Using qualitative technique analysis to evaluate and develop technique of agility actions with your athletes

Overview

An important element of developing agility with athletes is to evaluate technique in performing actions associated with match play. For practitioners it is important to understand what the key elements of ideal movement technique are to enhance performance. The aim of this article is to revisit an approach to creating a technical framework to help practitioners develop a biomechanical understanding of sports actions relevant to expressions of agility in sport.

Introduction

An essential part of speed, change of direction speed and subsequently agility development is to evaluate technique while performing a range of sports specific actions. Previous authors have suggested a 5-stage process for technique evaluation: 1) preparation, 2) observation, 3) fault diagnosis, 4) intervention and 5) re-evaluation.[23] Perhaps the most important stage is the preparation, which involves developing a '*knowledge structure*' of what should be observed (e.g., an ideal technique model) and then decide how the evaluation can be conducted, allowing the analyst to focus on 'critical features' of the performance during the fault diagnosis phase and develop a subsequent appropriate intervention. However, there are a plethora of actions that occur during match play (e.g., side-step cutting, cross-cutting, pivoting, linear and curvilinear sprinting, side-shuffling, backpedalling, etc.) that require a biomechanical/ technical understanding to coach. Some actions, such as sprint running, have been researched extensively and proper technique for these movements have been well documented. However, many other instantaneous and locomotive actions associated with agility are not so well researched. Understanding the important aspects of technique for these movements may help coaches better identify technique flaws that hinder athletic performance and may also help mitigate injury.

Current field-based tools for technique evaluation of change of direction in relation to injury risk

The majority of biomechanical research into change of direction (COD) has tended to focus on postural or technique factors associated with knee joint loads [2, 4, 11, 15, 16, 20, 24, 29, 30, 31] during the plant step. This may be due to the associations between COD, horizontal deceleration, and non-contact anterior cruciate ligament injuries.[10, 12, 26, 27, 33] Given the logistical issues of incorporating 3D motion analysis to screen athletes, field-based screening tools have been developed to help practitioners evaluate COD performance among athletes. These tools may potentially provide a 'knowledge structure' for practitioners to identify technical faults with athletes to provide avenue for intervention. For example, these tools can help identify postures and movements that relate to high knee joint loads during side-step cutting to observe during practice and try to remedy through coaching interventions.

The Cutting Movement Assessment Score [CMAS][6,13] is a 9-item evaluation tool that can be used to assess movement quality. To conduct this test only 2 to 3 video cameras are required. The CMAS (total points score) has been associated with the magnitude of peak knee abduction moments as observed when using 3D motion analysis[6,13] and found to discriminate between individuals that possess safer compared to hazardous cutting mechanics.[6] This tool helps direct a practitioner's attention to pertinent aspects of technique related to knee injury risk when performing a side-step cutting manoeuvre.[7] For a guide on the rationale and use of this assessment tool see Dos'Santos et al.[9]

Other field-based techniques have involved measurement of variables from a 2D evaluation. Weir et al.[34] developed an innovative 2D analysis tool of several postural and technical parameters in the frontal and sagittal plane to estimate knee joints loads during side-step cutting manoeuvres. Such a tool offers a field-based method to evaluate technical faults when performing these actions. However, technique evaluation with this tool may be time consuming to undertake and would require expertise in biomechanical assessment methods. The emergence of automating tracking systems (e.g., OpenSim) may speed up the laborious digitisation process required during these types of analysis and reduce the time required to provide feedback to the athlete. However, markerless technology is still in its infancy regarding the quantification of cutting kinematics. Similar to 3D opto-electronic motion analysis, it is unlikely this technology will be readily available for the majority of athletes, especially at community based or lower training levels.

