

Original article

Eccentric Strength and Countermovement Jump Force-Time Characteristics Predict Short-Distance Acceleration–Deceleration Performance in Elite Female Basketball Players

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Abstract

Basketball performance frequently depends on the ability to rapidly accelerate and decelerate over very short distances. This study examined whether anthropometric characteristics, countermovement jump (CMJ) force–time variables, and eccentric knee flexor strength could predict short-distance acceleration–deceleration performance in elite female basketball players. Forty-five players competing in the Icelandic top division (age: 23.4 ± 3.1 years; height: 177.2 ± 6.3 cm; body mass: 69.5 ± 7.1 kg) completed a testing battery including CMJ assessment on a force platform, eccentric hamstring strength testing using the Nordic hamstring exercise, and a 5-m acceleration–deceleration task measured with timing gates. Multiple linear regression analysis was used to determine the contribution of neuromuscular variables to velocity change performance. Several CMJ-derived force–time variables and eccentric strength metrics were associated with performance in the 5-m task. In particular, braking phase duration, eccentric peak velocity, vertical velocity at take-off, peak take-off acceleration, lower-limb stiffness, and eccentric knee flexor strength variables showed significant relationships with velocity change performance. These findings highlight the importance of both eccentric braking capacity and rapid concentric force production during short-distance acceleration–deceleration actions. Overall, the results suggest that phase-specific neuromuscular characteristics measured during CMJ and eccentric hamstring assessments can provide valuable insight into the mechanical determinants of short-distance velocity changes in basketball. Monitoring braking-related and force–time variables may therefore assist practitioners in identifying key physical qualities relevant to basketball-specific movement performance and in guiding targeted training interventions.

Keywords: neuromuscular performance, braking mechanics, stretch–shortening cycle, velocity change ability, force–time profiling, hamstring function, sport-specific locomotion

Introduction

Basketball performance is frequently determined within the first and last steps of movement, reflecting an athlete's capacity to accelerate into space and decelerate to stop, re-direct, and create separation. Although maximal sprint speed contributes to performance, basketball is characterised by short, explosive efforts initiated from static or low-velocity positions and followed by frequent braking actions during defensive slides, close-outs, cuts, and stop-start patterns. Time-motion analyses demonstrate that most high-intensity locomotor efforts occur over distances shorter than 5–10 m, emphasising the sport-specific relevance of initial acceleration (0–5 m) and rapid deceleration (Lockie et al., 2020; Scanlan et al., 2011).

Accelerations and decelerations therefore represent central components of basketball locomotor demands. Most maximal linear sprints in basketball are of short duration due to the dimensions of the court and the intermittent nature of the game (Lockie et al., 2020; Scanlan et al., 2011). Given that many basketball sprints last only 0.4–2.4 s, rapid changes in velocity play an important role in overall performance (Reina et al., 2019). These actions are often defined as velocity changes exceeding $\pm 2.5 \text{ m}\cdot\text{s}^{-2}$ (Roell et al., 2020). Female basketball match play further demonstrates frequent exposure to high-intensity decelerations, which may occur more often than acceleration actions and represent high-impact movements within game contexts (Roell et al., 2020; Scanlan et al., 2014). Match-analysis research therefore suggests that high-intensity movement quality represents a key physical component of basketball performance (Reina et al., 2019).

From a mechanical perspective, sprint acceleration requires athletes to generate substantial horizontal impulse within brief ground contact times to overcome inertia. Unlike maximal velocity sprinting, which involves greater vertical force production, early acceleration requires favourable horizontal force orientation and rapid force generation from low initial velocities. The ability to produce force within approximately 100–200 ms of ground contact is therefore critical, suggesting that time-specific force expression and impulse may be stronger predictors of short-distance acceleration than maximal force output alone (Wang et al., 2021).

Equally important in basketball is the ability to rapidly reduce velocity. Deceleration requires the absorption of kinetic energy through eccentric muscle actions and the management of large braking impulses within constrained distances. Effective braking performance depends on eccentric force capacity, impact attenuation, and joint moment control under high loading rates. Contemporary frameworks emphasise that braking is a complex neuromechanical task involving rapid force absorption under temporal and tactical constraints (Dos'Santos et al., 2018; Harper et al., 2022). This is particularly relevant to basketball, where deceleration capacity underpins change-of-direction performance across commonly used change of direction tests (Dos'Santos et al., 2019).

