant positive correlations were observed between CMJ vertical velocity at take-off and the 30 m linear sprint ($r = 0.825$, $p < 0.01$), 45° right ($r = 0.710$, $p < 0.01$), 90° right ($r = 0.771$, $p < 0.01$), 135° right ($r = 0.758$, $p < 0.01$), 135° left ($r = 0.714$, $p < 0.01$), and 45° left ($r = 0.390$, $p < 0.05$).

CMJ RSI-mod exhibited a strong negative correlation with sprint time in the Phase 1 30 m linear sprint ($r = -0.680$, $p < 0.01$) and a positive correlation with velocity in the Phase 2 30 m linear sprint ($r = 0.725$, $p < 0.01$). The DJ peak power had a negative correlation with Phase 2 sprint time in the 30 m linear sprint ($r = -0.488$, $p < 0.01$) and a positive correlation with momentum in the Phase 2 30 m linear sprint ($r = 0.778$, $p < 0.01$).

Significant positive correlations were noted between peak drive-off force in the DJ and Phase 2 velocity (30 m linear sprint: $r = 0.458$, $p < 0.05$) and momentum (Phase 2 deceleration momentum: $r = 0.789$, $p < 0.01$). The DJ RSI demonstrated a positive correlation with Phase 1 velocity and a strong association with Phase 2 velocity (30 m linear sprint: $r = 0.512$, $p < 0.01$).

For acceleration, CMJ height correlated positively with Phase 1 accelerations in the 30 m linear sprint ($r = 0.720$, $p < 0.01$), 45° right COD ($r = 0.619$, $p < 0.01$) and Phase 2 accelerations in the 30 m linear sprint ($r = 0.822$, $p < 0.01$). The DJ height had a similar positive correlation with acceleration in the Phase 1 30 m linear sprint ($r = 0.631$, $p < 0.01$).

Because velocity is the first derivative of position with respect to time and other kinematic variables (such as acceleration and momentum) share similar mathematical principles, we anticipated that they would exhibit analogous correlations. Consequently, only the velocity is presented in the main text; supplementary tables for time, acceleration, and momentum are provided.

Correlations with MDSA Metrics

Significant positive correlations were observed between CMJ height and MDSA Total ($r = 0.719$, $p < 0.01$), Area Forward, Area Backward, Area Left and Area Right (Table 5). The CMJ relative jump height had a positive correlation with MDSA Total ($r = 0.450$, $p < 0.05$), Area Forward, Area Backward and Area Left (Table 5). The CMJ concentric mean force exhibited positive correlations with MDSA Total ($r = 0.670$, $p < 0.01$), Area Forward, Area Backward, Area Left and Area Right (Table 5).

The CMJ peak power had positive correlations with MDSA Total ($r = 0.810$, $p < 0.01$), Area Forward, Area Backward, Area Left and Area Right (Table 5). The CMJ vertical velocity at take-off had positive correlations with MDSA Total ($r = 0.722$, $p < 0.01$), Area Forward, Area Backward, Area Left and Area Right (Table 5). CMJ RSI-mod exhibited positive correlations with MDSA Total ($r = 0.610$, $p < 0.01$), Area Forward, Area Backward, Area Left and Area Right (Table 5). Negative correlations were found between CMJ contraction time and MDSAs (Table 5) and between CMJ relative contraction time and MDSAs (Area Total: $r = -0.400$, $p < 0.05$).

For DJ metrics, jump height correlated positively with MDSA Total ($r = 0.650$, $p < 0.01$), Area Forward, Area Backward, Area Left, and Area Right (Table 5). The DJ peak power had positive correlations with MDSA Total ($r = 0.650$, $p < 0.01$), Area Forward, Area Backward, Area Left and Area Right (Table 5). The DJ relative peak power exhibited positive correlations with MDSA Total ($r = 0.575$, $p < 0.01$), Area Forward, Area Backward, Area Left and Area Right (Table 5).

