IAAF World Indoor Championships
BIRMINGHAM 2018
1–4 MARCH

BIOMECHANICAL REPORT

FOR THE

IAAF

WORLD INDOOR CHAMPIONSHIPS 2018

60 Metres Hurdles Men

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INTRODUCTION

The men's 60 m hurdles took place on the evening of Sunday 4th March. As it was the final event of the IAAF World Indoor Championships in Birmingham, the pressure was on midlands-born Andrew Pozzi to provide Great Britain and N.I. with their first men's medal of the championships. Pozzi went into the final as a potential favourite following his European Indoor Championships victory last year in Belgrade. However, other finalists such as Jarret Eaton and Aries Merritt (both United States) were showing good form throughout the season, whilst Pascal Martinot-Lagarde (France) and Milan Trajkovic (Cyprus) posted impressive times in the earlier rounds of these championships. At the start, Trajkovic was disqualified for a false start (IAAF Rule 162.8), meaning the final was to be contested between seven athletes. In the end, it was Pozzi who claimed the gold medallist with a season's best performance of 7.46 s, just 0.01 s ahead of silver medallist Jarret Eaton (United States). France's Aurel Manga claimed the bronze medal ahead of Aries Merritt.

IAAF
World Indoor Championships

Birmingham (GBR)
1-4 March 2018

RESULTS

60 Metres Hurdles Men - Final

RECORDS		RESULT	NAME	COUNTRY	AGE	VENUE	DATE
World Indoor Record	WIR	7.30	Colin JACKSON	GBR	27	Sindelfingen	6 Mar 1994
Championship Record	CR	7.34	Dayron ROBLES	CUB	24	Doha (Aspire Dome)	14 Mar 2010
World Leading	WL	7.42	Grant HOLLOWAY	USA	21	Clemson (USA)	9 Feb 2018

Area Indoor Record AIR · National Indoor Record NIR · Personal Best PB · Season Best SB

4 March 2018 16:59 START TIME

PLACE	NAME	COUNTRY	DATE of BIRTH	LANE	RESULT		REACTION	Fn
1	Andrew POZZI	GBR	15 May 92	4	7.46	SB	0.143	
2	Jarret EATON	USA	24 Jun 89	7	7.47		0.129	
3	Aurel MANGA	FRA	24 Jul 92	5	7.54		0.169	
4	Aries MERRITT	USA	24 Jul 85	1	7.56		0.141	
5	Pascal MARTINOT-LAGARDE	FRA	22 Sep 91	3	7.68		0.154	
6	Gabriel CONSTANTINO	BRA	9 Feb 95	2	7.71		0.176	
7	Roger IRIBARNE	CUB	2 Jan 90	8	7.77		0.172	
	Milan TRAJKOVIC	CYP	17 Sep 92	6	DQ 162.8		0.084	F1

NOTE IAAF Rule 162.8 - False Start

Timing and Measurement by SEIKO AT-60H-M-f--1--.RS1..v1 Issued at 17:06 on Sunday, 04 March 2018

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METHODS

Five vantage locations for camera placement were identified and secured. Each location had the capacity to accommodate multiple cameras placed on tripods. Three locations were situated on broadcasting platforms around the stadium whilst one was located in the VIP boxes to capture footage around the starting blocks and first 5 m (Figure 1). One further broadcasting platform was secured parallel to the first 10 m of the 60 m track (Figure 1).

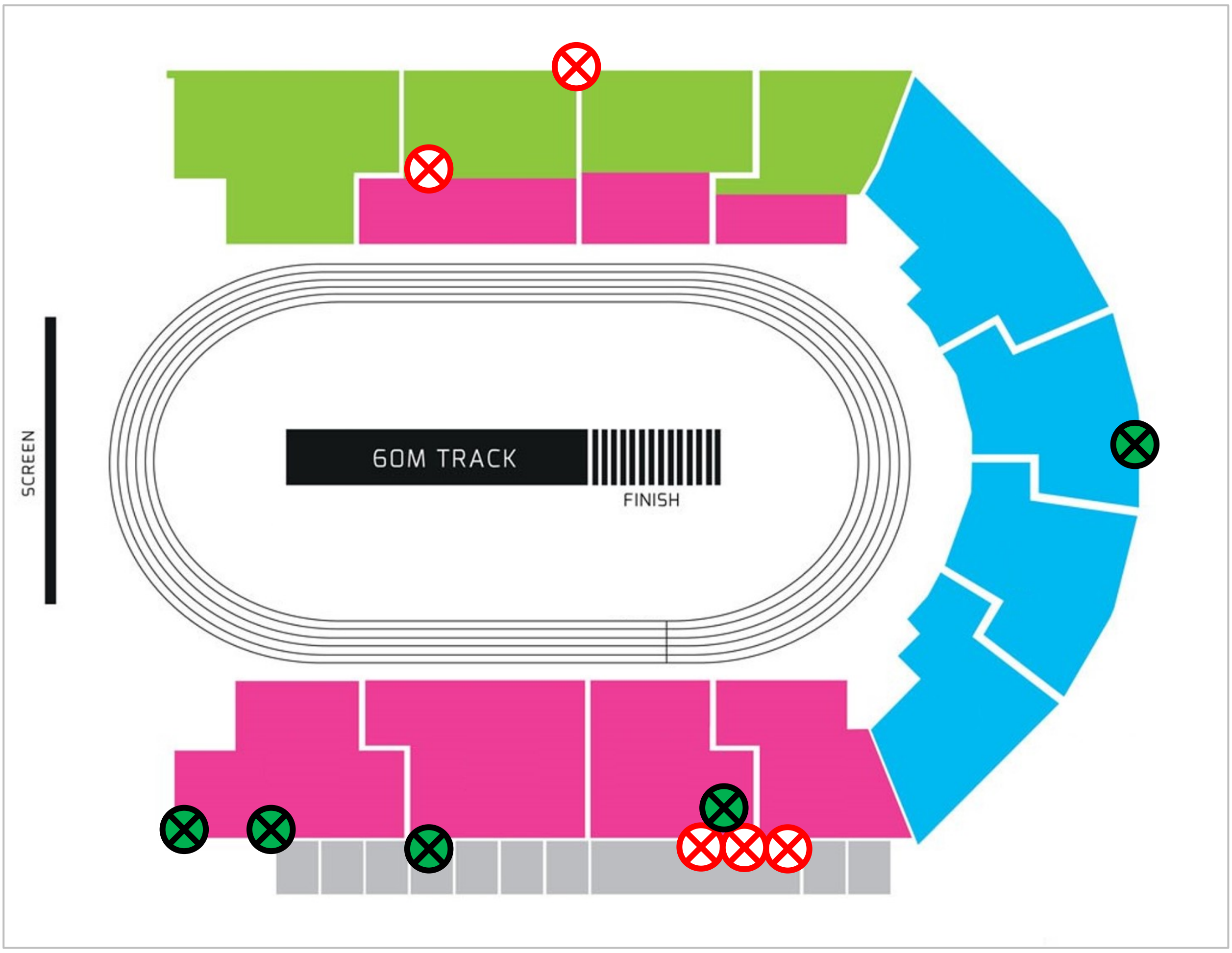

Figure 1. Camera layout for the men's 60 m hurdles indicated by green-filled circles.

A calibration procedure was conducted before and after the event. A rigid cuboid calibration frame was positioned on the running surface from one metre behind the starting line to five metres beyond the start line (Figure 2). This was repeated multiple times over discrete predefined areas along and across the track to ensure an accurate definition of a volume within which athletes were in the starting blocks and would complete three steps of the race. This approach produced a large number of non-coplanar control points per individual calibrated volume and facilitated the construction of bi-lane specific coordinate systems.

Figure 2. The calibration frame was constructed and filmed before and after the competition.

In total, 11 high-speed cameras were employed to record the action during the 60 m hurdles final. One Sony PXW-FS5 camera operating at 200 Hz (shutter speed: 1/1250; ISO: 2000-4000; FHD: 1920x1080 px) was positioned strategically with its optical axis perpendicular to the running direction covering the start line to the first hurdle in order to capture motion in the sagittal plane and provide footage for the analysis of the first hurdle time. Two Sony RX10 M3 cameras operating at 100 Hz (shutter speed: 1/1250; ISO: 2000-3600; FHD: 1920x1080 px) were used in a similar way to provide further split times between the other hurdles and the final hurdle and the finish line. Four Sony PXW-FS7 cameras operating at 150 Hz (shutter speed: 1/1250; ISO: 2000-4000; FHD: 1920x1080 px) were used to capture motion of athletes within the calibrated volume around block exit and the sprint start. Each of the four Sony PXW-FS7 cameras was paired with an additional Sony RX10 M3 camera operating at 100 Hz as a precaution against the unlikely event of data capture loss.

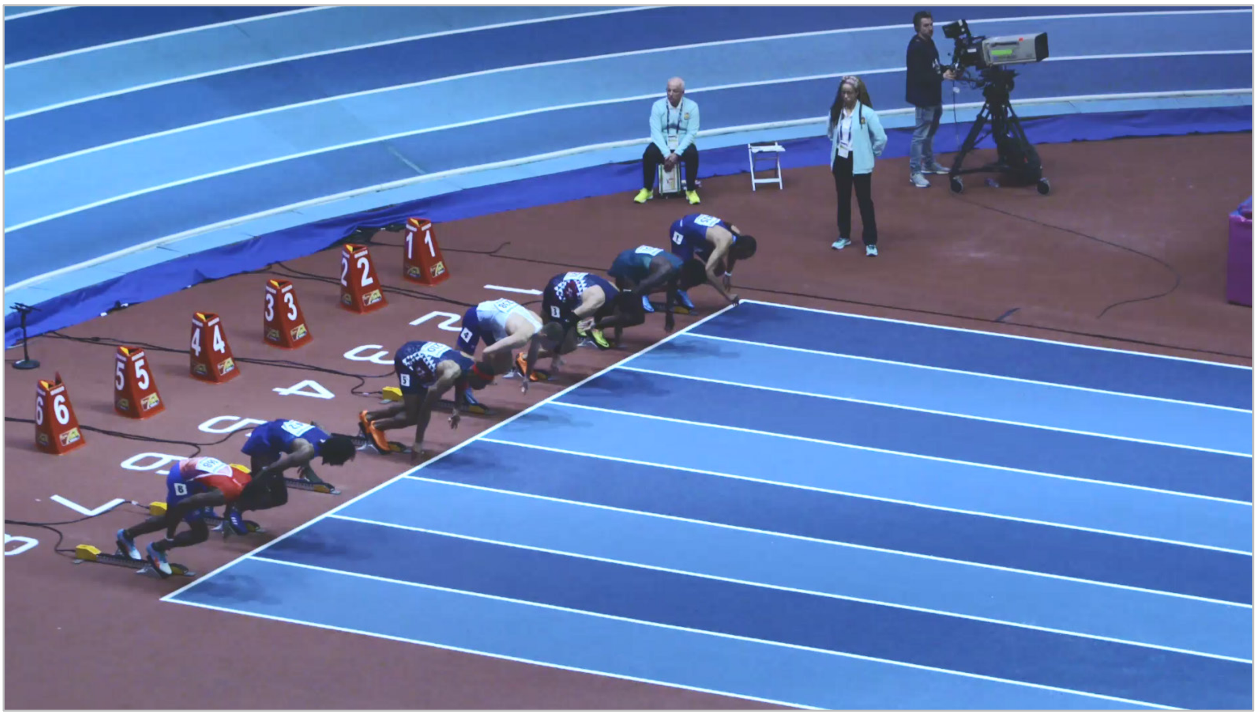

Figure 3. The block start of the men's 60 m hurdles final.

The video files were imported into SIMI Motion (SIMI Motion version 9.2.2, Simi Reality Motion Systems GmbH, Germany) and were manually digitised by a single experienced operator to obtain kinematic data. An event synchronisation technique (synchronisation of four critical instants) was applied through SIMI Motion to synchronise the two-dimensional coordinates from each camera involved in the recording. The digitising was centred upon critical events of the sprint start (e.g., set position, block exit, touchdown and toe-off) to provide key kinematic information of each athlete's sprint start performance. Each file was digitised frame by frame and upon completion, adjustments were made as necessary using the points over frame method. The Direct Linear Transformation (DLT) algorithm was used to reconstruct the three-dimensional (3D) coordinates from individual camera's x and y image coordinates. Reliability of the digitising process was estimated by repeating the process for randomly selected athletes with an intervening period of 48 hours. The results showed minimal systematic and random errors and therefore confirmed the high reliability of the digitising process.

De Leva's (1996) body segment parameter models were used to obtain data for the whole body centre of mass and for key body segments of interest. A recursive second-order, low-pass Butterworth digital filter (zero phase-lag) was employed to filter the raw coordinate data. The cut-off frequencies were calculated using residual analysis. Split times and temporal kinematic characteristics were processed were processed through SIMI Motion by using the 200 Hz, 100 Hz and 150 Hz footage respectively.