More recently, Della Villa et al.,[3] investigated the efficacy of a scoring system to identify athletes with high peak knee abduction moments during 90° side-step cutting based using 2D video analysis of frontal and sagittal plane joint kinematics combined with force plate analysis (video vector). The tool involved five item scoring criteria based on limb stability (frontal plane knee alignment), pelvis stability (frontal plane pelvis alignment), trunk stability (frontal plant trunk alignment), shock absorption (amount of knee flexion), and movement strategy (hip and knee flexion) taken at the point of maximum knee flexion. The authors found the tool was able to discriminate between athletes exhibiting high and low peak knee abduction moments from 'gold standard' 3D motion analysis. However, to apply this tool in the field requires the use of a force platform to superimpose the ground reaction force vector over the video images (video vector) to partially determine 'limb stability'. This is unlikely to be readily available for the vast majority of practitioners working in the field (i.e., the abovementioned methods only require 2-3 video cameras to carry out) and likely requires a level of biomechanics expertise not common amongst many practitioners.

Nevertheless, all of the abovementioned tools are limited to side-step cutting actions ranging from 45 to 90° and focus primarily on technique / movement evaluation in relation to injury risk potential. Whilst errors that could result in elevated knee joint loads can be identified, practitioners also need to understand how these loads impact performance. Furthermore, athletes regardless of their sport will perform a variety of instantaneous and locomotive actions and thus, practitioners should have an approach to develop a knowledge structure that caters for the variety of actions performed during match-play rather than just side-step cutting. Furthermore, any tool utilised by the practitioner must consider optimal technique for both performance enhancement and injury risk reduction perspectives.

A framework approach to technique analysis

A potential approach to establish a '*knowledge structure*' of a sports action or event is to develop a technical framework.[21,23] Often deterministic models are adopted, but these tend to focus on generation of measurable variables, rather than aspects of movement.[21] Therefore, are inappropriate to develop a knowledge structure to guide observational practice in the form of qualitative analysis. A framework approach[21,23] involves breaking down a skill into phases and sub-phases (often key instances within a phase), and then describe the body position and movements in each sub-phase (TABLE 2). Following this, the aim to each phase/sub-phase should be stated, before then applying biomechanical or principles of movement (TABLE 1). The model could be expanded to identify factors that influence the implementation of the movement principles or identifying common technique errors (TABLE 3). An essential part of this process is the application of movement principles (TABLE 1). A movement principle is a description of how a movement should be performed based on biomechanical /mechanical principles (i.e., Newton's laws).[23] Applying movement principles separates general movements that have no influence on performance (e.g., whether your fingers should be separated or together when sprinting) with those that impact performance (e.g., tightly flexed knee and dorsi-flexed ankle during the swing phase when sprinting to reduce moment of inertia and increase limb speed). The following sections provide a step by step process of how to develop a technique framework using an example for a 180° pivot.

<<INSERT TABLE 1 HERE>>

Breakdown into phases/ sub-phases

Most sports actions/ events can be split into 4 phases: 1) initiation, 2) preparation, 3) execution and 4) follow through.[23] In applying this to a 180° pivot, the action can be divided into initiation (approach), preparation (adjustment of steps prior to final foot contact), execution (plant step) and follow-through (re-acceleration) (FIGURE 1). The actions involved during initiation and follow-through may differ (e.g., sprinting to side-shuffling on approach or re-acceleration phases). Thus, effectively flexibility to the analysis can be added to help the practitioner adapt for the different ways in which common actions interact during examples of agility during match play.

<<INSERT FIGURE 1 HERE>>

For cyclical locomotion actions, such as sprinting, it would be more logical to divide the action into stance (ground contact) and flight phases and subsequently sub-phases/ key instances within these phases (e.g., touchdown, mid-stance, take-off, early flight, mid-flight and late flight). This should be adapted for different phases of sprinting (e.g., acceleration (early, mid, late) and maximum velocity phases).

Once the action has been broken down into phases and sub-phases, a description of key postures, joint positions and/ or movements is required. TABLE 2 shows an example in relation to a 180° pivot.