The DJ peak drive-off force correlated positively with MDSA Area Total ($r = 0.710$, $p < 0.01$), Area Forward, Area Backward, Area Left and Area Right (Table 5). The DJ RSI had positive correlations with MDSA Total ($r = 0.669$, $p < 0.01$), Area Forward, Area Backward, Area Left and Area Right (Table 5).

Table 4. Correlation metrics between velocities and concentric jump metrics

Jump Metrics	Phase 1 Velocity								Phase 2 Velocity							
	30m Sprint	45 R	90 R	135 R	Deceleration	135 L	90 L	45 L	30m Sprint	45 R	90 R	135 R	Deceleration	135 L	90 L	45 L
CMJ Jump Height [cm]	0.591**	0.540**	0.656**	0.647**	0.185	0.697**	0.657**	0.583**	0.825**	0.691**	0.766**	0.744**	0.221	0.705**	0.35	0.391*
CMJ RSI-modified [m/s]	0.535**	0.543**	0.502**	0.654**	0.157	0.630**	0.542**	0.597**	0.725**	0.578**	0.596**	0.576**	0.156	0.568**	0.31	0.364
CMJ Contraction Time [ms]	-0.319	-0.203	-0.116	-0.331	-0.082	-0.32	-0.171	-0.241	-0.325	-0.185	-0.146	-0.175	0.039	-0.197	-0.067	-0.086
CMJ Contraction Time:Eccentric Duration [%]	0.09	0.059	-0.018	-0.01	0.1	0.189	0.049	0.096	-0.023	-0.196	-0.215	-0.286	0.067	-0.171	-0.01	0.035
CMJ Concentric Mean Force [N]	0.448*	0.468*	0.463*	0.442*	0.114	0.553**	0.495**	0.532**	0.515**	0.593**	0.623**	0.612**	0.192	0.615**	0.620**	0.434*
CMJ Peak Power [W]	0.544**	0.610**	0.636**	0.592**	0.172	0.641**	0.648**	0.674**	0.653**	0.753**	0.811**	0.777**	0.290	0.728**	0.662**	0.518**
CMJ Vertical Velocity at Take-off [m/s]	0.592**	0.530**	0.656**	0.645**	0.188	0.694**	0.659**	0.571**	0.825**	0.710**	0.771**	0.758**	0.221	0.714**	0.328	0.390*
DJ Jump Height [cm]	0.574**	0.580**	0.615**	0.669**	0.165	0.589**	0.616**	0.601**	0.722**	0.625**	0.719**	0.702**	0.24	0.605**	0.433*	0.36
DJ Peak Power [W]	0.317	0.390*	0.386*	0.306	0.211	0.383*	0.388*	0.435*	0.488**	0.602**	0.613**	0.542**	0.345	0.520**	0.587**	0.371
DJ Relative Peak Power [W]	0.374*	0.380*	0.402*	0.357	0.147	0.363	0.373	0.381*	0.624**	0.639**	0.601**	0.532**	0.265	0.502**	0.445*	0.271
DJ Relative Eccentric Mean Force [N]	0.006	0.091	0.055	-0.015	0.188	0.106	0.153	0.076	0.118	0.484**	0.312	0.367	0.246	0.328	0.572**	0.322
DJ Relative Eccentric:Concentric Mean Force Ratio [%]	0.548**	0.526**	0.551**	0.554**	-0.016	0.559**	0.492**	0.575**	0.552**	-0.445*	0.611**	0.624**	-0.104	0.512**	-0.453*	-0.434*
DJ Peak Drive-Off Force [N]	0.351	0.371	0.369	0.287	0.107	0.461*	0.383*	0.425*	0.458*	0.619**	0.624**	0.642**	0.224	0.600**	0.741**	0.587**
DJ Relative Peak Drive-Off Force [N]	0.234	0.319	0.25	0.236	0.039	0.301	0.24	0.332	0.423*	0.507**	0.428*	0.474*	0.147	0.444*	0.393*	0.339
DJ RSI	0.382*	0.480**	0.429*	0.389*	0.179	0.419*	0.464*	0.482**	0.512**	0.685**	0.593**	0.601**	0.245	0.576**	0.537**	0.438*
DJ Drop Landing RFD [N/s]	0.085	0.113	0.033	0.05	0.008	-0.234	-0.003	0.048	-0.08	-0.02	0.033	0.104	0.104	-0.123	0.064	-0.142