Given these demands, practitioners increasingly rely on neuromuscular assessments capable of explaining acceleration–deceleration performance. The countermovement jump (CMJ) is widely implemented because it provides detailed force–time metrics beyond jump height. CMJ-derived variables offer insight into eccentric braking force, concentric impulse, rate of force development, and phase-specific temporal characteristics.

In addition to jump-based measures, the posterior chain—particularly the hamstrings—plays a critical biomechanical role during both propulsion and braking actions. During early acceleration, hip extension torque contributes substantially to forward propulsion, whereas during deceleration the hamstrings act eccentrically to control hip flexion and knee extension moments. Intervention research indicates that eccentric hamstring-focused training can enhance eccentric strength and may positively influence sprint performance (Freeman et al., 2019).

The present study therefore examined whether acceleration–deceleration performance in elite female basketball players could be predicted from anthropometric characteristics, CMJ force–time variables, and eccentric knee flexor strength. We hypothesised that eccentric strength and braking-related force–time characteristics would be strong predictors of short-distance acceleration–deceleration performance.

Methods

Experimental approach to the problem

A cross-sectional design was used to examine whether anthropometric characteristics, CMJ force–time variables, and eccentric knee flexor strength could predict short-distance acceleration–deceleration performance in elite female basketball players. These variables were selected because they represent key neuromuscular capacities involved in rapid force production, braking, and transition between eccentric and concentric muscle actions.

Participants

Forty-five elite female basketball players (age: 23.4 ± 3.1 years; height: 177.2 ± 6.3 cm; body mass: 69.5 ± 7.1 kg) competing in the Icelandic top division volunteered for this study. All participants were injury-free for at least six months prior to testing and engaged in regular basketball and strength training as part of their team programs minimum five times per week. Written informed consent was obtained from all participants. The study protocol was approved by the institutional ethics committee (SHV2023-048) and conducted in accordance with the Declaration of Helsinki.

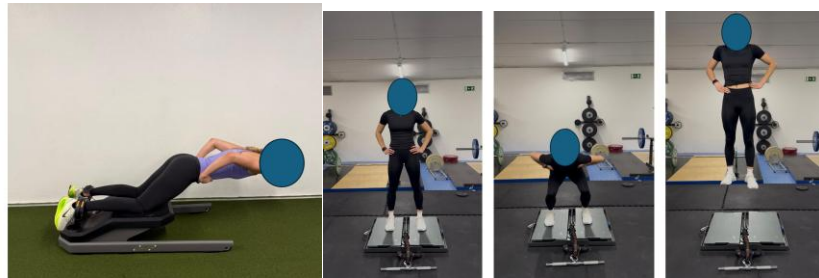
Measurements and Procedures

Countermovement jump performance was assessed using the force platforms (VALD Performance, Brisbane, Australia). Three maximal trials were performed with hands on hips. The average of three trials was used. Extracted variables included jump height (Impulse-momentum, cm), concentric mean force ($\text{N}\cdot\text{kg}^{-1}$), concentric mean velocity ($\text{m}\cdot\text{s}^{-1}$), eccentric mean force ($\text{N}\cdot\text{kg}^{-1}$), eccentric peak velocity ($\text{m}\cdot\text{s}^{-1}$), Reactive Strength Index (RSI)-modified, vertical velocity at take-off ($\text{m}\cdot\text{s}^{-1}$), peak net take-off force ($\text{N}\cdot\text{kg}^{-1}$), lower-limb stiffness ($\text{N}\cdot\text{m}^{-1}$), braking phase duration (ms), concentric phase duration (ms).

Eccentric strength was assessed using the Nordic hamstring curl exercise with a validated dynamometer NordBord (VALD Performance, Brisbane, Australia). Three maximal repetitions were performed. Variables: knee flexion maximal torque maximal torque (N/m), knee flexion average force (N/kg) and knee flexion maximal impulse (Ns) were exported.



Picture 1. Nordic curl.