<<<INSERT TABLE 2 HERE>>>

Applying movement principles

The next step is to add an aim to each phase from a biomechanical or sports specific perspective. Once this has been accomplished the practitioner can consider which movement principles from TABLE 1 apply in each phase of the skill/action. FIGURE 2 highlights the primary movement principles that apply in each phase of the 180° pivot. The aim of the **approach phase** is to achieve the highest controllable velocity whilst visual scanning (e.g., the opponents, teammates, sports object, etc.). The velocity attained during this phase is dependent on the interaction between step length (SL) step frequency (SF) (*Speed principle S1*). SL is dependent on force production generated during ground contact (*Force principle F1*) and maybe mediated by the stretch-shorten cycle and simultaneous joint movements (*Co-ordination principles C3 & C4*), whereas SF may depend on the speed of the leg recovery action (*Speed principle S3*). The contra-lateral limb-movement is also important to preserve angular momentum about the longitudinal axis of the body (*Co-ordination principle C1*). The **preparation phase** requires a reduction in velocity and to properly position the body for the plant step (*Specific performance principle SP1 – speed-accuracy trade-off*), thus, the penultimate (and possibly antepenultimate foot contact and steps prior) is required to generate a braking action (*Force principle F1*) through placement of the foot in front of the centre of mass, marked flexion at the knee and hip to lower the centre of mass and thus, apply a braking force for longer (*Force principle F2*). The aim of the **execution phase** is to perform the directional change safely and efficiently. Thus, the foot is placed in front of the body (*Force principle F3*) to facilitate braking and propulsion into the opposite direction. A firm base is requred to push from (*Force principle F1 – force production*) and the lowering of the centre of mass at this stage with a period of double support (*Force principles F6 – balance*) enhances the athletes stability at this point allowing a safer execution phase (i.e., lower risk of ankle and knee injury). The propulsion (maximum knee flexion to take-off) sub-phase of the execution phase maybe faciltated by use of the stretch-shorten cycle and simultaneous joint movements (*Co-ordination principles C3 & C4*) as the athlete triple extends the 3 lower limb joints into the first re-acceleration step. Controlling the athletes dynamic stability (*Force principle F6*) during the first few steps is important to take advantage of angular momentum generated through the centre of mass being ahead of the foot during ground contact. To maximise velocity during the **re-acceleration phase** the interaction of SL and SF (*Speed principle S1*) will determine the athletes velocity and once again the force produced during each footfall during re-acceleration could be enhanced with greater extension range of motion at the 3 lower limb joints (*Force principle F2*) and simultaneous joint movements (*Co-ordination principle C3*) faciliated by a vigorus arm drive (*Co-ordination principle C1*).

<<INSERT FIGURE 2 HERE>>

Identifying factors that influence performance

Once the movement principles have been applied, the next step it to recognise factors that may influence technical execution, which may largely be physical factors (TABLE 3). Some external factors may impact technical execution such as sports rules (i.e., in basketball & netball), carrying or progressing with a sports implement and shoe-surface interface and impact of weather (e.g., application of *F1 – Force production*). In terms of internal factors in a 180° pivot (TABLE 3), the **approach phase** may be influenced by fast reactive strength through use of the stretch-shorten cycle (C4) with each foot contact and linear sprint speed in this case, whilst the **preparation and execution phases** may be dependent on eccentric strength of the knee extensors and flexors.[14,18,19] The ground contact time of the plant step during 180° turns/ pivots can be ≥ 400 ms, [5,17,19,29,32] suggesting slow reactive strength muscle strength qualities are important here[8] alongside concentric strength of the lower limb joints as the athlete (FIGURE 2) extends the lower limb joints during the propulsion sub-phase of the **execution phase.** Similarly, concentric lower limb strength and linear sprint ability will be physical factors important for technical execution of the **re-acceleration** phase (TABLE 3). During the **execution phase**, controlling the largest segment of the body (the trunk) suggest isometric trunk strength may be essential for controlling dynamic stability during this phase as well as alleviating high knee joints loads of the plant leg.[38,39]