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table 5. Correlation metrics between MDSA and concentric jump metrics

	MDSA Area Total	MDSA Area Fwd	MDSA Area Bwd	MDSA Area Left	MDSA Area Right	MDSA Area Fwd %	MDSA Area Bwd %	MDSA Area Left %	MDSA Area Right %
CMJ Jump Height [cm]	0.719**	0.705**	0.716**	0.777**	0.594**	-0.334	0.334	0.569**	-0.569**
CMJ RSI-modified [m/s]	0.610**	0.606**	0.591**	0.640**	0.526**	-0.218	0.218	0.399*	-0.399*
CMJ Contraction Time [ms]	-0.182	-0.21	-0.122	-0.195	-0.153	-0.148	0.148	-0.106	0.106
CMJ Contraction Time:Eccentric Duration [%]	-0.102	-0.06	-0.143	-0.207	0.019	0.276	-0.276	-0.268	0.268
CMJ Concentric Mean Force [N]	0.810**	0.787**	0.839**	0.812**	0.726**	0.488**	0.488**	0.539**	-0.539**
CMJ Peak Power [W]	0.722**	0.706**	0.722**	0.788**	0.587**	-0.349	0.349	0.600**	-0.600**
CMJ Vertical Velocity at Take-off [m/s]	0.650**	0.638**	0.713**	0.707**	0.556**	-0.462*	0.462*	0.574**	-0.574**
DJ Jump Height [cm]	0.650**	0.638**	0.713**	0.707**	0.556**	-0.462*	0.462*	0.574**	-0.574**
DJ Peak Power [W]	0.650**	0.605**	0.651**	0.635**	0.540**	-0.444*	0.444*	0.415*	-0.415*
DJ Relative Peak Power [W]	0.575**	0.568**	0.571**	0.644**	0.437*	-0.345	0.345	0.523**	-0.523**
DJ Relative Eccentric Mean Force [N]	0.453*	0.443*	0.454*	0.408*	0.470*	-0.222	0.222	0.008	-0.008
DJ Relative Eccentric:Concentric Mean Force Ratio [%]	0.605**	0.589**	0.609**	0.596**	0.568**	0.294	-0.294	-0.234	0.234
DJ Peak Drive-Off Force [N]	0.710**	0.703**	0.719**	0.648**	0.715**	-0.342	0.342	0.219	-0.219
DJ Relative Peak Drive-Off Force [N]	0.491**	0.491**	0.470*	0.489**	0.453*	-0.126	0.126	0.197	-0.197
DJ RSI	0.669**	0.658**	0.662**	0.669**	0.615**	-0.277	0.277	0.286	-0.286
DJ Drop Landing RFD [N/s]	0.001	-0.041	0.057	0.021	-0.037	-0.211	0.211	0.088	-0.088

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Discussion

The principal aim of this study was to determine the associations between concentric CMJ and DJ metrics and sprint performance, including the novel MDSA approach. Higher concentric outputs were associated with a higher sprint velocity and a larger MDSA. Conversely, slower concentric timings, such as longer contraction times, tended to be associated with a smaller MDSA and poorer sprint performance.

The athletes in this study exhibited moderate sprint and COD performances typical of university-level competitors, with mean 30 m linear sprint times similar to previous research reflecting efficient concentric force application during acceleration (Furlong *et al.*, 2021). The COD times increased progressively with larger angles, which was consistent with the greater demands on concentric propulsive efficiency for velocity recovery following directional changes (Dos'Santos *et al.*, 2019; Morin *et al.*, 2015). These findings underscore the role of concentric metrics in mitigating performance decreases across directions, as evidenced by the observed velocity patterns (Morin *et al.*, 2015).