Picture 2. Countermovement jump

Velocity Change Performance: Acceleration–braking performance was assessed using a 5-m task. Athletes [accelerated](#) maximally and decelerated at 5 m. Timing gates (SmartSpeed Plus, VALD) recorded total time. Three trials were performed; the best trial was taken into further consideration and analysis. The measurement devices and testing protocols used in this study have previously demonstrated good validity and reliability for assessing neuromuscular performance and jump-derived force–time characteristics in athletic populations (Cormack et al., 2008; Merrigan et al., 2024; Anicic et al., 2023).

Statistical analyses

Descriptive statistics (mean \pm SD) were calculated for all variables (Table 1). A multiple linear regression model was used to examine the contribution of anthropometric and neuromuscular variables to velocity change performance. Prior to modelling, normality of residuals was assessed using the Shapiro–Wilk test, multicollinearity was assessed using variance inflation factors (VIF), linearity and homoscedasticity were visually inspected. Model results are presented as, regression coefficients, standard errors, 95% confidence intervals, p-values, model fit indices (R^2 and adjusted R^2). Statistical significance was set at $p < 0.05$. All analyses were conducted using Jamovi (Version 2.3.28).

Results

Table 1. Descriptive data for all variables collected.

Variables	Mean	SD
Body height [cm]	175.5	7.9
Body weight [kg]	72.4	9
Jump height (imp-mom) [cm]	27.4	5.8
Concentric mean force / BW [N/kg]	18.4	1.4
Concentric mean velocity [m/s]	1.3	0.1
Eccentric mean force / BW [N/kg]	9.9	0.5
RSI-modified [m/s]	0.3	0.1
Vertical velocity at take-off [m/s]	2.3	0.2
Eccentric peak velocity [m/s]	-0.9	0.3
CMJ stiffness [N/m]	7254.7	3776.9
Concentric mean power / BM [W/kg]	23.5	3.1
Lower-limb stiffness [N/m]	5087.3	2448.5
Peak take-off acceleration [m/s^2]	13	2.1
Force at zero velocity / BM [N/kg]	20.9	3.2
Braking phase duration [ms]	301.2	104.5
Braking phase duration:concentric duration [%]	111.9	30.1
Concentric impulse-100ms [N s]	80.3	23.4
Knee flexion maximal torque (N/m)	126.2	27.7
Knee flexion average force /BW (N/kg)	3.64	0.56
Knee flexion maximal Impulse (Ns)	3750.5	1727.3

The multiple linear regression model demonstrated an exceptionally strong predictive capacity, accounting for 100% of the variance in 5-m sprint performance ($R = 1.000$, $R^2 = 1.000$). This indicates that the anthropometric and CMJ-derived variables included in the analysis collectively explained all observed differences in early acceleration ability within this sample. A number of variables related to anthropometrics, neuromuscular performance, and force–time characteristics were significant predictors of short-sprint performance (Table 2). Body height was negatively associated with acceleration, suggesting that shorter athletes may adopt more favourable leverage or apply force more effectively during the initial steps. In contrast, higher body mass predicted better performance; however, as only total body mass was assessed, it is not possible to determine whether this reflects greater muscle mass or increased fat mass. Thus, the observed association suggests that greater whole-body mass may contribute to enhanced momentum generation, provided it is accompanied by sufficient force-production capacity. Jump height, take-off velocity, and eccentric peak velocity were among the strongest predictors. These findings highlight the importance of an athlete’s ability to rapidly transition from braking to propulsion and achieve high vertical velocities—qualities that also underpin horizontal acceleration mechanics. Greater lower-limb and CMJ stiffness were

also significant predictors, reinforcing the idea that athletes who can rapidly absorb and redirect forces tend to accelerate more effectively over short distances. Measures such as peak take-off acceleration, force at zero velocity, and maximal torque all contributed significantly. These variables reflect the athlete’s capacity to generate high force from low starting velocities—highly relevant to the first steps of a sprint when the athlete begins from near-zero speed. Both braking phase duration and the braking-to-concentric duration ratio were significant predictors of acceleration/deceleration time. Athletes who utilised shorter braking phases or demonstrated efficient braking-to-propulsion transitions tended to exhibit faster acceleration. This suggests that coordination of eccentric–concentric timing, rather than raw force output alone, plays a key role in early sprint performance and that early sprint performance depends not only on force production, but also on how well athletes coordinate the timing between eccentric and concentric actions.

