

Coaching Insights into Pickup Acceleration

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ABSTRACT

In team sports, sprint acceleration from a moving start, or, in coaching terminology, “pickup acceleration”—is a critical, yet different, skill that occurs more frequently than acceleration from a static start. Despite its importance, pickup acceleration remains underexplored compared to traditional sprint mechanics, which primarily focus on stationary starts. Given the paucity of research, a practice-based evidence approach was employed in this study, gathering insights from expert coaches (N = 13, coaching collegiate, professional, Olympic, or elite high school athletes) to identify the essential physical and technical attributes for enhancing pickup acceleration performance. The surveyed coaches identified lower body force and power production (54%), lower body elasticity and stiffness (38%), hip and ankle range of motion (15%), coordination (38%), and core rotational strength and stability (31%) as essential physical qualities for pickup acceleration proficiency. From a technical perspective, the change in center of mass height (31%) and center of mass angle (46%), anterior touchdown distance, and shin angle (23%), hip separation angle (23%), and optimization of step kinematics (step length and step frequency; 31%) were thought crucial to maximizing acceleration and efficiency. Additionally, distinctions were noted between acceleration from walking versus jogging starts, with each entry type requiring specific adjustments in force application and body alignment. Understanding the determinants and how to assess pickup acceleration can help delineate between track speed and sports speed, enabling coaches to tailor pickup acceleration training for improved performance in terms of sport specificity.

Keywords: Sprinting, Running, Speed, Training, Velocity

INTRODUCTION

In team sports such as soccer, rugby, and football, sprint acceleration is a critical athletic skill for success (Haugen et al., 2014). While much focus has been placed on static-start acceleration, many accelerations begin as a “pickup,” where athletes accelerate maximally from submaximal speeds like walking or jogging (Wdowski & Gittoes, 2020). These pickup accelerations are often reactive to scoring opportunities or tactical needs (Taylor et al., 2017), and typically outnumber static-start sprints in sports. For example, 32–66% of sprints in rugby union and the Premier League soccer (Lacome et al., 2014) begin from non-static positions. Thus, an athlete’s ability to accelerate in these conditions, rather than static starts alone, is a key determinant of sport-specific sprint performance. However, this aspect is often neglected in field-testing protocols, which primarily emphasize static-start accelerations (Cross et al., 2017). A typical pickup acceleration begins with a fluid transition from a walking or jogging entry, during which the athlete lowers their center of mass, increases stride frequency, and forcefully applies horizontal force to build momentum (see Figure 1). Based on their input, a test battery incorporating physical and technical measures is proposed, providing a foundation for practitioners to assess and train this motor quality. Given the limited empirical research on pickup acceleration, surveying experienced sprint coaches provided an opportunity to capture applied insights and theoretical perspectives that may inform practice and shape future experimental research.

Pickup acceleration remains underexplored compared to static start sprints, despite research showing that they involve distinct motor abilities (Pryer et al., 2025). Most studies (Segers et al., 2014; Segers, Lenoir, et al., 2007; Segers et al., 2013) have focused on steady gait transitions (e.g., walk-to-run), with limited exploration of faster entries

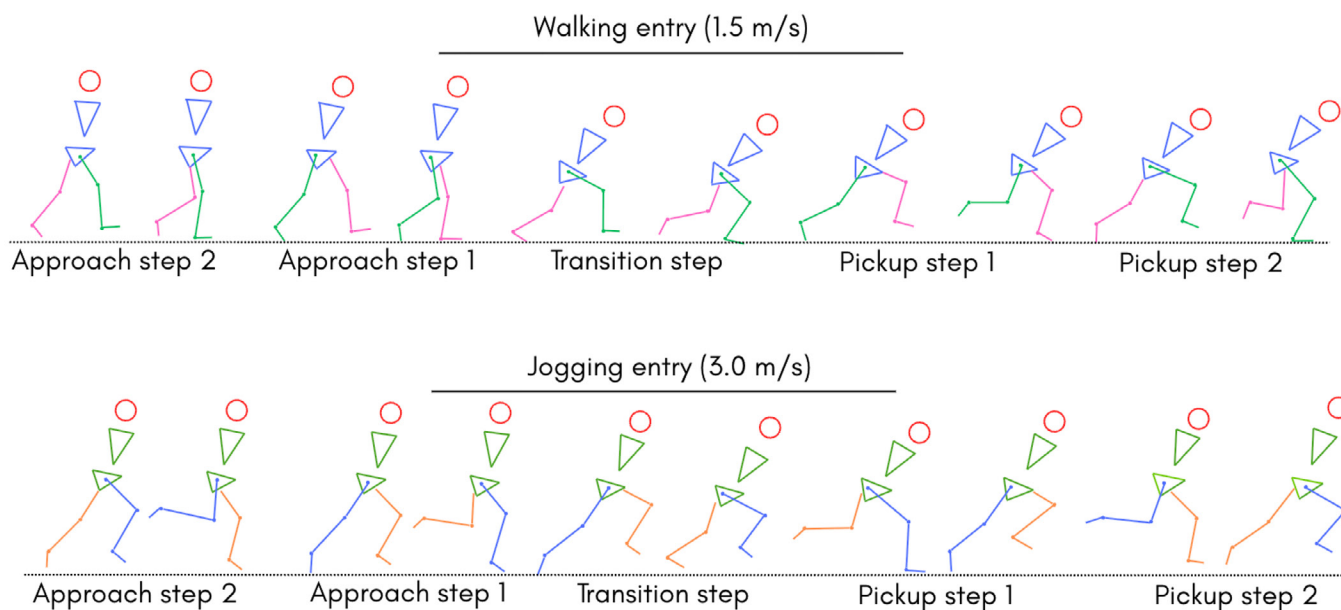


Figure 1. Diagrammatic representation of the pickup acceleration sequence for a walking entry (top) and a jogging entry (bottom).