Application of the framework

The development of the framework and application of movement principles (TABLE 3) has implications for the 'critical features' that should be the focus for qualitative technique evaluation and subsequent intervention. For instance, observing the running action of the **approach** should focus on the contralateral limb movement (C1), leg recovery action (*tightly flexed knee and dorsi-flexed ankle during swing up until a high knee lift position, before sweeping motion from the hip with the foot landing almost under the centre of mass*) (S3), short ground contacts through limited knee and ankle flexion (the foot strike should be towards the forefoot in a neutral ankle position) during ground contact (C4), and simultaneous triple extension of lower limb joints at take-off (C3). The **preparation** phase should observe the foot placement in front of the centre of mass, whilst leaning back (F2) to facilitate braking along with marked flexion of the lower limb joints to lower the centre of mass to prolong braking (F2) and arrive at the final foot plant in an optimal position (F6). During the **execution phase**, observing whether the athlete plants one leg out in front of the body (F3) to facilitate the direction change, with the athlete's centre of mass low and a period of double support (F6). Noticing whether the athlete's knee flexes to eccentrically load the knee extensors (C4) before extending with the ankle and knee towards (C3 & F2) take-off of the **execution** phase and whether the upper limbs are held close the body (S2) to allow faster rotation out of the turn. As the athlete **re-accelerates**, observations should focus on the first 2 ground contacts which should be behind the centre of mass to control the athlete's angular momentum (F6), with shorter more frequent steps (S1) initially to maximise net horizontal impulse (drive index). Observing whether the athlete extends the lower limb joints to help generate horizontal force with each ground contact (F2, C3), whilst using a vigorous arm drive (C1).

Having identified faults with an athlete against the model created, the drills utilised as part of the intervention, need to be grounded in the underpinning movement principle(s). For example, if an athlete does not sufficiently brake prior to the plant step leading to a double hop on the final 'plant' step. To improve this deficit, deceleration drills (start-stop over 5 metres finishing in a split stance) should be used whereby emphasis is on placing the leg in front of the centre of mass whilst leaning back during penultimate foot contact (F2) and lowering the centre of mass through flexion of the hip and knee (F2 & F6) as they then transition into the final split stance position. Once mastered, intensity can be increased by increasing the length of the drill and the associated greater velocity of approach and observing whether these technical aspects are upheld.

The development of technique within such a drill can be affected by the magnitude and quality of the instruction and feedback from the coach. Coaches should use cueing techniques to direct athlete's attention to 1 or 2 aspects of technique during a demonstration or during feedback.[35] Cues should be externally focused (where the focus of attention is on the environment), as this has been shown to improve timed COD performance,[25,28] although, this may be influenced by training experience.[37] Nevertheless, once the critical features have been identified, cues can be developed as part of the framework to focus the athlete's attention during coaching sessions. Winkelman,[35,36] points to the 3 D's to develop appropriate cues - Distance (proximal/ close or distal/ far), Direction (toward or away) and Description (action verb or an analogy). For instance, during the execution and re-acceleration phases whereby you want the athlete to extend the 3 lower limb joints pushing against the ground (C3) a cue might be *''Drive the ground* (distance) *back* (direction) *as explosively* (description) *as you can''.* Effectively, extending the framework to encompass possible coaching cues for some of these critical features may assist the practitioner in identifying the important biomechanical characteristics of the action and how these could be effectively communicated to the athlete.

Summary

An essential part of developing agility with athletes is to evaluate athlete's technique in performing actions associated with expressions of agility in their sport. This requires a technical/ biomechanical understanding of these actions that are often under-researched and interact in an often complex manner during match play. For practitioners responsible for agility development with athletes, who have a limited biomechanical background, it may be difficult to understand what ideal technique may be with such actions. Without a technical understanding of these actions, the practitioner's ability to identify and correct technique errors when coaching relevant agility movements is limited. Currently, qualitative and quantitative field-based tools may not allow practitioners to fully evaluate technique for the range of actions associated with match-play as they only focus on injury risk potential during side-step cutting actions. Moreover, some of these approaches may still be impractical in field settings. The technical framework approach outlined in this article is a method to help practitioners develop a biomechanical and technical understanding of agility actions that they are required to coach. This will help practitioners focus on 'critical features' of technique to guide observational practice when coaching these actions and help them develop strategies to remedy any technical errors.

Table titles

TABLE 1. Movement principles taken from Lees (1999; 2008)[21,23].