Table 2. Model Coefficients for velocity change (0-5 meters).

Variable	Estimate	SE	95% CI		t	p
			Lower	Upper		
Intercept	-7.62	0.50	-13.98	-1.25	-15.21	0.042
Body height [cm]	-0.01	0.0005	-0.01	-0.004	-21.06	0.030
Body weight [kg]	0.02	0.01	0.012	0.042	22.89	0.028
Jump height (imp-mom) [cm]	-0.32	0.01	-0.43	-0.21	-39.00	0.016
Concentric mean force / BW [N/kg]	0.20	0.028	-0.162	0.569	7.054	0.090
Concentric mean velocity [m/s]	-1.83	0.228	-4.736	1.070	-8.022	0.079
Eccentric mean force / BW [N/kg]	-0.105	0.001	-0.219	0.003	-12.303	0.052
RSI-modified [m/s]	0.088	0.10	-1.274	1.452	0.827	0.560
Vertical velocity at take-off [m/s]	8.302	0.146	6.444	10.161	56.755	0.011
Eccentric peak velocity [m/s]	1.760	0.033	1.334	2.187	52.461	0.012
CMJ stiffness [N/m]	0.003	0.001	0.001	0.002	-49.274	0.013
Concentric mean power / BM [W/kg]	-0.012	0.020	-0.276	0.251	-0.618	0.648
Lower-limb stiffness [N/m]	0.0004	0.001	0.001	0.002	32.453	0.020
Peak take-off acceleration [m/s ²]	0.068	0.001	0.044	0.092	36.180	0.018
Force at zero velocity / BM [N/kg]	0.085	0.01	0.009	0.161	14.190	0.045
Braking phase duration [ms]	0.003	0.0001	0.001	0.006	25.379	0.025
Braking phase duration:concentric duration [%]	-0.016	0.0005	-0.023	-0.009	-29.395	0.022
Concentric impulse-100ms [Ns]	-0.013	0.001	-0.026	0.0003	-12.744	0.050
Knee flexion maximal torque [Nm]	0.003	0.0002	0.0008	0.005	16.946	0.038
Knee flexion average force /BW [N/kg]	-0.110	0.001	-0.217	-0.003	-13.066	0.049
Knee flexion maximal impulse [Ns]	0.0004	0.0001	0.0001	0.0002	-31.057	0.020

Note. Estimate = regression coefficient; SE = standard error; Lower and Upper = lower and upper bounds of the 95% confidence interval; t = t-statistic; p = significance level.

Several commonly evaluated CMJ metrics—including concentric mean force, concentric mean velocity, RSI-modified, and mean power—did not significantly predict 5-m sprint times. This provides evidence that averaged force–velocity measures may not adequately capture the time-critical neuromuscular demands of early sprint acceleration.

Discussion

The purpose of this study was to identify neuromuscular determinants of short-distance acceleration–deceleration performance in elite female basketball players. The regression model demonstrated strong relationships between neuromuscular characteristics derived from countermovement jump force–time variables, knee flexion and early sprint performance, highlighting the mechanical qualities that may underpin rapid acceleration and braking ability in basketball-specific movements.