(Breddy, 2018; Jakeman et al., 2023; Kugler & Janshen, 2010) common in sports (Segers, Aerts, et al., 2007; Segers et al., 2008). To address this gap, this article uses a practice-based evidence approach by collecting insights from expert sports performance coaches on the physical and technical demands of pickup acceleration through an expert opinion questionnaire, a method previously applied in related research. This approach was chosen to gather feedback and theory from elite practitioners based on their extensive experience coaching sprint acceleration techniques.

METHODS

Participants

The participants in this study (N=13) included practitioners working in professional or collegiate sports, as well as private sector coaches with a minimum of 10 years (mean 22.7 ± 9.6 years) of experience coaching. All coaches worked with professional athletes (N = 7), Olympic/international-level athletes (N = 9), collegiate athletes (N = 4), or elite youth athletes (N = 2), and five held a PhD.

Data Collection

Coaches were invited to complete a simple online three-question form to survey their understanding of coaching pickup acceleration. The questions asked were: 1) What physical (strength/range of motion/neural) qualities do you train/or think should be trained, to improve pickup acceleration in your athletes, and does this differ between a walking entry

vs. a jogging entry? 2) What technical considerations do you train/or think should be trained to improve pickup acceleration in your athletes, and does this differ between a walking entry vs a jogging entry? 3) Do you have any other thoughts on the training of pickup acceleration? These questions were chosen as the focal point to help refine the scope of upcoming research on pickup acceleration. Once responses were returned, a thematic analysis was performed wherein all answers were anonymized and collated into similar themes. This information was then synthesized and used to populate the subsections on the physical and technical qualities that were thought to be important for pickup acceleration. Ethical approval was granted through the university's ethics committee, approval number 25/23.

RESULTS

Physical Qualities Perceived As Important For Pickup Acceleration

Lower Body Force and Power

Lower body force and power relative to body mass were thought to influence pickup acceleration performance by 54% of the coaches (see Figure 2). Progressive unilateral force development was thought to allow the monitoring of limb-to-limb differences while building appropriate force production capabilities. Four coaches emphasized the importance of maximal force production, with two suggesting that unilateral patterns (e.g., split stance or lunge) should be prioritized (Krzysztofik