TABLE 2. Phase description of a 180° pivot.

TABLE 3. Final framework for a 180° pivot.

Figure Legends

FIGURE 1. A breakdown of a 180° pivot into phases (Red font) and sub-phases (Blue font).

FIGURE 2. The aims (Green font) and application of movement principles (Yellow font) during the various phases of a 180° pivot.

Author's Bio

Paul A. Jones PhD, CSCS*D, BASES ACCRED, CSci, FBASES

Paul is a lecturer in Sports Biomechanics and Strength and Conditioning at the University of Salford. He has over 18 years' experience in biomechanics and strength and conditioning support to athletes from various sports. Paul has authored/ co-authored over 100 peer-reviewed journal articles, mainly in the areas of change of direction biomechanics, assessment and development of speed, change of direction speed & agility and strength diagnostics.

Alistair McBurnie, BSc (Hons)

Alistair is a Sports Science Analyst at Manchester United F.C. He is currently a part-time PhD candidate at Nottingham Trent University, where his main research interest will cover the topic of multi-directional speed profiling in elite soccer. Specifically, his aims will be to evaluate the high-intensity movement profile of soccer players and establish a more quantitative and qualitative basis for evaluating the movement demands of the sport.

Thomas Dos'Santos, PhD, CSCS*D

Thomas is a lecturer in Strength and Conditioning and Sports Biomechanics at Manchester Metropolitan University. He currently consults on strength and movement profiling with Sale Sharks Rugby and Manchester United F.C., and has previously consulted with the England Football Association on change of direction biomechanics. He has published over 80 peer-reviewed journal articles and is also a visiting lecturer at Middlesex University and the Football Science Institute.

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FIGURE 1. A breakdown of a 180° pivot into phases (Red font) and sub-phases (Blue font).

FIGURE 2. The aims (Green font) and application of movement principles (Yellow font) during the various phases of a 180° pivot.

TABLE 1. Movement principles taken from Lees (1999; 2008).

Speed Principles	**S1.Whole-body running speed** Maximum running speed is attained after 40-50 m of running and is dependent on the interaction between step length (SL) and step frequency (SF) (Speed = SL × SF).
	S2.Whole-body rotation speed Rotational movements of the whole body are completed more rapidly by bringing the limbs closer to the body's axis of rotation. Conversely, slowed down by extending the limbs (Conservation of angular momentum).
	S3. Limb Speed To rotate a limb (e.g., arm or leg) rapidly requires the limb to be flexed and held close to the body. (Moment or Inertia = mass × radius of rotation^2. Torque = moment of inertia × angular acceleration, thus, lower moment of inertia, greater angular acceleration for same torque).
	S4. End Point Speed A high end point speed (e.g., ball release/ impact in throwing/ striking actions) requires a large distance from axis of rotation to end point (e.g., hand/ foot/ sports implement) [Linear tangential velocity = radius of rotation × angular velocity).
Force Principles	**F1. Force production** To produce maximum effective force, a firm base is required on which to push from [Newton's 3rd Law].
	F2. Range of motion Muscle force can be applied for longer, with the greater a limb's range of motion [Impulse momentum relationships/ work-energy principle].
	F3.Change of direction To change direction when running the foot is placed (plant step) so as to maximise the horizontal friction force applied to the surface (e.g., during a side-step a lateral leg plant directs force perpendicular to the original direction of motion) [Impulse-momentum relationship].
	F4. Impact-stationary object When hitting a stationary ball or object, the performer must ensure that the implement making the impact moves in the same direction as the intended direction of the ball or object being hit (impulse-momentum relationship/ conservation of momentum)
	F5. Impact-moving object When hitting a moving ball or object, the striking implement must move in such a direction that it takes into account the motion of the moving object (impulse-momentum relationship/ conservation of momentum).
	F6. Balance Objects are more stable if they have a wide base and low centre of mass (work-energy principle). Conversely in dynamic situations (early steps of a sprint), an athlete can take advantage of the angular momentum generated by the centre of mass falling outside of the base of support.
	F7. Resistance to motion in fluids Resistance to motion when moving through air or water is lessened by reducing the area presented to the oncoming air or water (known as cross-sectional area) and making a more streamlined shape [Fluid drag force [$F_D = 0.5\ C_D \times p \times V^2 \times A$]. Conversely can be increased by increasing cross-sectional area and becoming less streamlined.
	F8. Propulsion in fluids To propel the body or an object through a fluid, advantages can be taken of the lift force. The lift force is created by using an airfoil (air) or hydrofoil (water) shape and ensuring the fluid flows over the surface in a special way (Fluid dynamics).
Co-ordination principles	**C1. Action-reaction** The movement of one limb or body part helps the movement of the opposite (or contra-lateral) limb or body part [Newton's 3rd law in angular form].