Definition of a step: the table below (Table 1) contains definitions of the variables in this report. However, it may first be beneficial to outline the definition of a step. The reason for this is that, typically in coaching, the movement from block exit to initial touchdown is coined as the first step of the race. However, here we define a step as being from touchdown of the ipsilateral leg to touchdown of the contralateral leg (see step length; Table 1). As the block exit does not have an 'ipsilateral touchdown' in the first case, it cannot be defined as a step. Therefore, the movement from block exit to first touchdown has been defined as the 'block clearance distance' (Table 1), and the step succeeding this movement has been defined as the first step.

Table 1. Definitions of variables.

Variable	Definition
Double-leg push time	The time between the initial movement in the starting blocks and the first foot leaving the starting block (after reaction time).
Single-leg push time	The time between the first foot and the second foot pushing away from the starting blocks.
Total push time	The total time spent in the block phase from initial movement to block exit. Calculated as double-leg push time + single-leg push time.
Total block time	The total time spent in the block phase from the starting gun to block exit. Calculated as official reaction time (provided by Seiko) + total push time.
Block clearance distance	The anteroposterior distance between the start line and the point of ground contact at initial touchdown after block exit.
Block flight time	Time between the point of block exit and the instant of initial ground contact.
Trunk angle (α)	The angle of the trunk relative to the horizontal and considered to be 90° in the upright position.
Hip angle (γ)	The angle between the trunk and the thigh and in considered to be 180° in the anatomical standing position.
Knee angle (β)	The angle between the thigh and the lower leg and is considered to be 180° in the anatomical standing position.

Shank angle (θ)	The angle of the lower leg relative to the running surface and is considered to be 90° when the shank is perpendicular to the running surface.
Swing thigh angle (δ)	The angle between the thigh of the swing leg and the vertical.
Ankle angle (ι)	The angle between the lower leg and foot and is considered to be 90° in the anatomical standing position.
Trunk-shank angle of incidence	The difference between the trunk angle (α) and the shank angle (θ) at key events.
CM height	The vertical distance between the body's CM and running surface.
CM setback position	The anteroposterior distance between the start line and the body's CM when in the set position.
CM anteroposterior position	The anteroposterior distance between the start line and the body's CM at block exit.
CM projection angle	The sagittal plane angle of projection of the body's CM, relative to the horizontal, from the set position to the point of block exit.
Contact time	The time that the foot is in contact with the ground.
Flight time	The time from toe-off of one foot to touchdown of the other foot.
Step time	Contact time + flight time.
Step length	The distance covered from touchdown on one foot to touchdown on the other foot (foot tips).
Step frequency	The number of steps per second (Hz). Calculated as 1 / step time.
Step velocity*	Step length divided by step time.
DCM TD	The anteroposterior distance between the ground contact point (foot tip) at touchdown and the body's CM.
DCM TO	The anteroposterior distance between the ground contact point (foot tip) at toe-off and the body's CM.

Hurdle split times#	Duration between each hurdle, between the start line and the first hurdle, and between the final hurdle and the finish line. Identified as the point at which the athlete's chest crosses directly above the hurdle.
Time to hurdle	Time taken to cross each hurdle from start of the race. Cumulative hurdle split times.
Athlete ranking	Ranking of each athlete at each hurdle. Determined by the hurdle split time, as described above.

Note: *CM = centre of mass.*

Step velocity calculation: please note that step velocity (marked in Table 1 with *) has been specifically chosen for coaching purposes. Although we feel a fully tracked CM horizontal velocity to be the most accurate method of presenting the velocity of movement, the method of presenting step velocity (step length divided by step time) is the most reproducible in a coaching setting due to equipment and time constraints, as well as being most commonly used when analysing maximal velocity sprinting. Step velocity has previously been compared against digitised CM velocity and the two methodologies show good levels of agreement and consistency, even though the values are changing substantially at this stage of the race. We therefore provide this variable in this way to provide concise yet accurate velocity data.

Hurdle split time calculation: please note that the hurdle split times in this report (marked in Table 1 with #) have been determined by the point at which the athlete's chest crosses directly above the hurdle. Although the typical method employed by coaches is to determine a hurdle split by the time that the athlete touches down beyond the hurdle. However, this method may not be the most appropriate in this setting, as determining the exact frame of take-off and touchdown can be difficult due to athletes being blocked by other athletes. Further, the method in this report also corroborates more closely with the method used for the official timings recorded at the finish line.

Temporal rankings: throughout this report, there are tables showing the rankings of each athlete for certain temporal variables at key events in the race. Apart from the athlete ranking at each hurdle (Table 1), these rankings do not indicate the athletes' actual positions in the race, but which athlete ranked first in this specific variable (e.g., time to first touchdown). These rankings are based on the cumulative times seen throughout the report, including the reaction time provided by Seiko.

RESULTS

Temporal and kinematic characteristics of block clearance

The following section of results provides temporal and kinematic characteristics of the set position and block clearance for each of the seven finishers in the final. It is worth noting that all athletes took seven steps to the first hurdle (including the 'block clearance distance') during the men's final.

Table 2. Temporal characteristics of block clearance for each of the finalists.

Athlete	Double-leg push time (s)	Single-leg push time (s)	Total push time (s)	Total block time (s)
POZZI	0.220	0.160	0.380	0.523
EATON	0.198	0.207	0.405	0.534
MANGA	0.218	0.167	0.385	0.554
MERRITT	0.253	0.167	0.420	0.561
MARTINOT-LAGARDE	0.208	0.180	0.388	0.542
CONSTANTINO	0.207	0.187	0.394	0.570
IRIBARNE	0.212	0.187	0.399	0.571

Table 2 (above) shows the time each athlete spent in the different phases that make up block exit. Total push time is the sum of double-leg push time and single-leg push time, whilst total block time is the sum of the official reaction time (data provided by Seiko) and total push time. As can be seen from the results, Andrew Pozzi displayed the shortest total block time of all finalists. This allowed Pozzi to be the first athlete to exit the blocks, despite only having the third shortest reaction time (Table 3). Figure 4 (below) shows the different phases of block exit as a percentage of total block time, showing that the medallists showed potentially differing characteristics. For instance, Eaton (silver medallist) appeared to show the longest relative single-leg push phase.

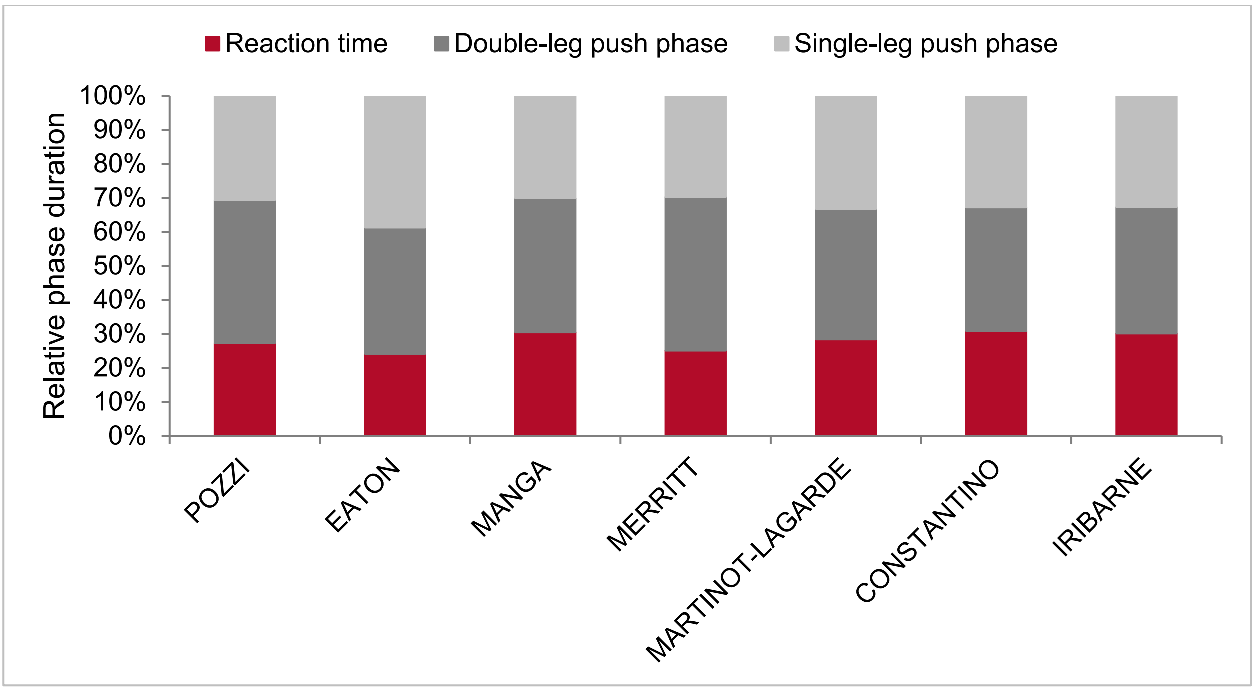

Figure 4. Relative duration of block exit phases, displayed relative to total block time for each finalist.

Table 3. Athlete rankings of key events around the sprint start. Rankings based on times.

Athlete	Ranking		
	Reaction time	Time to block exit	Time to first touchdown
POZZI	3	1	4
EATON	1	2	1
MANGA	5	4	3
MERRITT	2	5	6
MARTINOT-LAGARDE	4	3	2
CONSTANTINO	7	6	5
IRIBARNE	6	7	7

Figure 5 (below) shows the distance of block clearance (beyond the start line) for each athlete. Figure 6 (following page) shows the block flight time, which is the time taken from block exit to the first ground contact. As can be seen in Figure 5, Aurel Manga touched down closest to the start line, whilst 7th placed Roger Iribarne touched down furthest from the start line at initial touchdown. Figure 6 again shows contrasting patterns within the medallists, with Andrew Pozzi displaying the longest block flight time amongst all athletes (0.107 s), whereas Eaton showed the shortest (0.040 s).

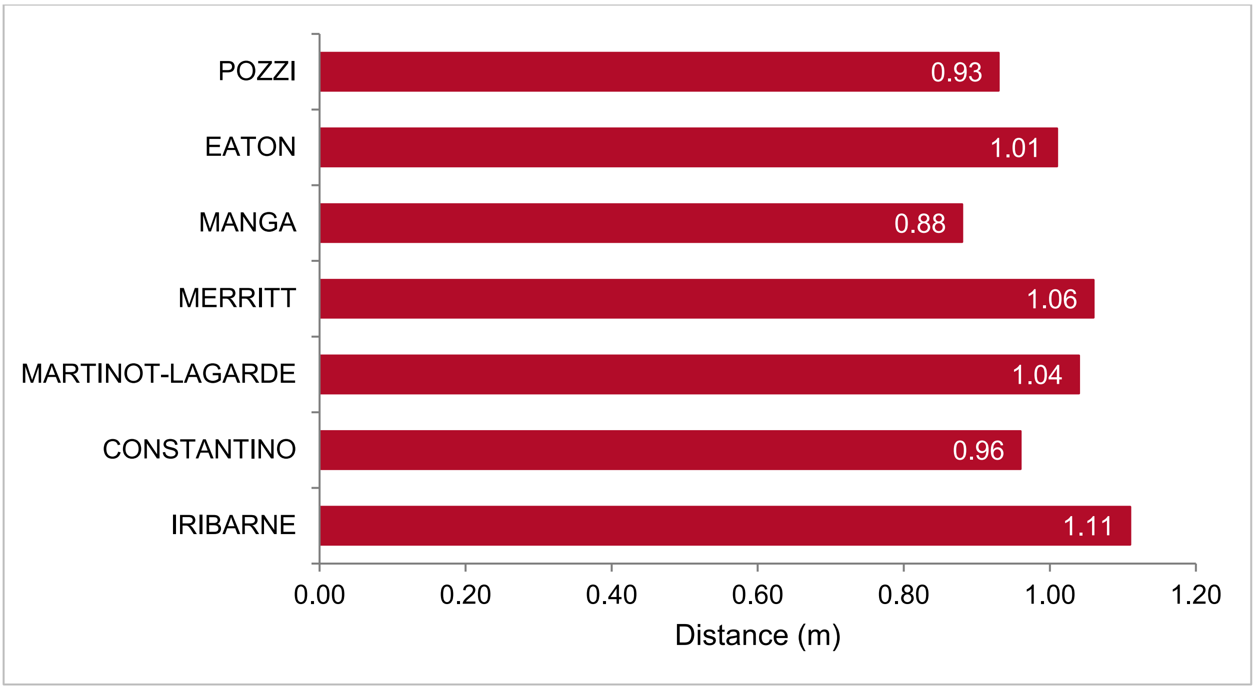

Figure 5. Block clearance distance (horizontal distance between start line and point of initial ground contact) for each of the finalists.