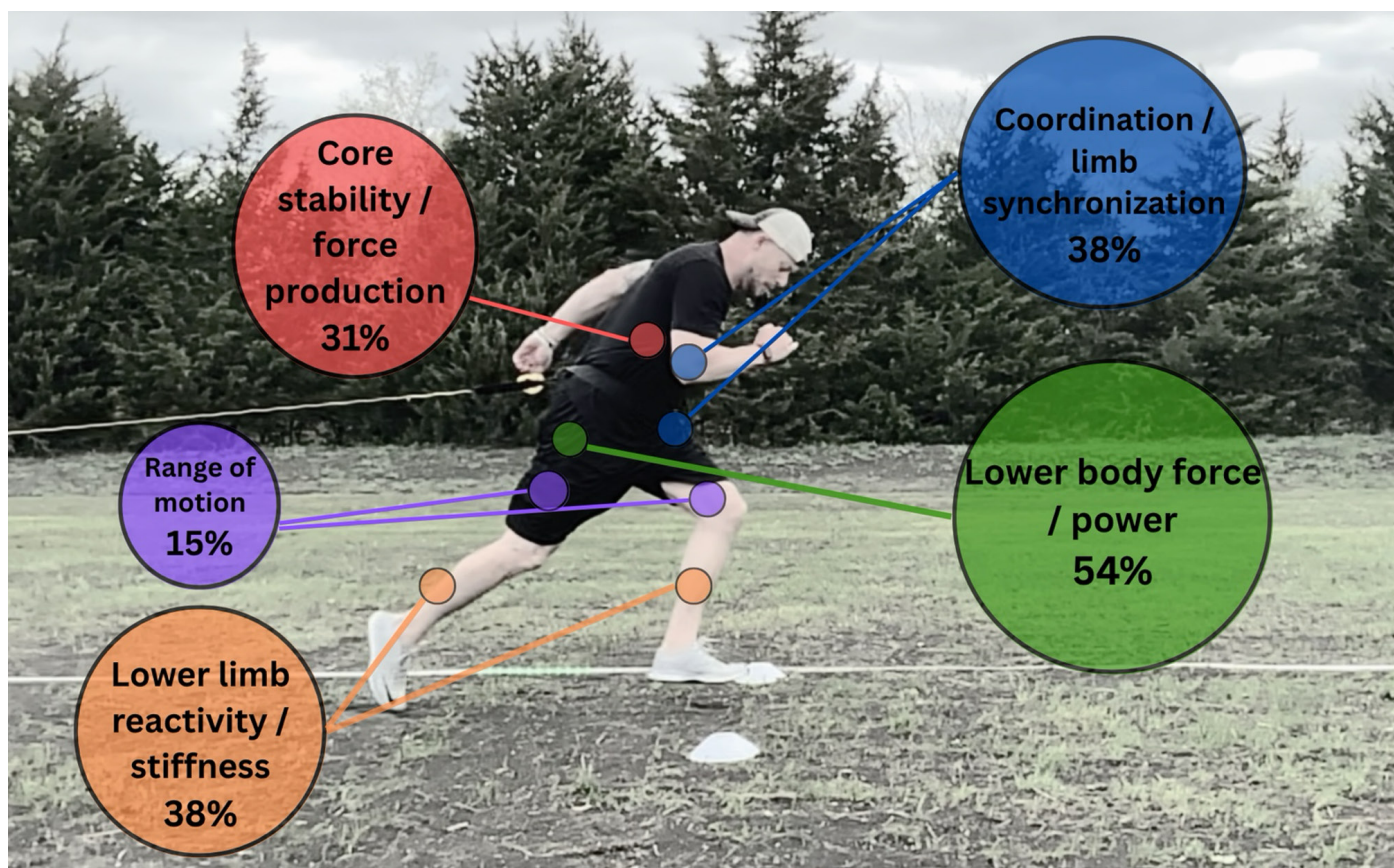


Figure 2. Physical qualities extracted from elite coach survey responses, and percentage of responses supporting each quality.

et al., 2022). One coach noted that high-amplitude force generation should be prioritized through unilateral exercises, such as high box step-ups and band-resisted reverse split squats, which increase posterior chain engagement and load demands by enhancing leverage mechanisms (e.g., positive shin angles).

Regarding force-velocity or power characteristics, 23% of coaches expressed ideas surrounding dynamic strength properties and their relationship to the chosen entry velocity. Specifically, it was noted that plyometrics, such as countermovement or horizontal-to-vertical jumps, would be well-suited for implementation into daily programming. Two coaches believed that the entry velocity would determine the area of the plyometric spectrum that should be targeted, with a walking entry focused more on slow single-leg squats (slow stretch shorten cycle (SSC)) (>250 ms) exercises and a jogging entry more focused on more dynamic or fast SSC (<250 ms) movements.

Of the coaches surveyed, 38% relayed the importance of hip flexor rate of force development (RFD). It was thought that pickup acceleration proficiency hinged on increasing leg speed through powerful hip flexion and extension. Additionally,

increased leg speed could be predicated on training the legs to switch as rapidly as possible using appropriate ranges of motion. One coach suggested that to improve hip flexion strength and RFD, athletes should train in a standing position that mimics the instant of toe-off, driving the knee forward through coordinated hip and knee flexion.

Lower Limb Reactivity/Stiffness

Elasticity around the hip and knee, as well as ankle stiffness, was thought critical for pickup acceleration by 38% of coaches. Specifically, a sudden drop in center of mass (CoM) height during the transition step may trigger a quadriceps stretch reflex and a stiffer SSC. At the ankle, it was thought that joint stiffness, indicated by a reduced dorsiflexion range of motion (ROM) upon ground contact, would propagate higher levels of propulsive force by increasing eccentric ankle joint power (especially at the soleus), which shortens ground contact time (GCT). Two coaches echoed these sentiments, emphasizing that optimal pickup acceleration depends primarily on how aggressively athletes attack the ground with their foot and ankle while maintaining proper leg stiffness. Secondly, the coaches expressed that pickup acceleration would likely rely on elastic qualities during a jogging entry

and could be improved through training. Similarly, two coaches said that speed-strength and elastic capabilities would more likely influence the faster entry velocities. Furthermore, the coaches also determined that these elastic and stiffness qualities could be manipulated through isometric training and fast SSC actions like pogo jumps (Moran et al., 2023).

Core Stability and Force Production

Force production at the core was reported as vital for pickup performance by 31% of coaches, who emphasized that greater core strength and control facilitate efficient force transfer, contributing to faster acceleration. One of the coaches suggested that core stability was imperative, especially at the instant of neuromuscular activation of the leg musculature, and that delayed or inefficient core engagement led to hindered force output and/or suboptimal force transfer directionality.

A second subtheme that emerged from the coaches' responses was related to sprint-specific core stability and its relevance for pickup acceleration. The transition between walking/jogging to sprinting gait was thought to require specific core stability. Two coaches suggested that strength in the posterior chain could drive torso stability and pelvic and lumbar control. Furthermore, they posited that this stability is likely crucial for managing trunk anti-rotation and theoretically could be improved by using breathing and bracing techniques (Sandrey & Mitzel, 2013).

Lastly, it was suggested that the core training should be logically planned out and progressions implemented in a coordinated manner. It was thought that integrated rather than isolated core exercises should be focused on, with stances progressing from standing to single-leg balance, emphasizing postural alignment. As athletes' skill levels advance, one coach suggested that these core exercises should incorporate increasing horizontal velocity, challenging them to maintain alignment from head to toe, engaging the abdominal muscles, and limiting upper body rotation.

Range of Motion

Hip ROM was highlighted as an essential physical quality for pickup acceleration performance by 15% of the coaches. It was proposed that the active range of motion (AROM) would be more critical in a jogging entry compared to a walking

entry, and these speed-dependent ranges would highlight movement-specific demands that could be improved upon. Finally, hip maximal flexion increases with velocity, resulting in longer step lengths (Novacheck, 1998) was also emphasised. Therefore, it can be inferred that limited hip mobility would lead to shorter step lengths and lower sprint velocities (Kessler, 2020).