Correlations with velocity Jump Height

It was anticipated that CMJ height would reflect the ability to generate high concentric forces and powers during the propulsive phase, which directly translates to enhanced ground reaction forces and the impulse production essential for rapid sprint initiation and maintenance (Comfort *et al.*, 2014; McMahon *et al.*, 2017b). For example, in elite sprinters, CMJ performance has been linked to superior acceleration phases due to optimised force-velocity profiles, where higher jump heights correspond to a greater mechanical power output during early sprint strides (Furlong *et al.*, 2021; Suarez-Arrones *et al.*, 2020). The consistency with our findings supports the notion that CMJ height serves as a proxy for concentric capabilities that underpin sprint efficiency. The positive correlations between CMJ height and sprint velocity in both phases highlight that elevated jump performance facilitates a higher peak velocity, especially in the linear and rightward COD directions (Furlong *et al.*, 2021; Jiménez-Reyes *et al.*, 2019; Suarez-Arrones *et al.*, 2020). This alignment is biomechanically grounded in the concentric phase of the CMJ, which mimics the rapid hip, knee and ankle extensions required for consistent high velocity sprinting (Harper *et al.*, 2020; Morin *et al.*, 2015). Similarly, CMJ concentric mean force and peak power have been shown to correlate strongly with sprint velocities by providing a stable base for power generation and directly influencing velocity attainment through optimised energy output in propulsive movements, further emphasising their role in sustained performance (Marques *et al.*, 2011). This aligns with our results, where these metrics exhibited moderate to strong positive associations across the Phase 2 velocities in linear and multidirectional sprints. Additionally, the results of our study further indicate that CMJ vertical velocity at take-off, a key indicator of explosive concentric output, contributes to higher sprint velocities by reflecting the athlete's ability to convert force into speed during ground contact (Morin *et al.*, 2015). Previous research has demonstrated comparable positive associations between CMJ-derived metrics and horizontal velocities in team sport athletes, emphasising the role of neuromuscular qualities in overcoming inertial forces during acceleration and deceleration (Dos'Santos *et al.*, 2018; Harper *et al.*, 2019; Thomas *et al.*, 2017). The results of our study extend this by incorporating multidirectional elements, where the stronger correlations in Phase 2 velocities suggest that CMJ height is particularly predictive of sustained speed under directional constraints, possibly due to the enhanced eccentric-concentric coupling efficiency (Dos'Santos *et al.*, 2018). The discrepancies with earlier work, such as weaker associations in deceleration velocities, may stem from the specific demands of our protocol, which included sharper angles, such as 135° COD, imposing greater braking requirements that are not fully captured in linear focused studies (Dos'Santos *et al.*, 2017; Harper *et al.*, 2019). This is biomechanically logical because acceleration relies on high concentric forces to propel body mass forward (Oleksy *et al.*, 2024; Morin *et al.*, 2015; Suarez-Arrones *et al.*, 2020). Our multidirectional extensions corroborate this, although the weaker correlations at sharper angles suggest that COD-specific demands, such as lateral forces, may dilute pure concentric contributions, explaining the variances from linear focused studies (Dos'Santos *et al.*, 2017, 2018). Similarly, CMJ concentric mean force, which quantifies the average force exerted during the upward propulsion, has been shown to correlate strongly with sprint velocities by providing a stable base for power generation, further emphasising its role in sustained performance (Comfort *et al.*, 2014). Furthermore, CMJ peak power, representing the maximum rate of work during the jump, aligns with these findings, as it directly influences velocity attainment through optimised energy output in propulsive movements (Marques *et al.*, 2011). Additionally, CMJ vertical velocity at take-off, a key indicator of explosive concentric output, contributes to higher sprint velocities by reflecting the athlete's ability to convert force into speed during ground contact (Morin *et al.*, 2015).