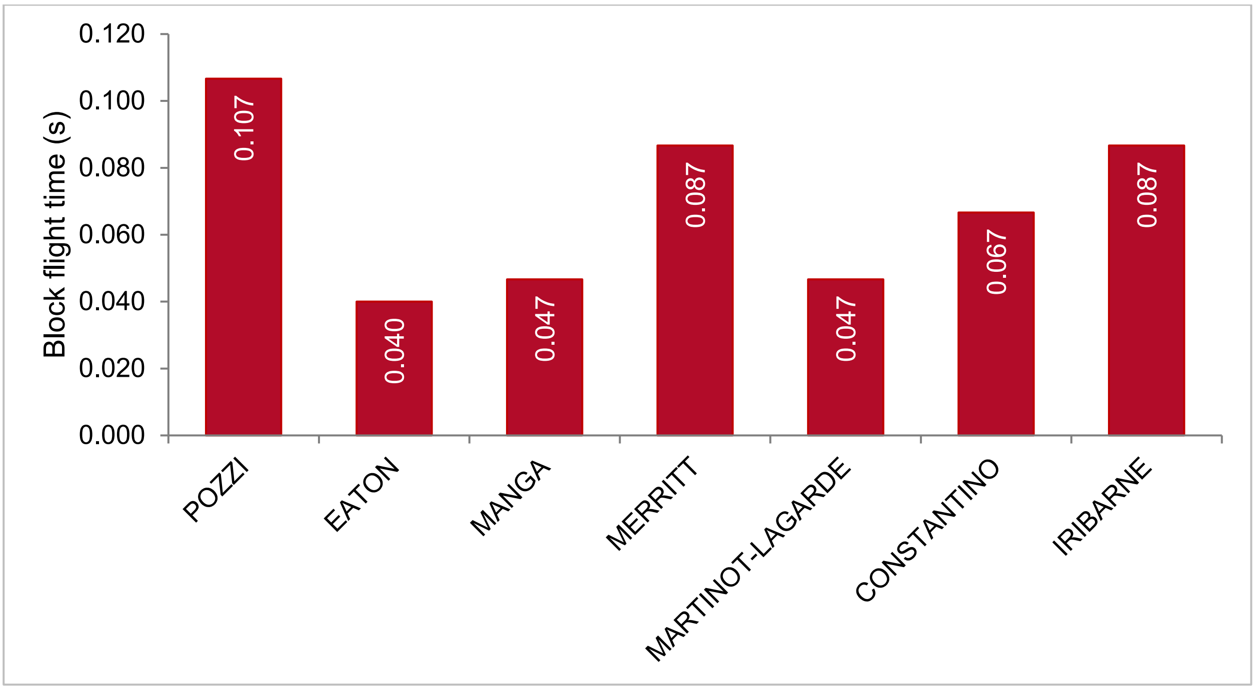

Figure 6. Block flight time (from block clearance to initial ground contact) for each of the finalists.

The fact that Pozzi showed clearly the highest block flight time (Figure 6) may explain why he was ranked 1st out of the blocks, but ranked 5th in terms of time to first touchdown (Table 3).

The following pages display the postural characteristics of each athletes' block set position. Figure 7 is designed to display a typical set position, and does not accurately represent any athlete in the field.

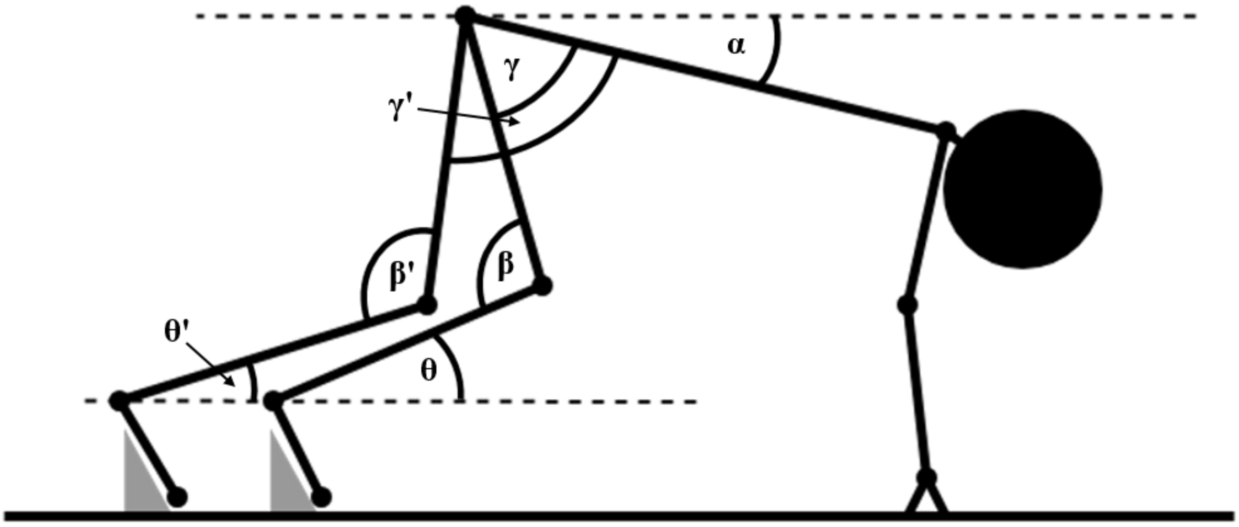

Figure 7. Body schematic denoting joint and segment angles measured in the set position.

Table 4. Joint and segment kinematics in the set position of the sprint start for all finalists.

Athlete	Joint angle (°)						
	α	γ	γ'	β	β'	θ	θ'
POZZI	−15.9	29.2	104.9	84.6	111.0	41.9	23.0
EATON	−24.7	29.8	77.7	95.2	133.0	37.9	33.0
MANGA	−19.4	47.8	58.8	98.8	105.2	31.0	27.8
MERRITT	−9.0	27.4	58.0	76.0	83.7	41.2	15.9
MARTINOT-LAGARDE	−22.4	39.7	86.8	100.5	140.8	36.8	32.2
CONSTANTINO	−13.2	33.3	68.0	79.0	98.7	30.1	19.6
IRIBARNE	−17.1	41.1	64.8	95.1	105.9	35.4	24.9

Note: *A negative trunk angle indicates the trunk is angled downwards (the shoulders are below the hips).*

As can be seen from Table 4, all athletes showed a negative trunk angle in the set position. This makes sense, although no clear trend can be seen within the field for any joint angle in the set position. The following page displays postural characteristics for each finalist at the point of block exit. As was the case with Figure 7, Figure 8 is designed to display a typical block exit, and does not accurately represent any athlete in the field.

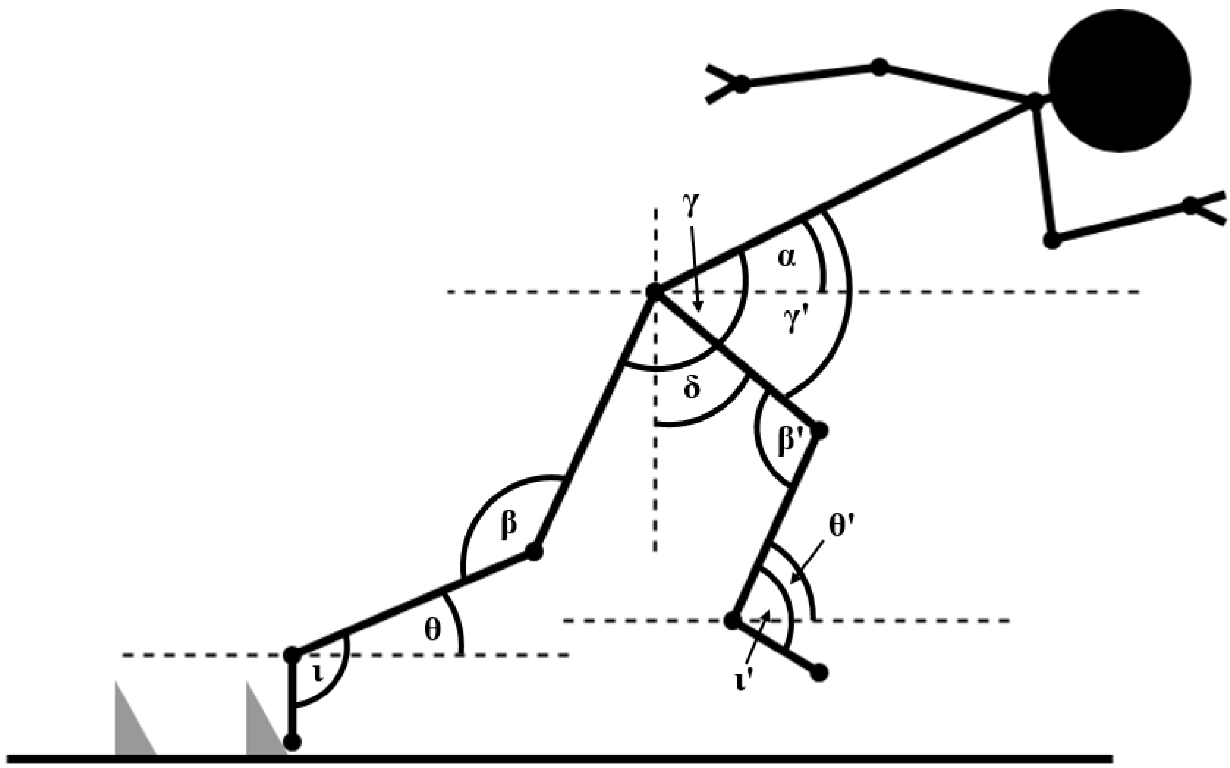

Figure 8. Body schematic denoting joint and segment angles measured at block exit.

Table 5. Joint and segment kinematics at the instant of block exit for all finalists.

Athlete	Joint angle (°)									
	α	γ	γ'	δ	β	β'	θ	θ'	ι	ι'
POZZI	32.6	173.6	119.4	53.1	179.5	72.6	37.4	36.0	134.7	84.0
EATON	42.1	176.5	68.8	64.5	168.7	79.7	27.2	54.5	132.6	92.2
MANGA	45.6	177.5	80.1	61.8	162.2	75.9	24.8	48.0	144.7	85.1
MERRITT	29.0	165.4	61.5	59.0	176.8	63.8	39.6	35.0	121.6	86.2
MARTINOT-LAGARDE	46.3	174.2	73.8	66.7	166.9	77.5	27.7	53.9	140.3	88.7
CONSTANTINO	49.6	177.5	82.8	60.5	158.6	75.9	26.9	46.2	154.6	84.3
IRIBARNE	44.4	177.9	83.1	56.8	174.2	63.8	32.8	31.4	139.5	88.9

Note: *The 2-D schematic above should not be used as a model to combine angles as different landmarks have been used for defining certain joint angles.*

As can be seen from Table 5, Andrew Pozzi (32.6°) and Aries Merritt (29.0°) appeared to show a lower trunk angle (angle α) than the other finalists (42.1 – 49.6°) at block exit. Pozzi also showed the most extended knee joint in the push-off leg (angle β) amongst the finalists (179.5°).

The following figure shows the angle of incidence between the trunk (angle α) and the trailing shank (angle θ), thus an angle of zero would indicate the trunk and shank segments are in parallel alignment. An incidence angle close to zero has potential connections to the direction of the force vector being produced by the athlete to the start block.

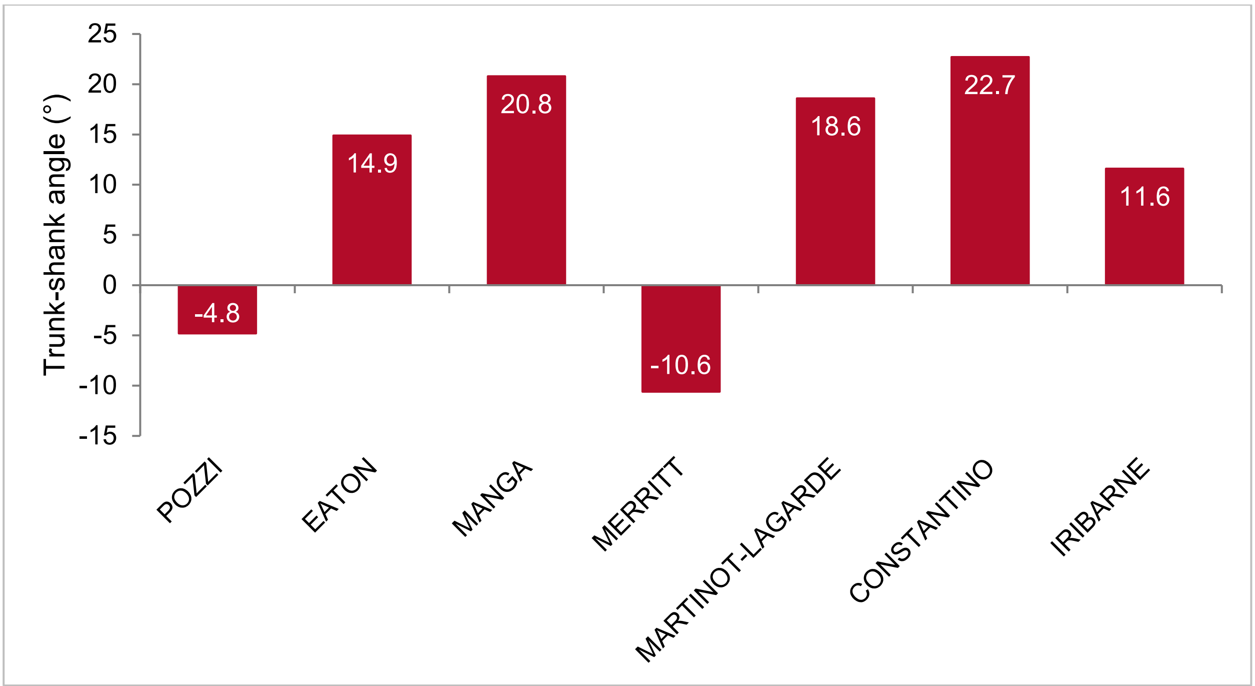

Figure 9. Trunk-trailing shank angle of incidence ($\alpha-\theta$) at block exit for each of the finalists.