Coordination and Limb Synchronization

The final physical theme thought necessary for optimizing pickup acceleration was coordination and limb synchronization, with 38% of coaches highlighting this quality. It was speculated that movement awareness would be significant, with a technical understanding of the movement being more important than the physiological qualities. The coordination pattern involved in synchronizing the drop in CoM height with the changeover in limb mechanics was included and equally important. This includes coordinating momentum and the perceptual timing of switching limbs in space with the intended acceleration.

The second subtheme identified by coaches was on movement efficiency and force generation. It was hypothesized that arm action could affect how the athlete coordinated their movement into the transition. One coach stated arm swing synchronization likely positively impacted force generation and movement efficiency, with elbow flexion increasing with the rise in CoM velocity. An increase in elbow flexion and glenohumeral movement velocity was thought to counterbalance the rotation of the torso and assist in proximal to distal force production (Macadam et al., 2018).

Technical Qualities Perceived As Important For Pickup Acceleration

Center of Mass Angle

The first overarching technical theme (see Figure 2) discussed by coaches was how athletes managed their CoM on the transition between gait patterns. Forty-six percent of the coaches emphasized that effectively managing this angle was critical for better pickup acceleration. First, it was thought that an athlete's body orientation directly influenced the direction of force application and that anterior-posterior shoulder-to-hip alignment played a critical role in optimizing pickup acceleration capability. One of the primary differences identified between a walking and jogging entry was that a walking

entry had a more vertical trunk angle than a jogging entry. For both entries, however, one of the primary requirements was the ability to shift the CoM in front of the base of support on the transition step. The degree of forward lean on the transition will likely differ between entries, with more forward lean needed when moving from a walk to a sprint. It was maintained that correct movement strategies would involve a forward lean of the entire body. Conversely, as one coach stated, moving the CoM forward through bending at the waist or excessive trunk collapse would seemingly be detrimental to performance.

Center of Mass Height

Of the coaches surveyed, 31% highlighted that effectively managing CoM height was a key technical quality for efficient pickup acceleration. It was generally believed that lowering the CoM height during the transition phase resulted from reconfiguring the stance leg on ground contact. The CoM height adjustment enables athletes to achieve greater horizontal projection, with knee and hip flexion angles potentially distinguishing different performance levels. It was theorized that acceleration from a walking entry would have positions similar to a 3 or 4-point stance, with the difference being a rapid downward CoM height change on the transition step. This level change would orient the trunk for propulsion by encompassing a forward lean and high heel lift. Maintaining the CoM in front of ground contact would increase the athletes' ability to generate horizontal force and push themselves forward into the subsequent accelerative steps. On a jogging entry, it was speculated that the faster velocity leading into the acceleration would limit the amount of CoM drop, suggesting that switching limbs efficiently to account for changes in CoM height became even more crucial.

Thigh Separation Angle

The thigh separation angle and swing leg mechanics were reported as essential for effective pickup acceleration performance by 23% of the coaches surveyed. Thigh separation is defined as the angular difference between the contralateral flexed and extended hips in the sagittal plane, measuring the relative position of the hips as one thigh moves into flexion and the other into extension (see Figure 3). From a static start, researchers have determined that combined thigh separation and take-off angles accounted for almost 90% of the explained variance

($R^2 = 0.89$) in acceleration performance on the first step (Walker et al., 2021).

Based on the coaches' feedback, it was expected that larger thigh separation angles would likely result in faster hip angular acceleration values through flexion, combined with 'paw back' mechanics during hip extension, resulting in higher levels of force production. It was assumed that a rapid exchange of the limbs was key; however, executing this effectively while in motion likely requires adjustments to step patterning. During a walking entry, it was identified that these mechanics could be disrupted by excessive knee flexion with hip extension as the leg moves behind the body (i.e., backside mechanics) during the early swing phase. Excessive knee flexion was believed to decrease the hip separation angle past optimal ranges and negatively influence flight time. This likely comes at the cost of proper timing throughout the swing as the leg moves in front of the body (i.e., front-side mechanics), ultimately reducing force production and decreasing flight time. Thus, it was presumed that during the early stages of acceleration from a walking start, recovery mechanics where the heel crosses between the knee and ankle of the stance leg would be advisable to limit excessive backside mechanics.

Anterior Touchdown Distance and Shin Angle Characteristics

Twenty-three percent of coaches thought the anterior touchdown distance and proper shin angles were critical, particularly from the transition step onward. Fifteen percent of coaches suggested that an optimal anterior touchdown distance (distance between the foot in contact with the ground and the vertical line of the CoM) was crucial for adequate pickup acceleration. It was further discussed that the foot striking down and back would give rise to a forwardly inclined shin angle (i.e., a negative shin angle), which orients the ground reaction forces more horizontally. The negative shin angle over the first few steps was hypothesized by the coaches surveyed to facilitate more horizontal hip projection while decreasing braking forces throughout the stance phase (Alt et al., 2022).