Peak Power and Drive-Off Force

This study observed that peak power and drive-off force may indicate that greater power output in the DJ propulsive phase enables faster times and higher momentum maintenance, particularly in linear sprints and during deceleration. This reflects the DJ's emphasis on fast SSC, where concentric power drives forward propulsion against gravitational and inertial loads (Dos'Santos *et al.*, 2021b; Ramirez-Campillo *et al.*, 2023). Previous research has observed similar relationships linking DJ power to multidirectional speed through enhanced force application during COD transitions (Dos'Santos *et al.*, 2021b). The positive correlations between DJ peak drive-off force and

Phase 2 velocity further reinforce this, as drive-off force represents the critical concentric impulse for overcoming deceleration and re-acceleration (Morin *et al.*, 2015; Morin & Samozino, 2016). Studies have investigated this in sprint contexts, showing that peak forces in jumps correlate with acceleration mechanics via optimised force orientation (Comfort *et al.*, 2014; Morin *et al.*, 2015). However, the nonsignificant deceleration velocity correlations could arise from our drop height differing from previous studies, potentially affecting eccentric preload and thus concentric output transferability (Harper *et al.*, 2019).

Reactive Strength Indices (RSI-mod and DJ RSI)

Similar patterns emerged for CMJ RSI-mod, with a positive correlation with velocity, indicating that athletes with superior reactive strength, characterised by high jumps relative to contraction time, excel in sprint tasks demanding quick force production. This was consistent with expectations, as RSI-mod encapsulates concentric efficiency within an SSC, which is crucial for repetitive ground contacts in sprinting (Dos'Santos *et al.*, 2018; Jones *et al.*, 2017; McMahon *et al.*, 2017b). Studies have reported similar findings, where RSI-mod from CMJ correlated positively with sprint velocities in athletes, attributing this to improved stiffness and energy return during propulsion (Dos'Santos *et al.*, 2018; Healy *et al.*, 2019). However, the nonsignificant association with Phase 2 deceleration times in our data contrasts with some of the literature, possibly due to the deceleration component's heavier reliance on eccentric control, which RSI-mod may not fully represent in concentric-focused analyses (Harper *et al.*, 2019). This highlights a possible limitation in using CMJ RSI-mod alone for deceleration prediction, differing from studies with more eccentric-emphasised protocols (Harper *et al.*, 2019; McMahon *et al.*, 2017b). The DJ RSI exhibited a positive correlation with velocity, which was more distinct in Phase 2, indicating its value in assessing reactive concentric capabilities for higher speed sprints. This was consistent with previous research, with DJ RSI quantifying the efficiency of utilising stored elastic energy concentrically, which is vital for multidirectional tasks (Ciacchi *et al.*, 2024; Dos'Santos *et al.*, 2018; McMahon *et al.*, 2017b). Previous research has documented comparable associations, where a higher DJ RSI predicted better COD velocities due to superior leg stiffness (Dos'Santos *et al.*, 2017).

Correlations with MDSA Metrics

The MDSA method was developed to provide a holistic metric of multidirectional sprinting by integrating linear 30 m sprints, decelerations, and COD at 45°, 90° and 135° angles in both directions into an octagonal area divided into forward, backward, left and right sections (Gordon & Green, 2026). This addresses the limitations of existing approaches that lack a single comprehensive value for assessing multi-directional sprint performance (Barrera-Domínguez *et al.*, 2024). This approach is useful for identifying asymmetries and performance weaknesses, providing coaches with a quantitative tool for talent identification and training optimisation in team sports that require vector-varied movements.