The following series of tables and figures refers to body CM parameters around the set position and block exit. Table 6 shows the height of the CM whilst in the set position and the anteroposterior distance of the CM behind the start line. CM setback positions ranged from 0.04 to 0.28 m, whilst CM height ranged from 0.65 to 0.72 m.

Table 6. Height and setback position of the centre of mass whilst in the set position for each finalist.

Athlete	CM height in set position (m)	CM setback position (m)
POZZI	0.65	0.28
EATON	0.66	0.14
MANGA	0.67	0.13
MERRITT	0.68	0.11
MARTINOT-LAGARDE	0.72	0.10
CONSTANTINO	0.69	0.04
IRIBARNE	0.66	0.08

Note: *CM = centre of mass. For the CM setback position, a positive value indicates the athlete's CM is behind the start line*.

Figure 10 shows the CM position of each athlete at the point of block exit. Coordinates of the CM are displayed relative to the start line (the start line is the origin in the figure). Beneath Figure 10, Figure 11 shows the CM projection angle from the set position to block exit for each of the finalists. This projection angle indicates the direction the CM is travelling at the point of block exit; 0° would indicate a horizontal direction, where 90° would indicate a vertical direction of travel.

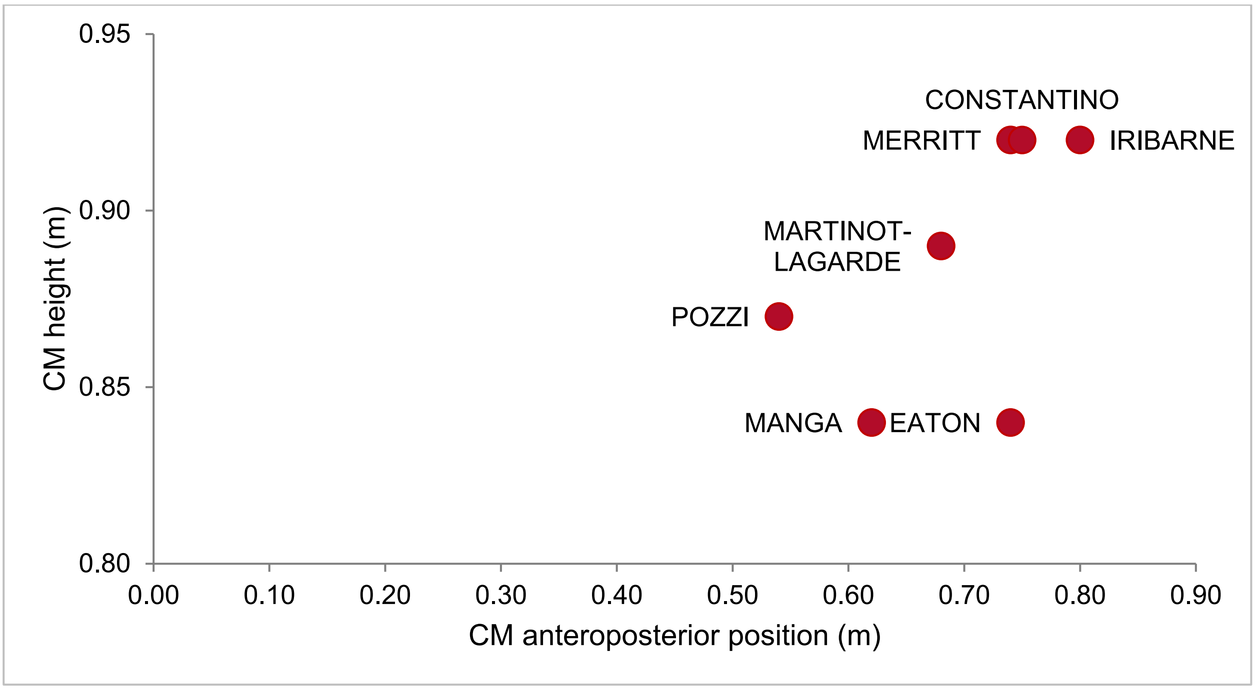

Figure 10. CM position (relative to the start line) for each finalist at the instant of block exit.

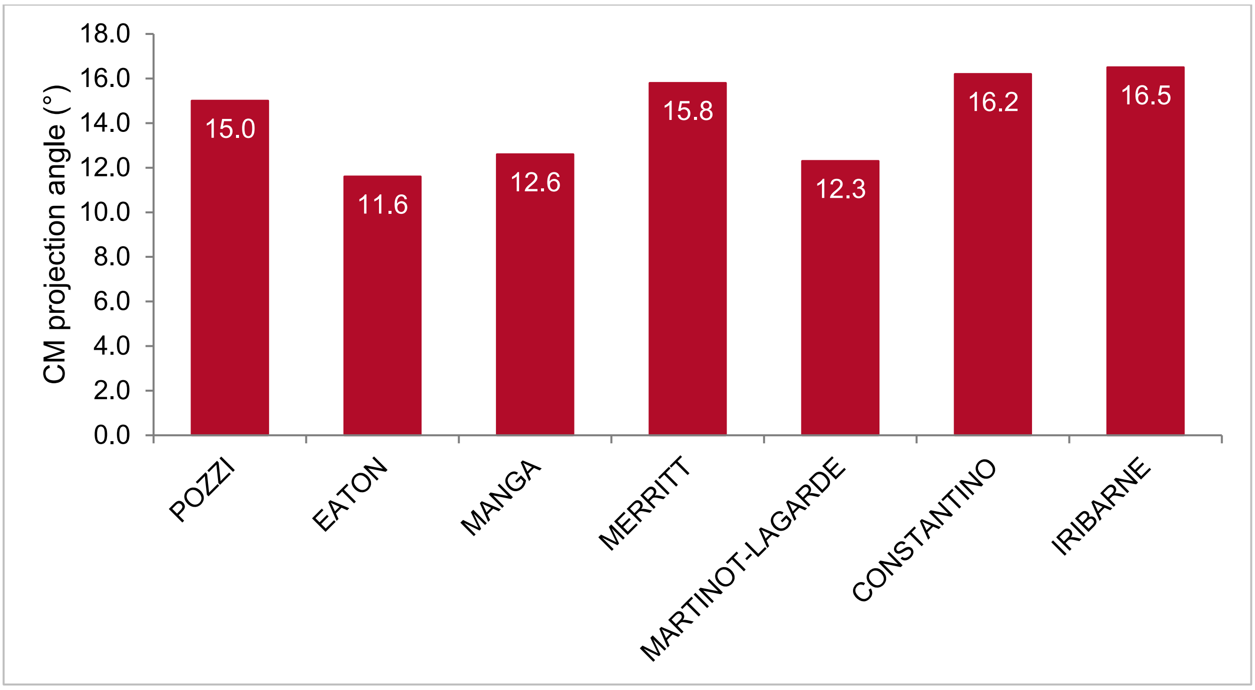

Figure 11. CM projection angle from set position to block exit for each finalist.

Temporal characteristics of the sprint start

The following section of results shows the temporal characteristics of the sprint start. Specifically, the first three steps of the race have been analysed for each athlete.

Table 7. Contact times of the first three steps of the race for each finalist.

Athlete	Contact time (s)		
	1st step	2nd step	3rd step
POZZI	0.180	0.153	0.133
EATON	0.247	0.173	0.140
MANGA	0.240	0.193	0.173
MERRITT	0.167	0.167	0.153
MARTINOT-LAGARDE	0.247	0.153	0.160
CONSTANTINO	0.207	0.167	0.180
IRIBARNE	0.187	0.147	0.140

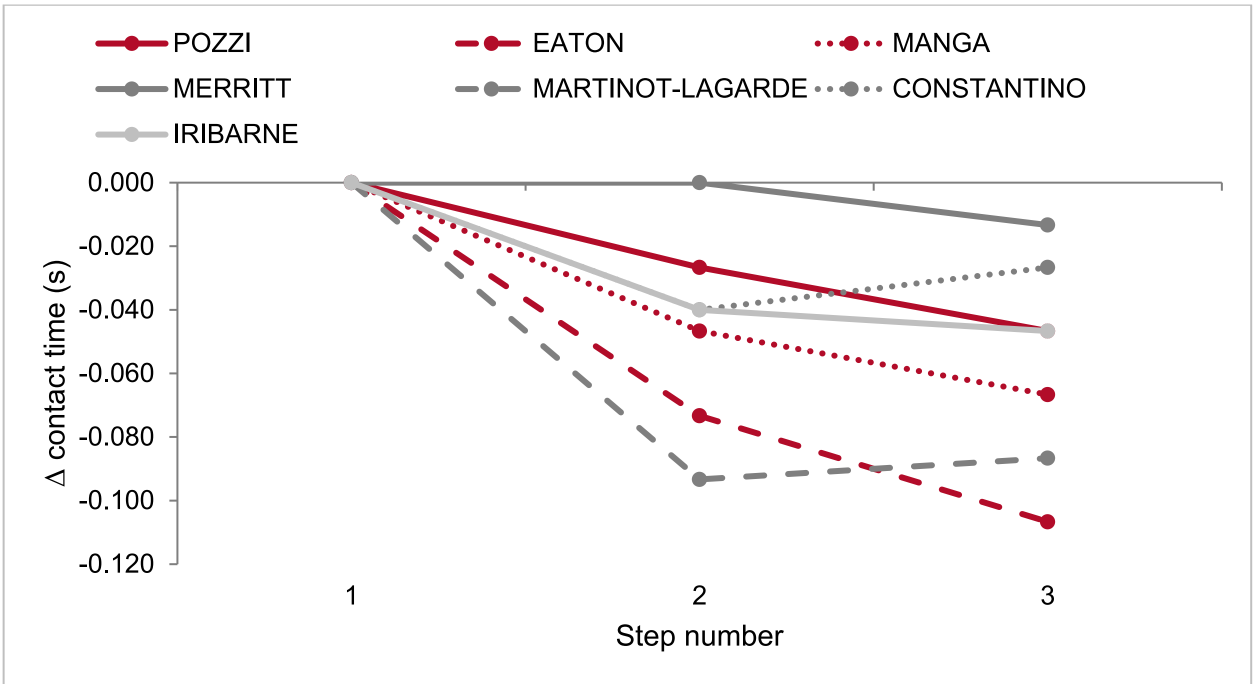

Figure 12. Change in ground contact time throughout the first three steps (1-2, 1-3) of the race for all (first contact is used as zero reference point for the other two contacts).

Table 8. Flight times of the first three steps of the race for each finalist.