A key finding of the present study was the importance of eccentric-related variables, including braking phase duration and eccentric peak velocity. These findings support previous research highlighting deceleration as one of the most mechanically demanding actions in multidirectional sports (Dos’Santos et al., 2018; Harper et al., 2022). During rapid deceleration, athletes must tolerate and dissipate high ground reaction forces while maintaining postural control and preparing for subsequent movement actions. Efficient eccentric force absorption may therefore reduce braking time and enable faster transition into re-acceleration. In basketball, this capability is particularly important because players frequently perform abrupt stops, defensive slides, cuts, and close-out movements that require rapid deceleration followed by immediate re-acceleration (Puente et al., 2017). From a mechanical perspective, the ability to rapidly generate eccentric force may allow athletes to control centre-of-mass momentum more effectively, improving both movement efficiency and stability during high-intensity game situations. In addition to eccentric braking characteristics, explosive concentric variables such as vertical velocity at take-off and peak take-off acceleration also contributed to the explained variance in sprint performance. These findings are consistent with existing literature linking rapid force production capabilities with acceleration ability during the initial phase of sprinting (Nimphius et al., 2010; Young et al., 2002). Early sprint acceleration requires athletes to generate large propulsive forces in a short time window, and countermovement jump variables reflecting concentric power production may capture an athlete’s ability to produce these rapid force impulses. Higher vertical take-off velocity and greater take-off acceleration may therefore reflect an enhanced ability to rapidly apply force against the ground, which may translate to improved horizontal acceleration during the first steps of sprinting. Lower-limb stiffness also emerged as a contributor to performance in the present model. This finding aligns with previous research suggesting that optimal musculotendinous stiffness enhances stretch–shortening cycle efficiency and improves force transmission during explosive movements (Brughelli & Cronin, 2008). Greater lower-limb stiffness may facilitate more effective storage and reutilisation of elastic energy during the eccentric–concentric transition, allowing athletes to maintain higher force outputs during rapid movement tasks. In the context of basketball, where players repeatedly transition between braking and propulsion phases, appropriate levels of stiffness may contribute to both efficient force transfer and movement economy during short explosive actions. The combined contribution of eccentric braking capacity, concentric force production, and lower-limb stiffness highlights the multidimensional neuromuscular demands associated with short-distance acceleration–deceleration performance. Rather than relying on a single mechanical quality, successful performance likely depends on the interaction between the ability to absorb force rapidly, stabilise the body during braking, and generate propulsive force during the subsequent acceleration phase. This integrated neuromuscular profile reflects the complex mechanical requirements of basketball locomotion, which frequently involves rapid transitions between acceleration, deceleration, and changes of direction over short distances.

Previous research has shown that the ability to accelerate and decelerate efficiently is strongly associated with both concentric and eccentric force-generating capacities, particularly during the braking and propulsive phases of movement (Harper et al., 2020; Dos’Santos et al., 2018). In basketball players, countermovement jump (CMJ) force–time characteristics such as braking impulse, concentric impulse, eccentric peak force, and reactive strength have demonstrated meaningful relationships with sprinting, change-of-direction ability, and overall performance (McMahon et al., 2018; Bishop et al., 2021). Similarly, eccentric knee flexor strength

has been linked to sprint acceleration capacity and braking efficiency, emphasising the importance of posterior chain strength in short-distance explosive actions (Bourne et al., 2017; Wang et al., 2023). Interestingly, previous research from our group showed that total Y-agility test time was not significantly associated with traditional strength and power measures, suggesting that full-test performance is influenced by additional perceptual and decision-making demands. However, when the analysis focused specifically on the initial 5-meter acceleration–deceleration phase, clear relationships emerged with strength-related variables. CMJ force–time characteristics, particularly eccentric braking variables, stiffness, concentric impulse, and take-off mechanics, together with eccentric knee flexor strength, showed strong predictive value for this short segment. This suggests that while total agility time reflects both physical and cognitive demands, the first 5 meters are more strongly determined by neuromuscular strength qualities, highlighting the importance of split-time analysis over total test duration alone.

Although the regression model explained a large proportion of the variance in performance, these findings should be interpreted with caution. Models containing multiple correlated neuromuscular variables may be susceptible to overfitting when applied to relatively small sample sizes, potentially inflating the apparent predictive capacity of the model. Therefore, the present findings should primarily be interpreted as identifying key mechanical contributors to short-distance acceleration–deceleration performance rather than representing a universally generalisable predictive model. Future research should aim to replicate these findings in larger samples and across different competitive levels to further clarify the relative importance of specific neuromuscular variables.

Practical Application

From a practical perspective, the present results suggest that training interventions targeting eccentric braking strength, rapid force production, and optimal lower-limb stiffness may be particularly beneficial for improving short-distance acceleration–deceleration performance in basketball players. Our findings indicate that early acceleration–deceleration performance depends not only on maximal strength or average power capacity but also on the timing and coordination of force application. Strength and conditioning programmes may therefore benefit from incorporating eccentric-focused strength exercises, plyometric training, and drills that emphasise rapid braking and re-acceleration. Monitoring CMJ force–time characteristics and knee flexor eccentric strength may also provide practitioners with useful insight into the neuromuscular qualities underpinning these movement capacities.