The positive correlations between CMJ and DJ heights with the total MDSA values and directional areas indicate that athletes with superior jump performance generate larger MDSA values, reflecting a greater multidirectional sprint ability. This was consistent with the patterns observed in sprint velocities in this study. Specifically, CMJ concentric mean force exhibited strong positive correlations with MDSA Total and all directional areas, suggesting that a stable force base during propulsion enhances multidirectional sprint capacity, which aligned with previous findings linking mean force to sprint performance in team sports (Comfort *et al.*, 2014; Marques *et al.*, 2011). Similarly, CMJ peak power exhibited robust positive correlations with MDSA Total and all directional areas, indicating that maximal energy output during the propulsive phase significantly contributes to larger sprint areas, which was consistent with previous research on power-driven sprint mechanics (Morin & Samozino, 2016). Additionally, the CMJ vertical velocity at take-off correlated strongly with MDSA Total and directional areas, underscoring its role in converting force into speed across varied vectors, as reported in previous studies of sprint acceleration (Morin *et al.*, 2015). These findings directly support the study's aim, as higher and more powerful jumps, indicative of concentric power, correspond to enhanced sprint abilities across directions, potentially through greater propulsive efficiency in varied vectors (Dos'Santos *et al.*, 2018, 2019; González-García *et al.*, 2024). Furthermore, this mirrors the relationships observed with individual sprint components where concentric displacement capabilities enhanced velocity and acceleration rates. Previous studies found similar links between jump height and COD area metrics, suggesting that concentric qualities facilitate rapid COD and acceleration post deceleration (Dos'Santos *et al.*, 2021b; Harper *et al.*, 2019). This substantiates MDSA's application as a holistic measure that integrates these isolated performance indices into a single, comprehensive value for assessing overall sprinting prowess in university athletes. Additionally, the particularly strong leftward associations were possibly due to dominant limb effects, while DJ metrics, including jump height, peak power and relative peak power, were positively correlated with MDSAs, indicating that fast SSC-derived concentric outputs predicted larger sprint areas, especially backward and leftward, akin to their roles in sprint momentum and drive-off force. Previous studies have reported similar correlations, linking DJ height and power to COD areas through neuromuscular adaptations (Dos'Santos *et al.*, 2018; Harper *et al.*, 2019), and DJ peak drive-off force showed robust positive correlations across MDSAs, underscoring its role in concentric propulsion for multidirectional sprint ability (Marques *et al.*, 2011). Previous research supports this through the alignment of peak forces with sprint mechanical determinants (Morin *et al.*, 2015; Morin & Samozino, 2016). The CMJ RSI-mod positively correlated with all MDSAs, implying

that reactive concentric efficiency enhanced overall multidirectional coverage. This aligned with existing biomechanical models where RSI-mod supports SSC utilisation across directions, paralleling its contributions to sprint velocities and quick force production (Dos'Santos *et al.*, 2018; Healy *et al.*, 2019; McMahon *et al.*, 2017b). Previous investigations have demonstrated the predictive role of RSI-mod in multidirectional speed, attributing it to improved energy transfer when changing direction (Dos'Santos *et al.*, 2018; Wilkinson *et al.*, 2012). In contrast, nonsignificant or negative trends with CMJ contraction time and relative contraction time suggest that prolonged concentric phases hinder MDSA. Specifically, slower force development limits sprint responsiveness, which is consistent with previous research that identified an inverse relationship between contraction time and performance in deceleration-inclusive tasks (Harper *et al.*, 2019). Finally, DJ RSI's positive associations confirmed the contribution of reactive concentric strength to MDSA, which was consistent with studies of RSI in agility contexts (Dos'Santos *et al.*, 2018; McMahon *et al.*, 2017b; Ramirez-Campillo *et al.*, 2023). Subsequently, this validates the CMJ and DJ concentric metrics as surrogates for MDSA and reinforces its applicability as a holistic tool that preserves the performance indices evident in isolated sprints, with minor variances highlighting protocol and population specificities (Dos'Santos *et al.*, 2018; Oleksy *et al.*, 2024; Thomas *et al.*, 2017).

Practical Implications

The findings underscore the value of concentric-focused jump training for enhancing multidirectional sprint performance in university athletes. Coaches and practitioners should prioritise exercises that develop CMJ and DJ metrics, such as jump height, peak power, drive-off force, and RSI, as they correlate positively with higher sprint velocities and larger MDSAs. For example, incorporating plyometric drills emphasising rapid concentric propulsion could improve holistic sprint proficiency across linear, deceleration and COD tasks at 45°, 90° and 135° angles, potentially benefiting team sports, such as hockey and rugby, where these movements are prevalent (Dos'Santos *et al.*, 2018; Morin *et al.*, 2015). Consistent monitoring of the jump parameters may aid in talent identification and individualised programming, particularly targeting athletes with slower contraction times to mitigate associations with poorer MDSA outcomes.