Athlete	Flight time (s)		
	1st step	2nd step	3rd step
POZZI	0.093	0.100	0.107
EATON	0.053	0.087	0.100
MANGA	0.060	0.060	0.073
MERRITT	0.087	0.087	0.107
MARTINOT-LAGARDE	0.080	0.080	0.093
CONSTANTINO	0.073	0.073	0.107
IRIBARNE	0.093	0.093	0.107

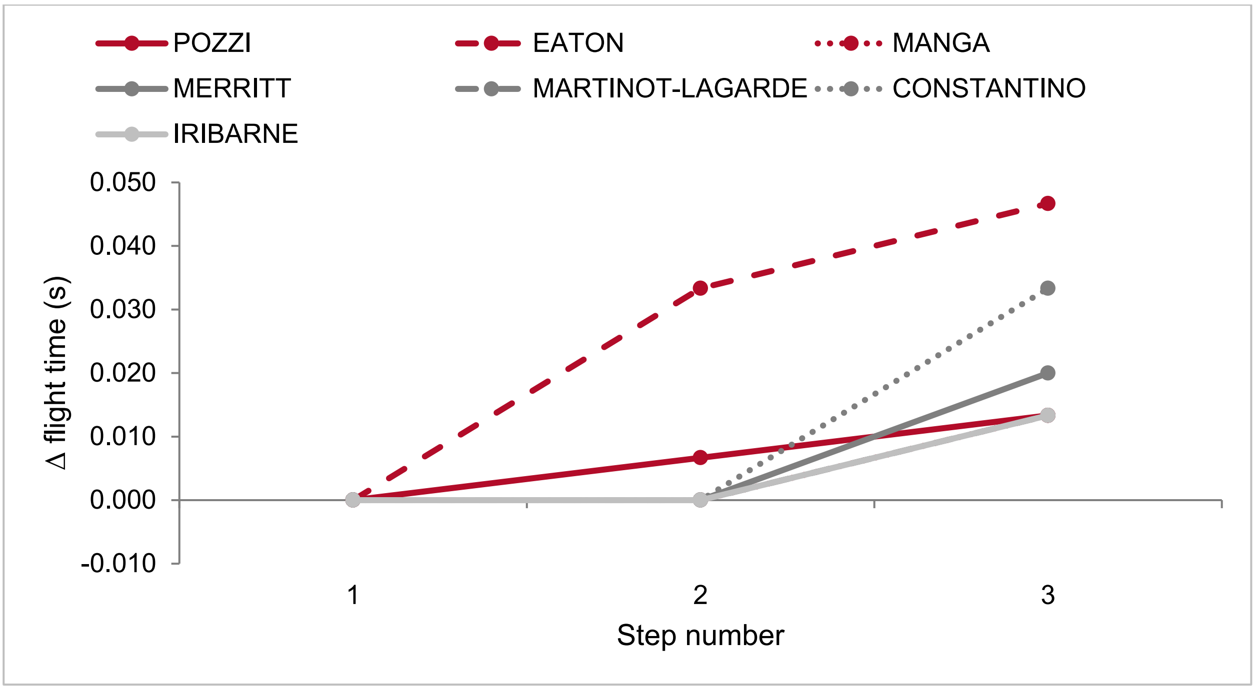

Figure 13. Change in flight time throughout the first three steps (1-2, 1-3) of the race for all finalists (first flight is used as zero reference point for the other two flights).

Table 9. Step times of the first three steps of the race for each finalist.

Athlete	Step time (s)		
	1st step	2nd step	3rd step
POZZI	0.273	0.253	0.240
EATON	0.300	0.260	0.240
MANGA	0.300	0.253	0.246
MERRITT	0.254	0.254	0.260
MARTINOT-LAGARDE	0.327	0.233	0.253
CONSTANTINO	0.280	0.240	0.287
IRIBARNE	0.280	0.240	0.247

Note: *Step times have been rounded to three decimal places.*

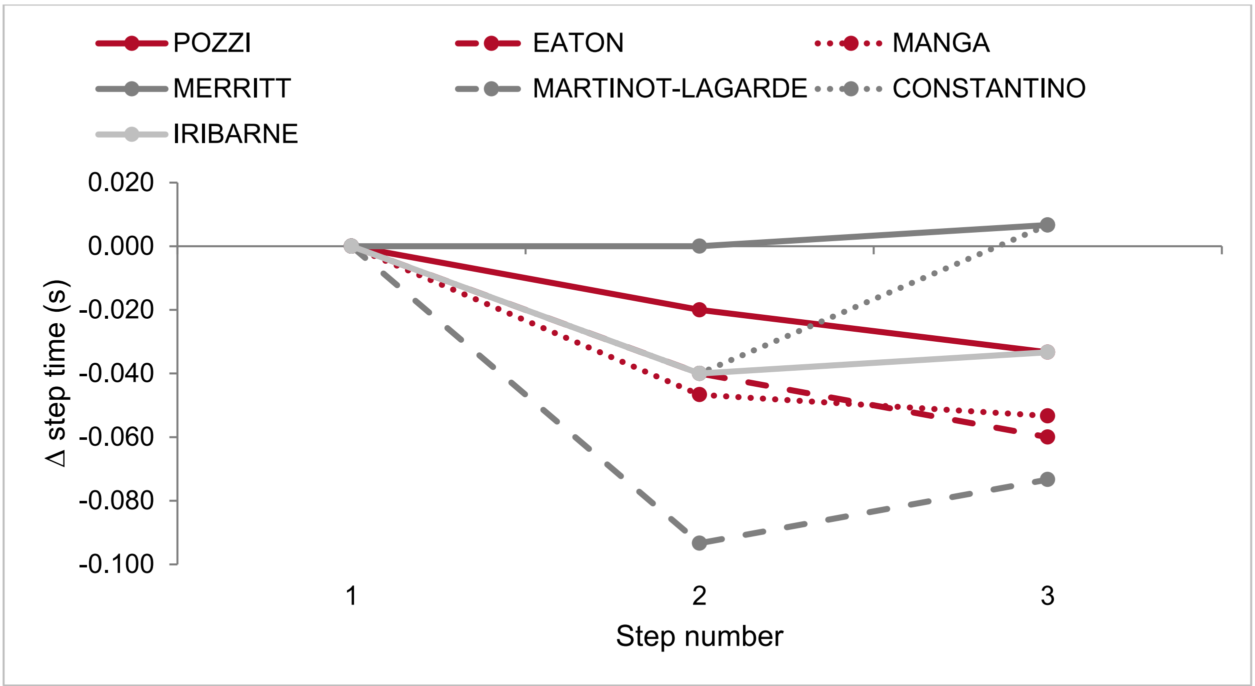

Figure 14. Change in step time throughout the first three steps (1-2, 1-3) of the race for all finalists (first step is used as zero reference point for the other two steps).

The following table shows the athletes' ranking to second, third and fourth ground contact. It should be noted here that this might not be indicative of the actual race rankings at these events, as touchdown time is individual to each athlete. Instead, these rankings provide an indication of which athletes reach their second, third and fourth steps earlier than other athletes do.

Table 10. Athlete ranking for second, third and fourth touchdowns (TD).

Athlete	Ranking		
	2nd TD	3rd TD	4th TD
POZZI	4	5	2
EATON	1	1	1
MANGA	=2	=3	3
MERRITT	=2	=3	5
MARTINOT-LAGARDE	5	2	4
CONSTANTINO	6	6	7
IRIBARNE	7	7	6

Kinematic characteristics of the sprint start

The following section of this report shows the kinematic characteristics of the three steps of the race for each athlete.

Table 11. Step lengths and step frequencies of the first three steps for each of the finalists.

Athlete	Variable	1st step	2nd step	3rd step
POZZI	Step length (m)	1.45	1.53	1.76
	Step frequency (Hz)	3.66	3.95	4.17
EATON	Step length (m)	1.37	1.55	1.74
	Step frequency (Hz)	3.33	3.85	4.17
MANGA	Step length (m)	1.43	1.55	1.70
	Step frequency (Hz)	3.33	3.95	4.05
MERRITT	Step length (m)	1.26	1.62	1.73
	Step frequency (Hz)	3.95	3.95	3.85
MARTINOT-LAGARDE	Step length (m)	1.32	1.54	1.69
	Step frequency (Hz)	3.06	4.29	3.95
CONSTANTINO	Step length (m)	1.27	1.66	1.83
	Step frequency (Hz)	3.57	4.17	3.49
IRIBARNE	Step length (m)	1.45	1.55	1.83
	Step frequency (Hz)	3.57	4.17	4.05

As can be seen from Table 11, athletes tended to increase their step length throughout the first three steps. This is typical for an acceleration phase of a sprint, as increasing both parameters will result in an increase in running speed. That being said, increasing step frequency is another means of achieving the same outcome (increasing running speed), but only the three medallists tend to show a progressive increase in step frequency throughout the first three steps. The other finalists tend to increase from the first step to the second, but then cannot increase again in the third step. It may also be worth noting that the gold and silver medallists showed the highest step frequency in the third step (4.17 Hz). Figure 15 (below) shows the step velocity for the first three steps of the race. Step velocity was calculated from step length and step time. With the exception of Iribarne (7th place), the three medallists showed the highest step velocity of the third step.

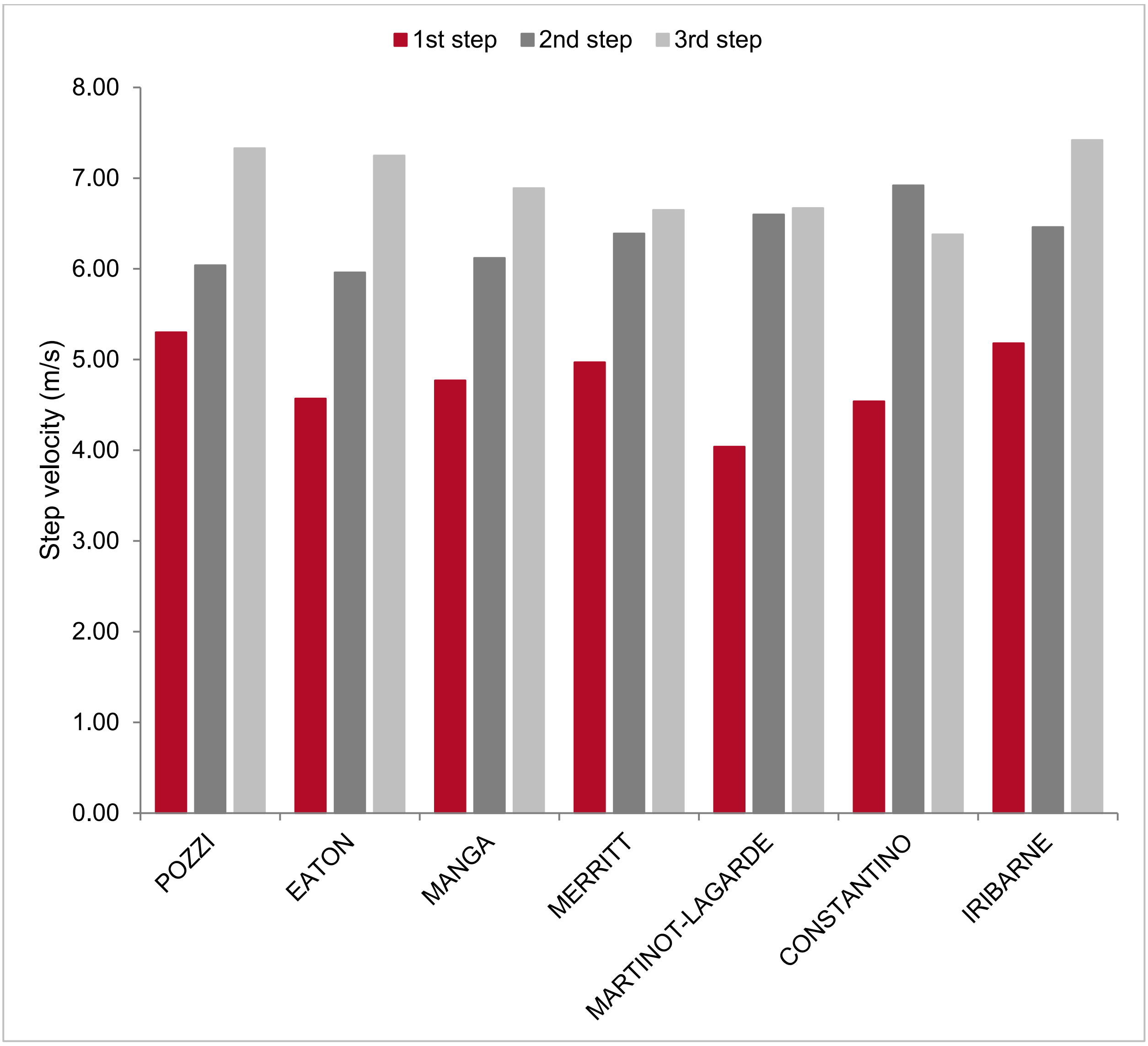

Figure 15. Step velocity for the first three steps of the race for each of the finalists.

The following two pages show the postural characteristics of each athlete's touchdown for the first three steps. Figure 16 is designed to display a typical touchdown posture and does not accurately represent any athlete in the field.