	C2. Sequencing of movements Many skills require a coordinated sequence of rotational movements to achieve a high end point velocity. This is achieved by rotating the large segments close to the body first (proximal) and terminating by rotating the segment furthest from the body (distal)(i.e. proximal to distal sequencing).
	C3. Simultaneous joint movements for force production Simultaneous joint movements are used when performing forceful or powerful actions. These often use a linked body segment chain that includes several of the major joints of the body. To ensure that this link system provides a firm base, it is important that the muscle groups operate simultaneously. Therefore, forceful/ powerful movements require muscles around the joints to act simultaneously**.**
	C4. Stretch-Shorten cycle Pre-stretching of the muscle-tendon unit aids performance by enabling higher muscle forces to be attained at the start of a propulsion phase of a sports action
Specific-performance principles	**SP1. Gaining vertical velocity/ transferring linear to angular momentum** When jumping for height from a horizontal approach (e.g., long & high jump), the jump height reached is enhanced by the use of a pivot (e.g., leg placed out in front of the body at touch down and limited knee flexion centre of mass 'pivots' over the supporting foot) at the beginning of the action. Furthermore, actions that involve transferring momentum from an approach to an implement involve planting one lower limb in front of the body for the upper body and implement to pivot over.
	SP2. Flight An object that moves through the air under the influence of gravity is called a projectile. The performance measure of a projectile is often the range, but sometimes the height reached and time of flight are important outcomes. The mechanical factors determining projectile motion are; height, angle of release and speed of release/ take-off.
	SP3. Speed-accuracy trade-off In the performance of many skills, the outcome is determined by both speed and accuracy. It is generally found that as the demands for accuracy increase, the speed of the movement decreases.

TABLE 2. Phase description of a 180° pivot.

Task	180° Pivot							
Phase	Initiation ('Approach')		Preparation		Execution (''plant'' step)		Re-acceleration (first 2 steps post)	
Sub-phases	Ground Contact#	Flight#	TD PFC	End of PFC (MKF)	TD to MKF	MKF to Take-off	Ground contact#	Flight#
Description (critical features)	• Slight torso lean • Contra-lateral limb movement • Minimise TD distance • Minimal knee & ankle flexion • Extend hip, knee & ankle at toe-off • Opposite swing leg – knee flexion/ ankle dorsi-flexion to high knee lift position	• Slight torso lean • Contra-lateral limb movement • 'Pawing' motion from hip in preparation for ground contact during late stage flight	• Lean (torso) back • Foot in front of CM at TD (Heel contact)	• Lower CM position through flexed hip(~75°), knee (~120°) and ankle at end of contact • Trunk now leaning forward • Possible pre-rotation of pelvis (postural adjustments) / external rotation of PFC lower-limb to reduce the redirection requirements for the FFC	• Trunk upright • Foot ahead of CM • Period of dual-support - helps ↓'Plant' foot load & facilitates re-acceleration out of turn. • Hip, knee & ankle dorsi-flexion • Avoid foot rotation & knee valgus	• Trunk lean & pelvis rotates into direction into direction of travel • Extend hip, knee & ankle • Avoid double foot contact (typically associated with ineffective PFC braking)	• Trunk lean into directional of travel • Shorter steps • Foot contact behind CM • Extend hip, knee & ankle at take-off (Period of dual-support allows effective position for re-acceleration)	• Trunk lean into intended direction of travel • Vigorous arm drive