Step Length and Step Frequency Interaction

It was emphasized that the interaction between stride length (SL) and step frequency (SF) was proposed as significant by 31% of coaches. Specifically, it was theorized that higher speeds

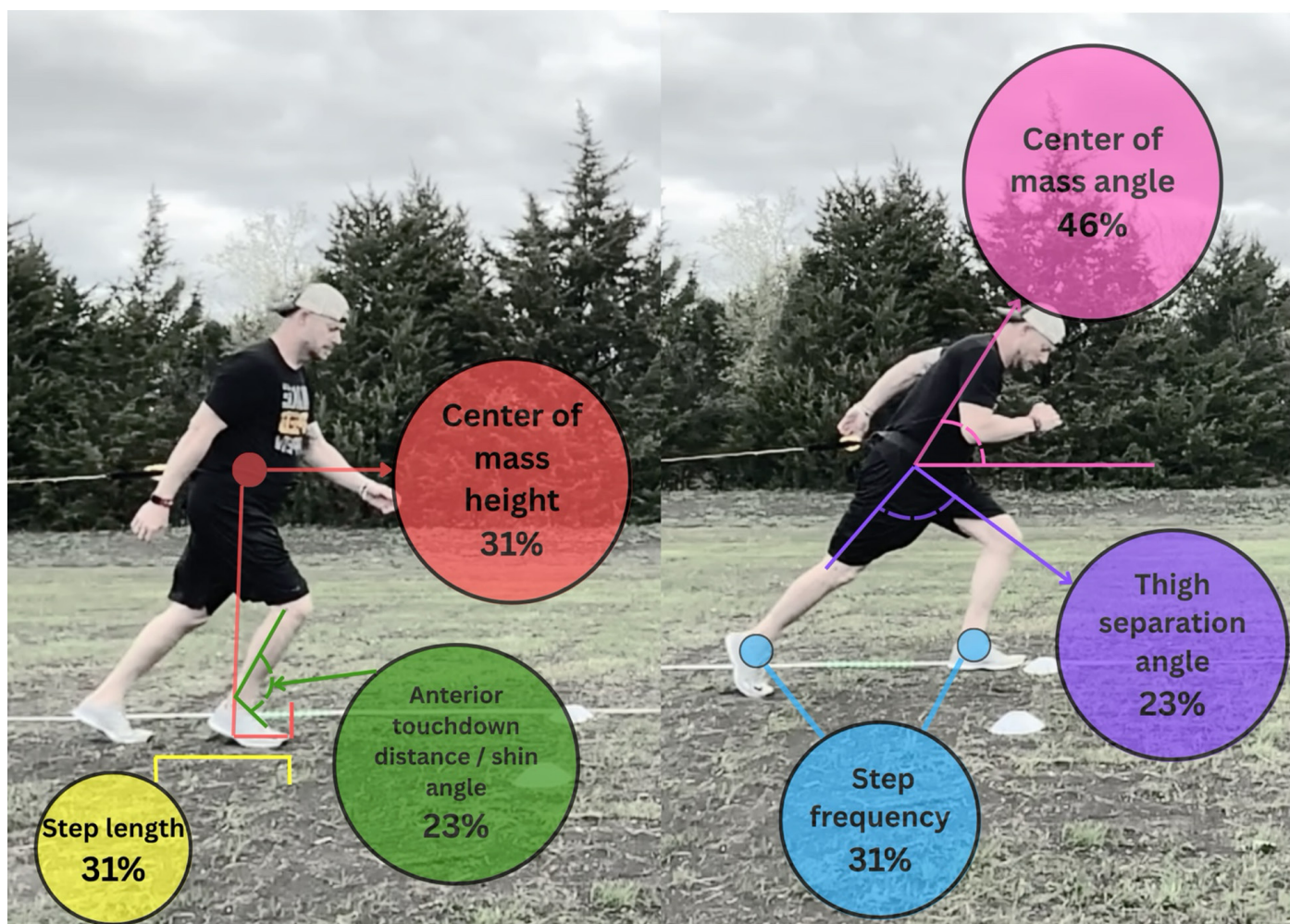


Figure 3. Technical qualities thought important by surveyed coaches.

resulted from optimizing the contribution of SL and SF during a pickup. If an athlete's step length becomes excessively long, pickup acceleration performance may decline due to a reduction in step frequency or a more vertical shin angle, increasing braking forces (Kessler, 2020). It was theorized that targeting higher SF through increased leg speed could be more beneficial during a jogging entry. The coaches further hypothesized that the contribution of these two primary determinants of pickup acceleration should be individualized based on the athlete's weaknesses. Furthermore, it was suggested that optimizing hip separation, increasing SL, and providing adequate SF should result in higher speeds.

Assessment of pickup acceleration qualities

Physical Assessment

The previous section identified the physical qualities elite coaches considered necessary for optimizing pickup acceleration. Given these comments, the next step in advancing practice in this area is understanding how to measure and monitor these physical qualities. This section synthesizes the

key physical attributes and presents a scientifically backed assessment framework (see Table 1) that links each quality to relevant assessments, specifies key variables, and highlights their associated reliability.

Force and Power Assessment

Unilateral force and power qualities were noted as likely determinants of pickup acceleration. The coaches suggested that the isometric force production of the hip flexors, hip extensors, and ankle plantar flexors would be worth monitoring. It was thought that peak force (i.e., maximal strength) and RFD over 150-250 milliseconds (explosive strength) were the primary variables of interest. Traditionally, these muscle groups have been tested using an isokinetic dynamometer, which is impractical for field-based practitioners due to the cost, size, and availability of this lab-based equipment. Standing isometric hip flexion, extension, and supine ankle plantar flexion peak forces are reliable when tested using portable fixed dynamometers (Davis et al., 2017; Kollock et al., 2010; Woodbridge et al., 2024), hand-held dynamometers (Minuti et al., 2023), and force plates (Mattiusi, 2022). Force testing using

Table 1. Physical qualities determined by coaches as important for pickup acceleration, suggested tests, variables, and reliability measures.