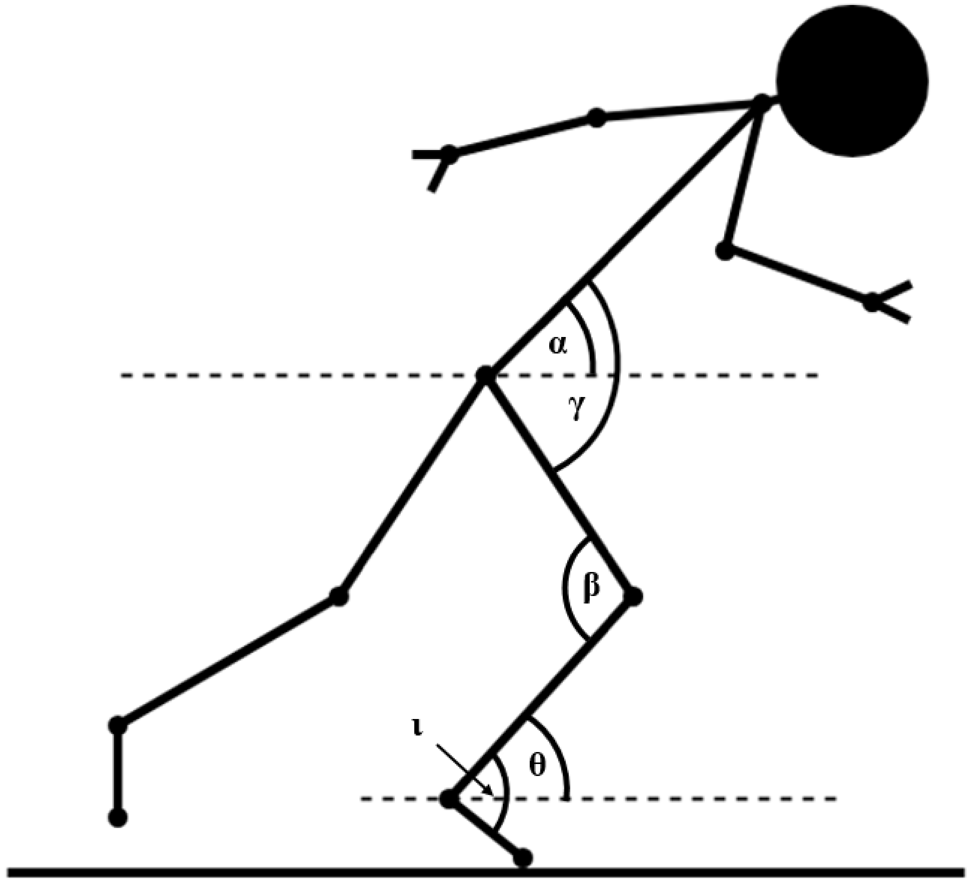

Figure 16. Body schematic denoting joint and segment angles measured at touchdown.

Table 12. Joint and segment angles at touchdown for the three medallists.

Athlete	Step number	Joint angle (°)				
		α	γ	β	θ	ι
POZZI	1	42.4	141.1	106.7	43.2	81.5
	2	49.0	117.2	117.6	55.1	94.3
	3	53.6	140.9	118.5	58.3	89.6
EATON	1	43.3	79.6	90.5	52.8	87.3
	2	42.7	88.6	103.4	56.4	97.4
	3	51.1	108.9	121.0	60.3	99.5
MANGA	1	48.2	93.5	88.7	48.2	88.5
	2	52.1	89.9	94.6	58.7	97.2
	3	59.0	102.0	104.1	65.2	94.9

Table 13. Joint and segment angles at touchdown for the remaining finalists.

Athlete	Step number	Joint angle (°)				
		α	γ	β	θ	ι
MERRITT	1	38.5	102.0	113.8	48.7	86.9
	2	44.0	108.7	122.2	61.9	97.6
	3	48.0	98.5	118.1	67.2	93.5
MARTINOT-LAGARDE	1	51.5	94.6	89.4	53.3	85.3
	2	52.9	105.0	100.7	47.0	94.3
	3	57.8	112.0	109.6	60.6	96.2
CONSTANTINO	1	51.5	106.2	92.4	39.9	86.4
	2	57.8	111.6	100.2	45.1	92.3
	3	55.6	97.3	106.3	66.2	89.6
IRIBARNE	1	39.4	101.2	100.3	42.4	90.4
	2	46.0	102.2	108.1	50.1	87.4
	3	50.9	110.7	115.9	58.7	94.1

Athletes tend to increase trunk angle (angle α) throughout the sequence of ground contacts. The progression in trunk angle indicates a transition from the block start towards high velocity running. This is of particular importance in the hurdles, as the athletes have a limited number of steps (typically 7 or 8) to form a posture that will ensure a successful clearance of the first hurdle. Most athletes generally showed a more acute shank angle (angle θ) at touchdown of the first step (average: 46.9°) when compared to the second and third ground contacts (averages: 53.5° and 62.4°, respectively). The following pages show the athletes' postural characteristics at toe-off for the first three steps. As with Figure 16, Figure 17 is designed to show a typical toe-off posture and does not accurately represent any athlete in the field.

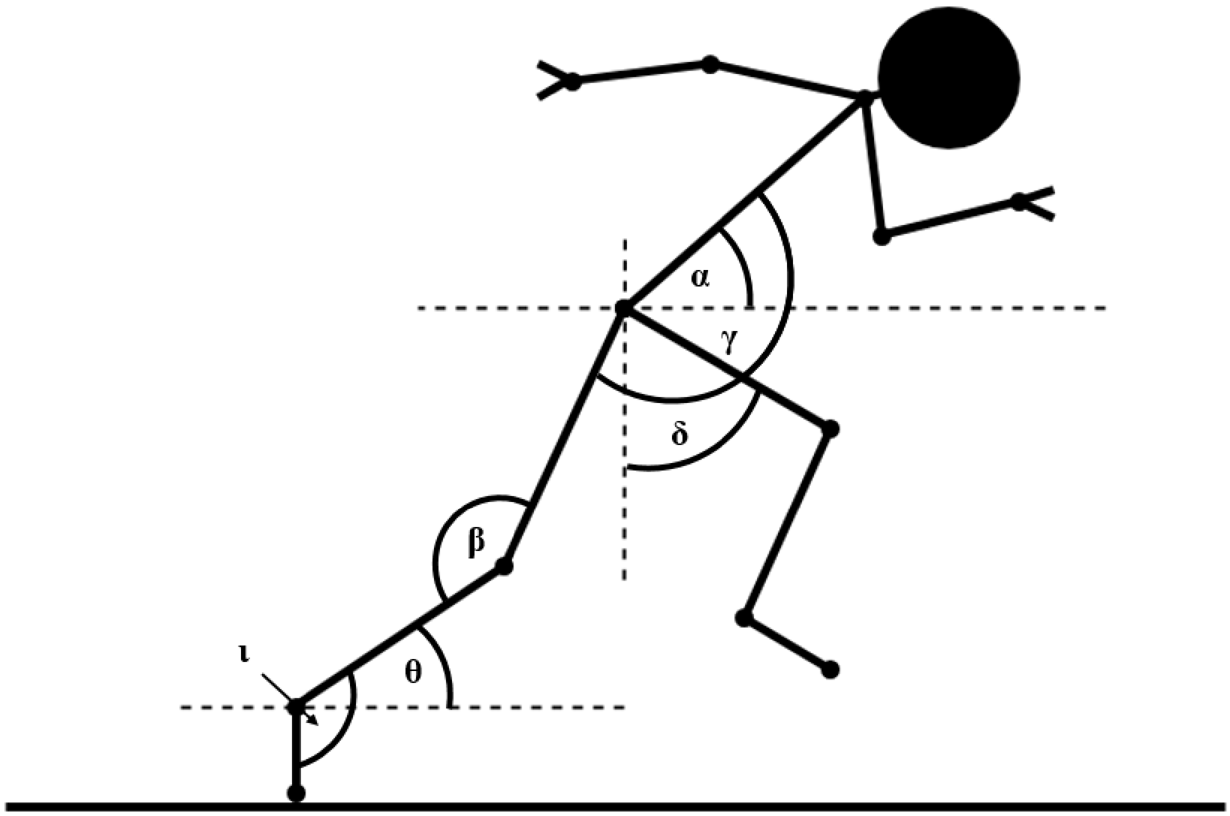

Figure 17. Body schematic denoting joint and segment angles measured at toe-off.

Table 14. Joint and segment angles at toe-off for the three medallists.

Athlete	Step number	Joint angle (°)					
		α	γ	δ	β	θ	ι
POZZI	1	50.5	173.7	70.7	168.2	36.2	129.0
	2	49.4	176.7	73.3	171.7	37.0	120.9
	3	56.8	169.6	76.3	171.8	40.4	122.2
EATON	1	41.5	168.3	65.7	153.7	24.6	134.4
	2	50.8	177.4	66.8	169.8	37.0	142.1
	3	51.5	171.3	75.3	166.4	37.3	130.9
MANGA	1	53.7	176.8	74.3	158.0	29.3	143.3
	2	60.7	177.1	71.4	153.7	28.7	141.8
	3	61.2	174.1	72.2	162.1	32.1	131.5

Table 15. Joint and segment angles at toe-off for the remaining finalists.

Athlete	Step number	Joint angle (°)					
		α	γ	δ	β	θ	ι
MERRITT	1	43.8	168.1	67.4	167.6	38.7	123.2
	2	41.8	173.1	70.3	173.2	40.3	145.8
	3	56.1	175.8	75.7	163.9	37.8	131.7
MARTINOT-LAGARDE	1	53.6	175.4	75.1	161.6	28.7	131.1
	2	61.3	171.6	75.0	163.5	32.5	128.4
	3	55.8	173.5	75.2	161.0	35.1	123.9
CONSTANTINO	1	54.4	178.8	73.2	158.5	29.8	139.9
	2	63.3	171.4	71.6	162.0	33.3	159.6
	3	58.9	176.0	72.1	158.4	30.4	131.8
IRIBARNE	1	42.5	169.1	66.5	162.5	32.3	129.2
	2	53.1	177.5	74.4	167.8	36.9	121.4
	3	53.0	174.1	67.1	169.0	39.9	123.7

Figure 18 (below) shows the change in trunk angle throughout the first three steps at toe-off. As previously mentioned, athletes tend to show a progressive increase in trunk angle at both touchdown and toe-off. According to Figure 18, Pozzi and Merritt were the only two athletes to show a reduction in trunk angle from toe-off of the first step to toe-off of the second step. This is interesting, as these also showed a notably lower trunk angle at block exit than the other athletes (Table 5). These athletes then showed a sharper increase at step number three, whereas the other athletes tended to increase only slightly, or even slightly decrease.

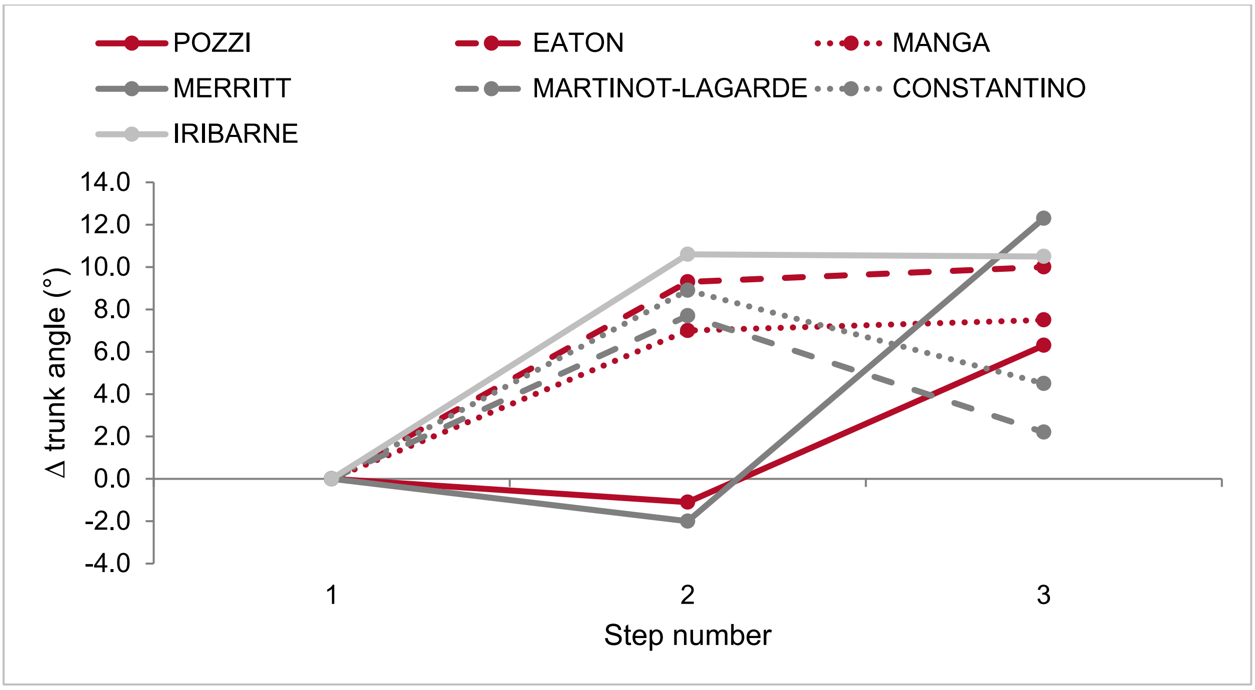

Figure 18. Change in trunk angle at toe-off throughout the first three steps (1-2, 1-3) of the race for all finalists (first toe-off is used as zero reference point for the other two toe-offs).

The following two pages contain four tables (Tables 16-19). Tables 16 and 17 show the trunk-shank angle of incidence at touchdown and toe-off, respectively, for the first three steps of the race. Tables 18 and 19 show the anteroposterior location of the CM relative to the point of ground contact, both at touchdown (Table 18) and toe-off (Table 19). Data are shown for the first three steps of the race. As can be seen from Table 18, some athletes touch down with their CM ahead of the point of ground contact. This may corroborate with some of postural characteristics shown previously.

Table 16. Trunk-shank angle of incidence at touchdown for the first three steps for each of the finalists.