Limitations

This study was subject to several limitations inherent to its correlational design. Primarily, while significant associations were identified between concentric jump metrics from the CMJ and DJ and various sprint performance indicators, including MDSA, the cross-sectional nature precludes establishing causality. It remains unclear whether enhancing concentric outputs directly improves multidirectional sprinting or if superior sprint performers inherently exhibit better jump characteristics. Additionally, the sample size of 28 university-level hockey and rugby players, encompassing both males and females, may limit the generalisability to elite or single-sport populations, with results also potentially influenced by varying training backgrounds and sport-specific demands. The assessments were conducted in controlled, pre-planned conditions without reactive elements, which may not fully replicate the unpredictable decelerations and COD in competitive scenarios (Harper *et al.*, 2019; Dos'Santos *et al.*, 2017).

Future research should address these gaps through longitudinal interventions to examine the effects of targeted concentric strength training on sprint and MDSA outcomes. Larger, more homogeneous samples and the incorporation of reactive tasks could enhance ecological validity. Additionally, exploring kinetic asymmetries or higher drop heights in DJ protocols might provide deeper insights into concentric contributions across diverse angles.

Conclusions

This study investigated the relationships between concentric-dominant jump kinetics and multidirectional sprint performance, specifically through the novel MDSA method. The primary findings indicate that concentric metrics, namely CMJ height, concentric mean force, peak power, and vertical take-off velocity—serve as robust predictors of both Phase 1 and Phase 2 sprint velocity across linear and COD vectors. These associations reinforce the theoretical premise that concentric explosive power is the primary "engine" of displacement in trained athletes, providing the necessary impulse to overcome inertia during initial acceleration and re-acceleration transitions. Conversely, prolonged CMJ contraction times were associated with reduced MDSA segmental areas, suggesting that slower force-development phases hinder an athlete's responsiveness in dynamic, multidirectional environments.

The introduction of the MDSA method provides a proven, credible, and applicable solution that facilitates an evolution in the field of athletic profiling. Traditionally, practitioners have relied on isolated linear sprint or singular COD tests, which often fail to capture the holistic multidirectional ability an athlete utilises during match play. By integrating velocity data from eight equidistant directions into a single area-based metric, the MDSA offers a mathematically rigorous and objective quantification of total sprinting proficiency. This research establishes that a larger MDSA is not merely an outcome of superior technique but a direct reflection of an athlete's underlying concentric power capacity.

Conversely, prolonged CMJ contraction times were associated with reduced MDSA segmental areas, suggesting that slower force-development phases hinder an athlete's responsiveness in dynamic, multidirectional environments. This result demonstrates that the efficiency of the athletic "engine" depends not just on the amount of

force produced, but on how quickly that force is applied. In the high-stakes environment of elite sport, where a game-changing turn or transition is often decided in a fraction of a second, these data prove that a lesser concentric profile directly shrinks an athlete's MDSA regardless of their straight-line speed. This allows practitioners to clearly distinguish between athletes who are merely fast in a linear sense and those who possess the true multidirectional proficiency required for the complex, multi-angled demands of professional competition.

Significance of this work is further implied by the recommendations for future longitudinal and sport-specific research. While this study confirms the hierarchical dominance of concentric power, future investigations should incorporate reactive strength (e.g., DJ RSI) and eccentric braking capacity to further refine the predictive accuracy of the MDSA. Furthermore, transitioning this method into a longitudinal monitoring tool would enable coaches to track the expansion of an athlete's multidirectional envelope throughout a competitive season, providing a sensitive gauge for both performance readiness and injury-related performance decay. Ultimately, this research redefines multidirectional assessment as a cohesive paradigm, bridging the gap between laboratory-based kinetics and the complex realities of field-based performance.

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