Physical Qualities	Tests	Technology Variables	Reliability (Reference)
Lower body strength			
Unilateral strength and power	Standing isometric hip flexion	Peak force (N)	ICC >0.91, SEM <.82 N (Kollock et al., 2010)
	Standing isometric hip extension	Peak force (N)	ICC >0.97, TE <4.3% (Woodbridge et al., 2024)
		Impulse (Ns)	ICC>0.88, CV% <8.5 (Woodbridge et al., 2024)
	Isometric ankle plan-tar flexion	Peak force (N)	ICC 0.97, CV% 4.7 (Cho et al., 2023)
Lower limb stiffness, elasticity, and power			
Horizontal leg and ankle reactivity	3-hop test	hRSI	ICC 0.68-0.72, CV% 10.7-12.5, TE 0.16-0.90 (Sarabon et al., 2023)
Vertical reactivity	10/5 pogo test	vRSI	ICC 0.96, CV% 1.92 (Southey et al., 2023)
Elasticity	CMJ	EUR	ICC 0.89-0.99, TE 3-8% (Suchomel et al., 2016)
	Squat Jump		
Core strength and stability			
Anti-rotation strength and power	Instrumented isometric horizontal rotation	Peak Force (N)	ICC 0.80, CV% 12.06 (Rodriguez-Perea et al., 2023)
Joint mobility			
Hip range of motion	Supine hip flexion	AROM (°)	ICC 0.92, SEM 4.29° (Mohammad et al., 2021)
	Prone hip extension	AROM (°)	ICC 0.82-0.97, SEM 1.4-3.5 ° (Mohammad et al., 2021)
Ankle range of motion	Ankle plantarflexion	AROM (°)	ICC 0.53, SEM 3.27° (Mohammad et al., 2021)

Key: AROM, active range of motion; hRSI, horizontal reactive strength index; N, Newtons; Ns/kg, Newton seconds per kilogram; N/m, Newton per meter; ms, milliseconds; m, meters; °, degrees; PSAP, prestretch augmentation percentage; ICC, intraclass correlation coefficient; CV%, coefficient of variation; TE, typical error; SEM, standard error of measurement.

portable fixed dynamometers was shown to have excellent reliability (ICC > 0.96 and TE < 4.3%, SEM <6.2%) (Cho et al., 2023; Kollock et al., 2010; Woodbridge et al., 2024). RFD reliability for these measures has not been established.

Lower Limb Reactivity/Elasticity Assessment

Coaches emphasized the importance of monitoring and assessing the stiffness and elasticity of the lower body in both bilateral and unilateral movements, as well as in vertical and horizontal directions. Stiffness is the ratio of applied force to the change in displacement (Enqvist et al., 2024; Moran et al., 2023), and elasticity refers to the ability of muscle-tendon units to store and release mechanical energy during the SSC (Yamazaki et al., 2022). Based on our analysis and consistent with insights from other practitioners, a more considerable change in joint flexion angles during the transition between walking/jogging gait and sprinting patterns may indicate suboptimal joint or leg stiffness. In field settings, stiffness can be assessed using the

reactive strength index (RSI) or reactivity coefficient (Sarabon et al., 2023). Although force plates are preferred for directly measuring this variable, rather than relying on a proxy, inertial measurement units (IMUs) offer a practical alternative due to their portability and accessibility (Comyns et al., 2023). One of the most common reactivity tests is the 10/5 pogo test, in which the athlete performs 10 consecutive pogo jumps, focusing on minimizing ground contact time. The five best jumps are then averaged and used to calculate RSI (Southey et al., 2023). When calculated from an IMU (Output Capture, Output Sports, Dublin, IE) in our lab, the vertical reactivity coefficient from the 10/5 pogo test was found to have excellent intra-trial reliability (CV = 2.99%) (Slocum, personal communication, April 26, 2025).

Elasticity has been commonly assessed using the eccentric utilization ratio (EUR) (McGuigan et al., 2006). EUR can be calculated using jump height, peak power, or peak force, providing the practitioner with similar information (EUR: CMJ height/power/

force ÷ SJ height/power/force (Suchomel et al., 2016)). Calculating EUR provides some insight into how effectively an athlete utilizes the SSC, with higher values indicating greater elastic contribution and coordination. However, it is essential to acknowledge that limitations exist in this metric. Specifically, the difference between CMJ and SJ performance reflects not only the reuse of elastic energy but also greater pre-activation and active contractile contribution during the countermovement (Bobbert & Casius, 2005), meaning that EUR should be interpreted as an indirect measure rather than a pure indicator of SSC function. Therefore, while EUR should not be viewed as a pure measure of SSC function, it can still provide helpful insight into an athlete's ability to coordinate elastic and neuromuscular contributions during jumping tasks. EUR is often assessed through force plate testing (Suchomel et al., 2016), but can also be determined with an IMU (Slocum, personal communication, April 26, 2025), and has been found to be reliable (CV = 0.79 to 6.00%).