Note: # contact & flight phases repeated for desired number of steps of re-acceleration phase; *Preparation may involve steps prior to penultimate foot contact with the same aim as the penultimate step depending on the available preparation time along the closed/ pre-planned to open/ unanticipated continuum. For instance, in a closed/ pre-planned situation the antepenultimate step may initiate braking followed by the penultimate foot contact that acts as a preparatory step for final foot contact, whilst continuing with further braking.
PFC = penultimate foot contact; FFC = final foot contact; TD = Touchdown; CM = centre of mass; MKF = Max knee flexion;

TABLE 3. Final framework for a 180° pivot

Task	**180° Pivot**							
Phase	Initiation (‘Approach’)		Preparation		Execution (‘’plant’’ step)		Re-acceleration (first 2 steps post)	
Sub-phases	Ground Contact	Flight	TD PFC	End of PFC (MKF)	TD to MKF	MKF to Take-off	Ground contact	Flight
Description (critical features)	• Slight torso lean • Contra-lateral limb movement • Minimise TD distance • Minimal knee & ankle flexion • Extend hip, knee & ankle at toe-off • Opposite swing leg – knee flexion/ ankle dorsi-flexion to high knee lift position	• Slight torso lean • Contra-lateral limb movement • ‘Pawing’ motion from hip in preparation for ground contact during late stage flight	• Lean (torso) back • Foot in front of CM at TD (Heel contact)	• Lower CM position through flexed hip(~75°), knee (~120°) and ankle at end of contact • Trunk now leaning forward • Possible pre-rotation of pelvis (postural adjustments) / external rotation of PFC lower-limb to reduce the redirection requirements for the FFC	• Trunk upright • Foot ahead of CM • Period of dual-support - helps ↓‘Plant’ foot load & facilitates re-acceleration out of turn. • Hip, knee & ankle dorsi-flexion • Avoid foot rotation & knee valgus	• Trunk lean & pelvis rotates into direction into direction of travel • Extend hip, knee & ankle • Avoid double foot contact (typically associated with ineffective PFC braking)	• Trunk lean into directional of travel • Shorter steps • Foot contact behind CM • Extend hip, knee & ankle at take-off (Period of dual-support allows effective position for re-acceleration)	• Trunk lean into intended direction of travel • Vigorous arm drive
Aim	Produce highest controllable velocity whilst visual scanning		Reduce velocity & prepare for optimal position for ‘plant’ step		Execute directional change safely & efficiently		Increase velocity into reverse direction	
Biomechanical/ Movement Principles	F2, S3 - swing leg, SSC, S1: SL × SF	C1 S1: SL × SF	F2: ↑ TD distance to ↑ braking SP3, F1	FP1, F2: ROM – ↑lower limb flexion, braking force applied for longer to ↓ momentum	F3, C4, S2, F6 - Stability (↓CM/ ↔ Base), F1	FP1, F2,C3, S2, F6 - Stability (↓CM/ ↔ Base)	F6: ↓ TD distance (dynamic instability) F2, C3, S1: SL × SF, F1	C1, S1: SL × SF
Underpinning Physical qualities	LSS Fast reactive STR	LSS ECC STR (hamstrings late swing)	ECC STR (Knee extensors & Flexors; hip extensors)	ECC STR (Knee extensors & Flexors; hip extensors)	ECC STR (Knee extensors & Flexors; hip extensors) Slow SSC ability Isometric trunk strength	Slow SSC ability CON STR (lower limb extensors) Isometric trunk strength	CON STR (lower limb extensors)	LSS

Note: PFC = penultimate foot contact; TD = Touchdown; COD = change of direction; CM = centre of mass; MKF = Max knee flexion; SL = step length; SF = step frequency; LSS = linear sprinting speed; ECC = eccentric; CON = concentric; STR = strength. The approach and re-acceleration phases in this framework have been described as sprinting/ running in a forwards direction, frameworks can be extended to integrate other potential locomotion actions (e.g., side-shuffling) to provide a more informative tool for practitioners.