Conflict of interests: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

- Aničić, Z., et al. (2023). Assessment of countermovement jump metrics: Reliability of force–time variables. *Sports Biomechanics*. <https://doi.org/10.3390/life13010190>
- Ben Abdelkrim, N., El Fazaa, S., & El Ati, J. (2010). Time–motion analysis and physiological data of elite under-19-year-old basketball players during competition. *British Journal of Sports Medicine*, 44(2), 165–170. <https://doi.org/10.1136/bjism.2008.048033>
- Bishop, C., Read, P., Chavda, S., & Turner, A. (2021). Inter-limb asymmetries: Understanding how to calculate differences from bilateral and unilateral tests. *Strength and Conditioning Journal*, 43(4), 1–14. <https://doi.org/10.1519/SSC.0000000000000371>
- Bourne, M. N., Opar, D. A., Williams, M. D., Shield, A. J., & Timmins, R. G. (2017). Eccentric knee flexor strength and risk of hamstring injuries in rugby union: A prospective study. *The American Journal of Sports Medicine*, 43(11), 2663–2670. <https://doi.org/10.1177/0363546515599633>
- Brughelli, M., & Cronin, J. (2008). A review of research on the mechanical stiffness in running and jumping: Methodology and implications. *Scandinavian Journal of Medicine & Science in Sports*, 18(4), 417–426. <https://doi.org/10.1111/j.1600-0838.2008.00769.x>
- Cormack, S. J., Newton, R. U., McGuigan, M. R., & Doyle, T. L. (2008). Reliability of measures obtained during single and repeated countermovement jumps in an elite athlete population. *Journal of Strength and Conditioning Research*, 22(1), 178–186. <http://doi.org/10.1123/ijsspp.3.2.131>