The coaches intimated that pickup acceleration mostly relied on horizontal force propulsion and orientation, which was transmitted through the foot-ankle complex to the triceps surae complex. Therefore, assessments such as the unilateral horizontal drop jump (Schuster & Jones, 2016) or triple hop (Sarabon et al., 2023) may be beneficial for measuring leg and ankle stiffness as proxies of pickup acceleration capabilities. The transition step in pickup acceleration exhibits longer GCT (~0.43 s) compared to non-pickup acceleration GCT (0.17-0.23s in early acceleration) (Murphy et al., 2003; Segers et al., 2008), highlighting the need to evaluate both fast SSC (<250 ms) and slow SSC (>250 ms) (Flanagan & Comyns, 2008) capabilities. The coaches suggested that the triple hop test could be used to test horizontal reactivity and fast SSC capability. Good reliability has been established using 2D video to collect hRSI (horizontal RSI, ground contact time ÷ jump distance) from a triple hop test ICC 0.68-0.72, CV% 10.7-12.5) (Sarabon et al., 2023).

Rotational Strength and Anti-Rotation Capacity

Given the core musculature's role in stabilizing the rotary demands of athletic movements, such as sprinting (Rodriguez-Perea et al., 2023), coaches emphasized the importance of assessing oblique isometric anti-rotation force capability from a standing position. While trunk isometric strength is traditionally measured using an isokinetic

dynamometer, typically seated to isolate muscle groups (McIntire et al., 2007), this approach lacks ecological validity for dynamic sports actions. The coaches surveyed preferred a standing assessment that more accurately reflected the integration of the upper and lower limbs during sprint acceleration. Although such standing assessments are not yet common practice (Rodriguez-Perea et al., 2023), recent evidence supports their utility. Specifically, peak force measured during an isometric standing horizontal cable rotation using a portable fixed dynamometer has shown excellent reliability (ICC = 0.80, CV% = 12.06%) (Rodriguez-Perea et al., 2023). However, the reliability of RFD in these movements remains to be established.

Range of Motion Assessment

Coaches identified ROM as a critical factor in pickup acceleration performance, significantly impacting lower-body kinetic chain function. Given this information, it was believed that hip mobility (specifically hip flexion and extension) and ankle mobility (ankle plantar flexion) affected performance, with deficiencies in ROM potentially compromising function.

Hip and ankle AROM has frequently been assessed using goniometers (Krause et al., 2011; Martin & McPoil, 2005; Stolowski et al., 2023), digital inclinometers, and, more recently, IMUs (Stolowski et al., 2023). These assessments are typically conducted in seated, prone, and supine positions (Krause et al., 2015). Researchers have established acceptable inter-trial reliability with CVs of 3.6-6.8% for plantarflexion, 1.7-1.9% for hip flexion, and 4.5-4.8% for hip extension (Slocum, personal communication, April 26, 2025).

Coordination Assessment

Sprint coordination assessment has received limited scholarly attention, with fewer than ten studies published in the past decade (Bayne, 2020; Donaldson et al., 2023; Donaldson, 2023; Donaldson et al., 2022; Okudaira et al., 2021). Most studies examine in-phase (moving in the same direction) and anti-phase (moving in opposite directions) limb movements using 3D video motion capture and IMUs (Donaldson et al., 2023; Donaldson et al., 2022), followed by manual digitization to identify joint kinematics for each step. This process is laborious and time-consuming without automation, necessitating manual finding of each joint center for each step. For instance, (Donaldson, 2023) reported

collecting 101 individual kinematic reference points for each early acceleration step when studying sprinters. They found that faster-accelerating athletes focused on hip separation on the first step, concurrent swing leg retraction, and trail leg hip and knee flexion for steps 2-4. Due to the effort involved, assessments requiring extensive processing, such as the one used by Donaldson, are impractical for field-based practitioners who need efficient, easily analyzable methods. As a result, visual inspection and real-time augmented feedback of inter-limb timing via 2D video analysis remain the most practical assessment options. The reliability of these measures has not been established.

Technical Assessment

CoM Angle and Height Assessment

Over half of the coaches suggested that CoM positioning and adjustments were key indicators of pickup acceleration performance. CoM angle and height were proposed to help distinguish between performance levels and should be considered during pickup acceleration assessments. The trunk angle at toe-off (e.g., take-off angle, consisting of

the line drawn between the hip and big toe, relative to the global horizontal) increases with velocity and correlates very strongly with the force application angle ($r=0.93$, $p<0.001$) (Kugler & Janshen, 2010). Take-off angle assessments using video analysis, averaged over two trials, were reliable (ICC = 0.72, CV% = 8.2%) (Hunter et al., 2004).

Transitioning from a walk or jog to a sprint led to adjustments in the CoM height during the pickup acceleration step, a factor that 42% of coaches emphasized. The primary variable of interest mentioned was the downward change in CoM displacement seen during early ground contact. CoM downward displacement from a static start, captured via 2D video and averaged across two trials, has been shown to have good reliability (ICC = 0.77; CV% = 9.2%) (Hunter et al., 2004).

Thigh Separation Angle Assessment

The thigh separation angle was considered a key metric for assessing pickup acceleration performance by the coaches surveyed. Previously, coaches speculated that a difference in separation angle would be beholden to entry velocity; this

Table 2. Technical qualities perceived as important for pickup acceleration, suggested tests, variables, and reliability measures.