Athlete	Trunk-shank angle (°)		
	1st step	2nd step	3rd step
POZZI	−0.8	−6.1	−4.7
EATON	−9.5	−13.7	−9.2
MANGA	0.0	−6.6	−6.2
MERRITT	−10.2	−17.9	−19.2
MARTINOT-LAGARDE	−1.8	5.9	−2.8
CONSTANTINO	11.6	12.7	−10.6
IRIBARNE	−3.0	−4.1	−7.8

Table 17. Trunk-shank angle of incidence at toe-off for the first three steps for each of the finalists.

Athlete	Trunk-shank angle (°)		
	1st step	2nd step	3rd step
POZZI	14.3	12.4	16.4
EATON	16.9	13.8	14.2
MANGA	24.4	32.0	29.1
MERRITT	5.1	1.5	18.3
MARTINOT-LAGARDE	24.9	28.8	20.7
CONSTANTINO	24.6	30.0	28.5
IRIBARNE	10.2	16.2	13.1

Table 18. Anteroposterior distance to the centre of mass (DCM) at touchdown (TD) for the first three steps for each of the finalists.

Athlete	DCM TD (m)		
	1st step	2nd step	3rd step
POZZI	0.07	−0.01	−0.06
EATON	−0.10	−0.04	−0.02
MANGA	−0.06	−0.17	−0.22
MERRITT	0.07	−0.04	−0.16
MARTINOT-LAGARDE	−0.15	0.02	−0.16
CONSTANTINO	0.07	0.02	−0.27
IRIBARNE	0.08	0.05	−0.06

Note: *A negative values shows that the body's CM is behind the point of ground contact, whereas a positive value means that CM is ahead of the ground contact point.*

Table 19. Anteroposterior distance to the centre of mass (DCM) at toe-off (TO) for the first three steps for each of the finalists.

Athlete	DCM TO (m)		
	1st step	2nd step	3rd step
POZZI	0.91	0.83	0.78
EATON	1.03	0.95	0.88
MANGA	1.00	0.94	0.89
MERRITT	0.80	0.91	0.81
MARTINOT-LAGARDE	0.93	0.84	0.83
CONSTANTINO	0.91	0.92	0.87
IRIBARNE	0.97	0.87	0.86

Note: *A negative values shows that the body's CM is behind the point of ground contact, whereas a positive value means that CM is ahead of the ground contact point.*

Figures 19 and 20 show the progression of the CM vertical projection at key events around the sprint start. Figure 19 (below) contains the three medallists, whereas Figure 20 (bottom of page) contains the remaining finalists. The key events are made up of the set position (SP), block exit (BE), and each subsequent touchdown (TD1-3) and toe-off (TO1-3) for the first three steps. All values are represented relative to the values of SP.

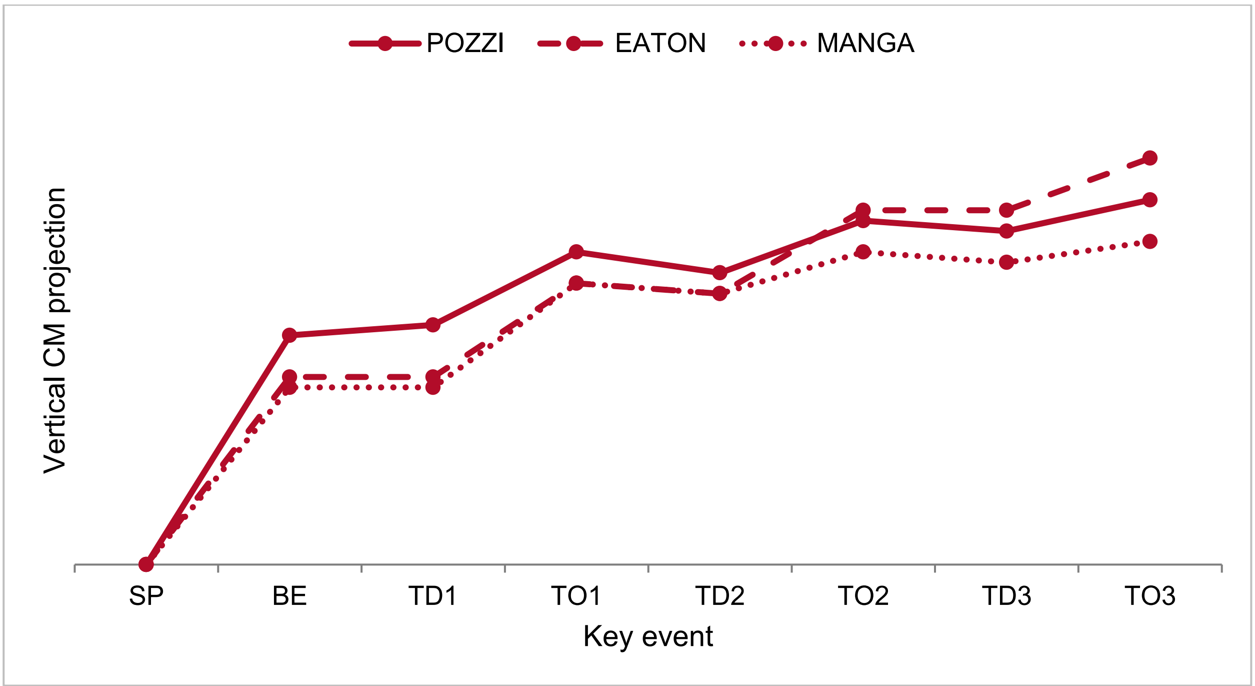

Figure 19. Vertical projection of the CM pathway throughout multiple key events during the sprint start for the medallists only.

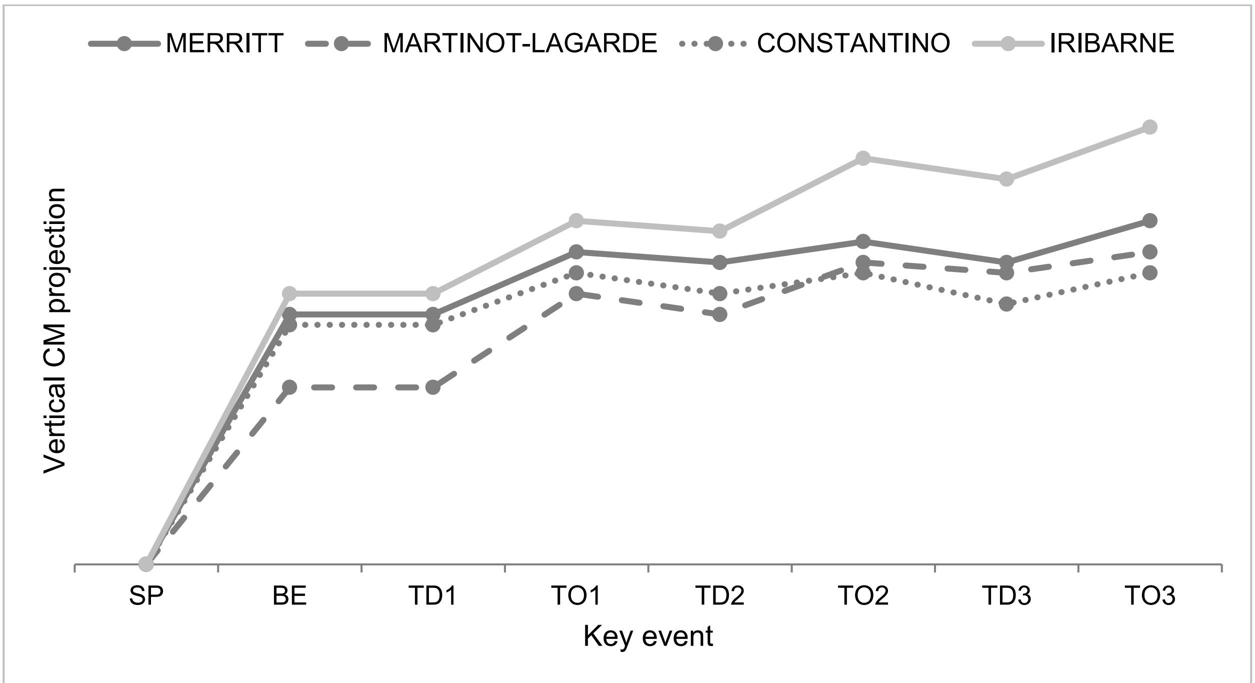

Figure 20. Vertical projection of the CM pathway throughout multiple key events during the sprint start for the remaining four finalists.

Hurdle split time analysis

The following section of results concerns each athlete's split time between each hurdle, as well as the cumulative split times and athlete rankings throughout the race. Table 20 (below) shows the individual split times for each athlete, between the start line and the first hurdle, between hurdles, and from the final hurdle to the finish line. As can be seen from Table 20, gold medallist Andrew Pozzi was the only athlete to have two sub-one second between-hurdle splits (H3 – H4: 0.99 s; H4 – H5: 0.99 s). No athlete displayed a between-hurdles split time shorter than 0.99 s and only the medallists managed to display at least one sub-one second split at some point in the race (Pozzi: H3 – H4 and H4 – H5; Eaton: H3 – H4; Manga: H4 – H5). Compared to the other two medallists, Eaton shows a relatively slow run-in to the line (H5 – FINISH: 0.95 s).

Table 20. Athlete split times between the start line and hurdle 1 (H1), between each hurdle (H1 – H5) and between H5 and the finish line.

Athlete	Hurdle split times (s)					
	START – H1	H1 – H2	H2 – H3	H3 – H4	H4 – H5	H5 – FINISH
POZZI	2.51	1.03	1.05	0.99	0.99	0.89
EATON	2.47	1.02	1.02	0.99	1.02	0.95
MANGA	2.57	1.06	1.05	1.01	0.99	0.86
MERRITT	2.53	1.05	1.04	1.01	1.01	0.92
MARTINOT-LAGARDE	2.55	1.06	1.09	1.04	1.03	0.91
CONSTANTINO	2.58	1.07	1.06	1.03	1.05	0.92
IRIBARNE	2.52	1.06	1.10	1.09	1.06	0.94

Note: *'Start – H1' includes reaction time. Data have been rounded to two decimal places.*

On the next page, Table 21 shows the cumulative race time for each athlete and Figure 21 shows the athlete ranking at each hurdle, based on cumulative split times. As can be seen from Figure 21, the top two finishers (Pozzi and Eaton) were in the top two race positions at H1, highlighting the importance of an effective block exit and sprint start. Even though the gold and silver medallists were in first and second place for the entire race, Manga had to recover from a poor start to move into third place only after the final hurdle.

Table 21. Time to each hurdle and the finishing time for each of the finalists.

Athlete	Time to each hurdle (s)					
	H1	H2	H3	H4	H5	FINISH
POZZI	2.51	3.54	4.59	5.58	6.57	7.46
EATON	2.47	3.49	4.51	5.50	6.52	7.47
MANGA	2.57	3.63	4.68	5.69	6.68	7.54
MERRITT	2.53	3.58	4.62	5.63	6.64	7.56
MARTINOT-LAGARDE	2.55	3.61	4.70	5.74	6.77	7.68
CONSTANTINO	2.58	3.65	4.71	5.74	6.79	7.71
IRIBARNE	2.52	3.58	4.68	5.77	6.83	7.77

Note: *'H1' includes athlete reaction times. Data have been rounded to two decimal places.*

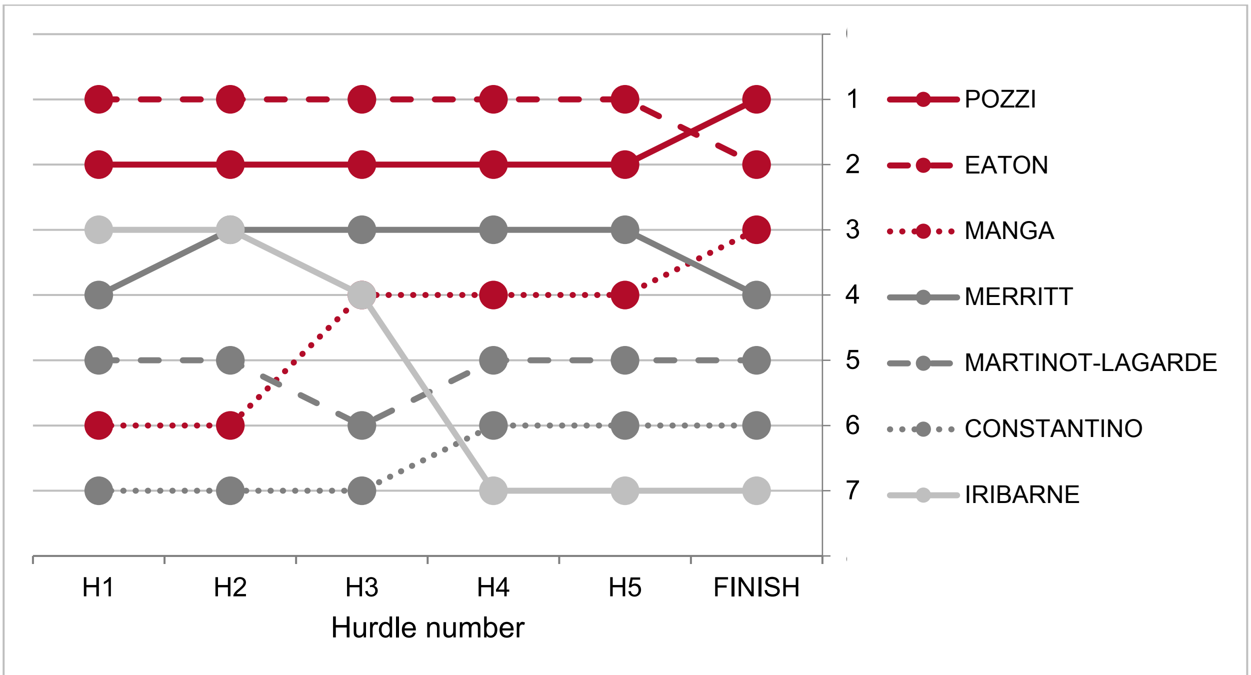

Figure 21. Athlete ranking at each hurdle throughout the final.