- Dos'Santos, T., McBurnie, A., Thomas, C., Comfort, P., & Jones, P. A. (2019). Biomechanical determinants of the modified and traditional 505 change of direction speed test performance. *Journal of Strength and Conditioning Research*, 33(3), 674–684. <https://doi.org/10.1519/JSC.0000000000002479>
- Dos'Santos, T., Thomas, C., Jones, P. A., & Comfort, P. (2018). Mechanical determinants of faster change of direction speed performance in male athletes. *Sports Medicine*, 48(9), 2006–2024. <https://doi.org/10.1007/s40279-018-0964-9>
- Dos'Santos, T., Thomas, C., Jones, P. A., & Comfort, P. (2018). Assessing deceleration ability in sport: A theoretical framework for testing and training strength and conditioning practitioners. *Strength and Conditioning Journal*, 40(4), 36–47. <https://doi.org/10.1007/s40279-025-02339-7>
- Drinkwater, E. J., Pyne, D. B., & McKenna, M. J. (2008). Design and interpretation of anthropometric and fitness testing of basketball players. *Sports Medicine*, 38(7), 565–578. <https://doi.org/10.2165/00007256-200838070-00004>
- Freeman, B. W., Young, W., Talpey, S., Smyth, A., Pane, C. L., & Wundersitz, D. (2019). The Nordic hamstring exercise increases eccentric hamstring strength and sprint performance in young athletes. *Journal of Strength and Conditioning Research*, 33(10), 2662–2669. <https://doi.org/10.1519/JSC.0000000000002547>
- Harper, D. J., Hobbs, S. J., Moore, J. L., Reeve, M. W., & Hewitt, J. (2022). Eccentric force–velocity characteristics in professional team-sport athletes. *International Journal of Sports Physiology and Performance*, 17(1), 40–50. <https://doi.org/10.1123/ijspp.2021-0200>
- Harper, D. J., Carling, C., & Kiely, J. (2020). High-intensity acceleration and deceleration demands in elite team sports competitive match play: A systematic review and meta-analysis of observational studies. *Sports Medicine*, 50(10), 1923–1947. <https://doi.org/10.1007/s40279-019-01170-1>
- Lockie, R. G., Schultz, A. B., Callaghan, S. J., & Jeffriess, M. D. (2014). The relationship between bilateral differences of knee flexor and extensor isokinetic strength and multidirectional speed. *Journal of Sports Sciences*, 32(6), 518–526. <https://doi.org/10.1080/02640414.2013.841270>
- Lockie, R. G., Beljic, A., Duchenev, S. C., Kammerer, J. D., & Dawes, J. J. (2020). Relationships between linear speed and lower-body power in team-sport athletes. *International Journal of Exercise Science*, 13(4), 583–596. <https://doi.org/10.3390/sports6020030>
- McMahon, J. J., Rej, S. J. E., Comfort, P., & Lake, J. P. (2018). Countermovement jump phase characteristics of senior and academy rugby league players. *Journal of Strength and Conditioning Research*, 32(3), 645–650. <https://doi.org/10.1123/ijspp.2016-0467>
- Merrigan, J. J., Strang, A., Eckerle, J., Mackowski, N., Hierholzer, K., Ray, N. T., Smith, R., Hagen, J. A., & Briggs, R. A. (2024). Countermovement jump force–time curve analyses: Reliability and comparability across force plate systems. *Journal of Strength and Conditioning Research*, 38(1), 30–37. <https://doi.org/10.1519/JSC.0000000000004586>
- Nimphius, S., McGuigan, M. R., & Newton, R. U. (2010). Relationship between strength, power, speed, and change of direction performance. *Journal of Strength and Conditioning Research*, 24(4), 885–895. <https://doi.org/10.1519/JSC.0b013e3181d4d41d>
- Oliver, J. L., & Meyers, R. W. (2009). Reliability and generality of measures of acceleration, planned agility, and reactive agility. *International Journal of Sports Physiology and Performance*, 4(3), 345–354. <https://doi.org/10.1123/ijspp.4.3.345>
- Puente, C., Abián, J., Salinero, J. J., & Del Coso, J. (2017). The physical and physiological demands of basketball refereeing during competition. *International Journal of Sports Physiology and Performance*, 12(8), 1103–1111. <https://doi.org/10.1123/ijspp.2016-0393>
- Reina, M., Mancha-Triguero, D., García-Santos, D., García-Rubio, J., & Ibáñez, S. J. (2019). Physical demands of U16, U18 and senior female basketball players during competitive games. *Sports*, 7(4), 46. <https://doi.org/10.3390/sports7040046>
- Roell, M., Roecker, K., Gehring, D., & Gollhofer, A. (2020). Player monitoring in team sports: Validity and reliability of wearable GPS systems. *Sports*, 8(2), 23. <https://doi.org/10.3390/sports8020023>
- Scanlan, A. T., Dascombe, B. J., & Reaburn, P. R. J. (2011). A comparison of the activity demands of elite and sub-elite Australian men's basketball competition. *Journal of Sports Sciences*, 29(11), 1153–1160. <https://doi.org/10.1080/02640414.2011.582509>
- Scanlan, A. T., Dascombe, B. J., Reaburn, P. R. J., & Dalbo, V. J. (2014). The physiological and activity demands experienced by Australian female basketball players during competition. *Journal of Science and Medicine in Sport*, 17(6), 543–548. <https://doi.org/10.1016/j.jsams.2013.08.001>
- Sheppard, J. M., & Young, W. B. (2006). Agility literature review: Classifications, training and testing. *Journal of Sports Sciences*, 24(9), 919–932. <https://doi.org/10.1080/02640410500457109>
- Spiteri, T., Hart, N. H., & Nimphius, S. (2015). Offensive and defensive change-of-direction ability in female basketball athletes. *Journal of Sports Sciences*, 32(3), 302–314. <https://doi.org/10.1080/02640414.2013.825730>
- Young, W., McDowell, M., & Scarlett, B. (2002). Specificity of sprint and agility training methods. *Journal of Strength and Conditioning Research*, 15(3), 315–319.
- Wang, R., Hoffman, J. R., Tanigawa, S., Miramonti, A. A., La Monica, M. B., Beyer, K. S., Church, D. D., Fukuda, D. H., & Stout, J. R. (2023). Relationship between eccentric hamstring strength and sprint performance in collegiate athletes. *Journal of Strength and Conditioning Research*, 37(2), 412–419. <https://doi.org/10.5336/sportsci.2023-97965>