Qualities	Tests	Variables	Reliability
CoM management			
CoM Angle (take-off angle)	Video analysis of CoM position relative to horizontal at toe off	Trunk flexion angle (°)	ICC 0.72, CV% 8.2% (Standing & Maulder, 2017)
CoM height	Video analysis of CoM vertical drop	Trunk downward displacement (mm)	ICC 0.77, CV% 9.2% (Standing & Maulder, 2017)
Swing phase and hip separation mechanics			
Thigh separation angle	Video analysis between hip at peak flexion and contralateral hip at extension	Angle of split between made between flexed thigh and extended thigh (°)	N/A
Stance phase and anterior touchdown mechanics			
Anterior touchdown distance	Video-based distance measured between front foot contact and line from CoM at initial contact	Distance relative to height (m)	ICC 0.90, CV% 5.74 (Hunter et al., 2004)
Shin angle at toe off	Video analysis of front shin angle at toe-off	Angle between global horizontal and shin closest to camera (°)	ICC 0.92, SEM 0.8° (Dingenen et al., 2018)
Step kinematics			
Step length	Video analysis of step length (m)	Distance between ground contact of right foot to ground contact of left foot (m)	ICC 0.96, CV% 1.34% (Hunter et al., 2004)
Step frequency	Video analysis of step frequency	Steps taken per second (Hz)	ICC 0.88, CV% 1.52 (Hunter et al., 2004)

Note: CoM, center of mass; °, degrees; mm, millimetres; m, meters; Hz, Hertz; ICC, intraclass correlation coefficient; CV%, coefficient of variation; SEM, standard error of measurement

assertion has yet to be tested. However, it can be assumed that the separation angle would be larger for a walking entry due to the increase in leg speed and the rapid amplification of horizontal force production. Using 2D video and a multi-regression analysis, Miyashiro et al. (2019) established a method to determine the hip angle at toe-off, with faster runners exhibiting a larger hip angle and greater hip angular displacement. Other researchers (Donaldson, 2021) established the reliability of an IMU's placement for multiple standing posture calibration trials ($TE = 0.43\text{--}1.90^\circ$) before undertaking a study that elicited thigh separation measures (Donaldson et al., 2023). Still, despite being used as in the articles listed above, the explicit reliability of the thigh separation angle has not been established using 2D video.

Anterior Touchdown Distance and Shin Angle Assessment

The coaches believed that the anterior touchdown distance and the shin angle made during the early touchdown of the transition step likely influence acceleration mechanics and were worth assessing. It was hypothesized that a shorter anterior touchdown distance (in meters; relative: divided by the athlete's leg length, absolute: absolute distance) would lead to decreased braking forces and would likely differ based on the entry velocity. Therefore, examining the rotation-extension strategy (i.e., shin-roll), wherein the CoM is translated over the stance leg before hip, knee, and ankle extension, may be valuable. The key metric for this strategy is the angle formed between the shin and the foot at early ground contact, with a more acute angle being favored for optimal performance. Absolute and relative anterior touchdown distances during sprint acceleration, measured via 2D videography, have been found reliable (absolute distance ICC 0.65, CV% 15%; relative distance ICC 0.90, CV% 5.74) (Calderbank, 2023; Hunter et al., 2004). The shin angle relative to the foot at early ground contact of a sprint acceleration has also been found to have acceptable reliability when measured using 2D video (ICC=0.92; SEM < 1°) (Dingenen et al., 2018).

Step Kinematics Assessment

Step kinematics (SL and SF) were deemed crucial by coaches for sprint speed and were considered key for monitoring pickup acceleration performance. When analyzing step kinematics, the use of 2D video analysis has become standard practice

(Hunter et al., 2004); however, IMUs (Nagahara et al., 2020) and linear position encoders (Sugisaki et al., 2024) have become more widely accepted with some limitations. Measures of SL and SF are easy to assess from video-based analysis and IMUs, whereas SF is not reliable from a linear position encoder (Sugisaki et al., 2024). With SL and SF likely increasing rapidly after the transition step, investigating the magnitude of how these outputs change from the transition step in higher-performing athletes was felt to be warranted (De Smet et al., 2009; Jakeman et al., 2023). SL and SF acquired through 2D video have been found to have good reliability (ICC<0.88; CV% >1.52%) (Hunter et al., 2004).

CONCLUSION AND FUTURE RESEARCH DIRECTIONS

Pickup acceleration is a complex movement pattern that requires an understanding of both physical and technical skills to enhance performance. However, compared to the existing literature on static start acceleration, it remains relatively unexplored, which motivated the survey. Coaches identified differences in acceleration mechanics when starting from a walk versus a jog, as each entry velocity altered the technical, temporal, and force demands over the first few steps. Key physical performance factors identified (and percent of coaches reporting) included lower body force and power production (54%), lower body elasticity and stiffness (38%), hip and ankle range of motion (15%), coordination (38%), and core rotational strength and stability (31%). Technical factors focused on changes in CoM height (31%), CoM angle (46%), anterior touchdown distance, and shin angle (23%), as well as hip separation angle (23%), and optimization of step kinematics (SL and SF; 31%). These factors provided the framework for an assessment battery to understand pickup acceleration performance. The measures identified are generally reliable when collected using standard sports science equipment, except for RFD and thigh separation angles. This assessment battery could help improve understanding of pickup acceleration mechanics, and more importantly, it could provide coaches with a practical means to monitor and enhance athletic performance. By identifying the physical and technical demands associated with pickup acceleration and matching relevant assessments to these demands, coaches can build more targeted programs that will enhance pickup acceleration ability. Future researchers need to collect data

using these assessments to establish the utility of these measures and their relationship to pickup acceleration performance.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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