COACH'S COMMENTARY

Coaching commentary – Matthew Wood

As a spectacle, the men's high hurdles are arguably among the most eagerly anticipated events at any World Championships. To the neutral observer the sense of jeopardy and skill allied with the global field on display help to make this a must watch event at the Birmingham Championships. In something of an "athletics Ryder Cup", the best of European and homegrown talent went head to head with the top USA sprint hurdlers. A home victory for Andrew Pozzi added to the atmosphere that inevitably surrounded the event. To win gold male hurdlers must be capable of making real time adaptations under extreme competitive pressure. In an event of small but significant margins male hurdlers, and therefore their coaches, face a unique set of challenges compared to other event groups.

The tension at the start of the race potentially resulted in a false start from one athlete. The subsequent race start, analysed in these data, was therefore the second or reset start. This may have some bearing on subsequent performances and could perhaps account for the range of reaction times recorded. A tactic might have been for athletes to 'sit' in the blocks rather than anticipate the gun and perhaps risk triggering a second false start and therefore elimination. The makeup of individual total block times reflects the unique physical capabilities and anthropology of each athlete. All seven successful finalists utilised a seven-stride approach to hurdle one. This requires a relatively long first step from the blocks, however we see from the data this too is highly individual. Coaches of male sprint hurdlers therefore need to consider the optimal block and acceleration strategy for their specific athlete.

Presenting each athlete's total block time as a percentage of total time for each of the phases is an interesting approach, and further highlights the individual solutions demonstrated in the final. Coaches should therefore be cautious in their interpretation of a good start in sprint hurdles. For example, an advantage of a fast reaction may result in a less optimal push phase resulting in reduced block projection. The knock on effect to subsequent steps may be detrimental to the ultimate goal of the start in hurdles, which is to achieve an optimal take-off for hurdle one. In effect, athletes who rush in the blocks may limit their ability to accelerate aggressively in the initial three steps. Starting success is therefore less about making the steps fit the space, but is essentially a puzzle of how the athlete achieves that fit in order to set up the first hurdle clearance.

A key debate, certainly for coaches working with male hurdlers, is whether to perform seven or eight steps to hurdle one. The current data suggest that a crucial characteristic required of an athlete in order to execute a seven-step start successfully is the ability to transfer force horizontally from the blocks in the initial three steps. Caution should perhaps be applied when attempting to identify seven steppers purely based upon limb length, as Aries Merritt demonstrates, an excellent ability to project from the starting blocks is essential to executing a seven step approach despite being one of the shortest hurdles athletes.

It is common practice for hurdles coaches to work with step lengths as a way of modelling the hurdles event. The data presented here yet again shows very adeptly how unique each athletes' personal solution is to the approach of hurdle one. Despite there being an observable consistency across all the performances in this final, the differences in quantitative data suggests that coaches need to design practice tasks that reflect the athletes' individual capabilities in order to achieve the most effective coaching intervention possible.

The inclusion of block set up and the resulting analysis of the shape athletes are able to achieve on block exit is enlightening as once again it promotes that coaches need to adopt an experimental approach to coaching the hurdle start. The athletes in the final displayed an individual rhythm of acceleration that is critically influenced by the interaction between the athletes initial set up and their capabilities to apply forces. The lower trunk angles displayed by Pozzi and Merritt perhaps reflect their need to achieve horizontal distance but require a relatively longer time to do this than Eaton who covers a comparative distance in a shorter time. The three medallists demonstrate an ability to increase step frequency in harmony with increases in step length. This is particularly advantageous to hurdlers adopting a seven-step approach in order to establish a functional frequency between the hurdles. The debate between either an eight- or seven-step start being optimal has been concerned with the need to generate stride frequency into the first hurdle above a potential advantage that fewer steps and therefore greater stride length may offer. However, it would appear that the medallists in this instance have found individual solutions to achieve a balance of stride length, to make the seven steps, and frequency to achieve an effective hurdle take-off. Coaches therefore should focus their efforts on developing athletic competencies on block exit whilst balancing the need for stride frequency into the first hurdle.

It is clear from the data that the hurdle start position is distinctive compared to that for a sprint start. Some of this variation may be attributed to the individual differences in physique. The necessity to achieve an optimal shank angle for accelerative purposes, as with sprinters, is balanced with hurdlers along with a requirement to make the steps required to reach the first hurdle take-off. Those athletes capable of achieving an optimal block exit that affords good acceleration as well as making the required step length potentially create an optimum situation to achieve a higher velocity at hurdle take-off. The attempt to represent the data relative to a reference value (such as set the set position height or ideally athlete stature) is valuable for coaches as in a real world coaching environment coaches' face this same challenge.

As is expected, athletes increase trunk angle as the number of steps progresses from the blocks. Pozzi and Merritt demonstrate lower trunk angles on block exit and in their second step in comparison to the other finalists. This results in a more noticeable transition between the intentions to push (accelerate) and increase frequency. Both of these athletes seemingly have the ability to achieve high frequency whilst intentionally being patient in the acceleration of the first three steps. Eaton's approach to hurdle one reflects a superior ability to achieve both horizontal projection in conjunction with frequency; this is an impressive ability to have. Coaches should be aware that an athletes' ability to transition between acceleration and higher velocity upright postures is a necessary skill for developmental hurdlers to master. The use of variation as a stimulus for learning has potential benefits in this respect and coaches should be mindful, especially with younger hurdlers, not to become overly specialised to competition parameters but enable athletes to adapt their step lengths and stride frequency to achieve a variety of take-off tasks e.g., long jump.

A common coaching analysis tool is to take the touchdown time from each hurdle rhythm unit. The data presented here corroborates a widely accepted coaching rule that an aspirational unit time should be one second. This infers that one potential strategy coaches could adopt is to design representative tasks that expose athletes to hurdle clearances at one-second intervals. This could be achieved by either lowering the hurdle to afford faster clearances and subsequent running speeds or by manipulating the hurdle spacing to an optimum scale for the individual athlete. However, coaches may be reluctant to do this as they may adopt a strategy of adapting the athlete to the competition specifications. The later strategy may be an appropriate strategy for senior athletes however this may be short sighted in the developmental categories.

The chart representing each athlete's race position at each point of the race is of particular interest to coaches. The key take away message is one that returns us to our first observation; the men's high hurdles is an event beset with potential twists and turns at each hurdle. Athletes therefore need to be capable of staying in the moment and remain attentive until the finish line. The task therefore for male hurdlers is to strike an optimal balance between stride length and frequency that affords a high velocity take-off before each hurdle with the minimum loss of centre of mass height, therefore maintaining their velocity between the hurdles. The athletes' ability to be in the moment right to the end of the race is exemplified by the switching of places in the final segment of the race between Eaton and Pozzi, for silver and gold respectively, and Manga who runs himself into a Bronze medal position. In conclusion, the men's 60 m Hurdles event at world level is characterised by the significance of each segment of the race, from start to finish.

Historical analysis and coaching commentary – Pierre-Jean Vazel

For the first time, a comprehensive biomechanical study on 60m hurdles is published. This commentary will be divided in two parts: an exploration of the evolution of the approach to the first hurdle, and interviews of the 3 medallists who share their personal experience of the Birmingham final from a technical point of view.

The 2018 edition of the IAAF World Indoor Championships confirmed a trend in men's 60m hurdles initiated in the current decade: the generalisation of the 7 steps approach to the first hurdle. For the second time in history, after the 2014 edition, all the finalists opted for this option instead of the traditional 8 steps start (number of 7 and 8 steppers among the finalists for each world indoor championship edition).

Location	7 steps	8 steps
1985 - Paris	2	4
1987 - Indianapolis	3	5
1989 - Budapest	0	6
1991 - Sevilla	1	7
1993 - Toronto	2	6
1995 - Barcelona	1	7
1997 - Paris	0	8
1999 - Maebashi	0	8
2001 - Lisboa	1	7
2003 - Birmingham	1	7
2004 - Budapest	1	7
2006 - Moskva	1	7
2008 - Valencia	1	7
2010 - Doha	3	5
2012 - Istanbul	4	4
2014 - Sopot	8	0
2016 - Portland	7	1
2018 - Birmingham	8	0

However, this revolution is not accompanied by faster times. The best non-qualifying marks have remained relatively stable since the turn of the century (average mark for all the editions per decade):

- 1980s - 7.870 s
- 1990s - 7.670 s
- 2000s - 7.616 s
- 2010s - 7.622 s

While the 7 steps approach has been tried for a century, mainly in Europe during the seventies and eighties, Cuban Dayron Robles was the first international star to be successful with, as he broke the 110m hurdles world record in 2008 with 12.87 s. The Americans had immediate success switching from 8 to 7 steps, as David Oliver made the change in the Fall of 2009 and the following summer lowered the national record to 12.90 s. The World Record was improved to 12.80 s in 2012 by Aries Merritt, who used 8 steps since his debuts as a High School Freshman in 1999 and didn't do 7 steps until Fall of 2011 (Behm 2018). These successes, among others, seem to have inspired a generation of hurdlers to adopt the 7 steps. One less step implies to either change the hurdling leg or switch the starting block pads. Athletes would usually feel comfortable to use the same leg in front of the blocks as the one which will make the impulse before the first hurdle, which occurs while using 8 steps approach. However, powerful hurdlers might come too close to the hurdle at take-off, hence have the choice to either move the starting-blocks a little back from the start line, or switch feet on the block pads and use 7 steps approach.

Empirically, it is commonly believed that the 8 step approach favours an orientation towards step frequency while the 7 step approach implies needs more amplitude in the steps. The documentation in the Birmingham 2018 reports provides data on step length for the first 3 steps for 60m hurdles final as well as 60m dash. The comparison of the total distance covered in the first 3 steps from the blocks in hurdle races and flat races supports these hypotheses.

Event	Distance covered over the first 3 steps (m)	Range (m) (min-max)
60m hurdles	4.69	4.55 – 4.83
60m dash	3.85	3.53 – 3.99

Even if we take in account the fact that body height influences step length and hurdlers finalists were taller than the sprinters (mean body height 1.88 m vs 1.77 m), the difference in the distance covered for the first three steps clearly shows that the 7 steps forces hurdlers to use longer steps as they would in a sprint race. For example, during 2006 world indoor championships, Terrence Trammell competed in both 60m hurdles (gold medal, 7.43 s) and 60m (bronze, 6.54 s). At the 10 metre mark, using 7 steps approach for the first hurdle, he did 6.1 steps, while for the 60m dash he did 7.1 steps.

For 8 step starters, the distance covered is usually around 3.60 m in elite male hurdlers which is shorter than what sprinters do. Therefore, the 13.72 m distance (15 yards) between the starting-line and the first hurdle – a convention since 1864 - is tricky and implies a choice for the hurdler: to start using either a high frequency or a high amplitude, but not a median way which would be optimum to reach the highest running velocity. Moving the first hurdle back by a meter would allow that. In this aspect it should be no coincidence that the 60m hurdles world record of 7.30 s, which stands since 1994, was set by Colin Jackson, an 8-step user and of relatively short of stature (1.82 m) compared to Birmingham's finalists. Jackson was using an almost identical number of steps at 10m whether he was running a 60m or a 60m hurdles, as in the 1994 European Indoor Championships where he won both titles (6.49 s and 7.38 s).

We would advise to adopt the 7 or 8 step approach depending on each hurdler's stature and ability to start fast with either an amplitude or frequency tendency. Using markers on the track and the athlete's feelings should weigh more on the decision than imitating the current world best' style. On a funny historical note, switching from 3 steps to 2 steps in the interval between the hurdles (9.14 m) has already been tested as early as 1886! A New-Yorker, Malcolm Webster Ford had his name associated with jumps (long jump world best holder with 7.085 m) rather than hurdles. In Outing magazine (Summer 1891), he recalled his experience: "I managed to negotiate four hurdles successfully but landed on the fifth all in a heap, not being able to keep on". According to Ford's calculations, using 2 steps in the interval requires a long jump over the obstacle of about 5.80m, whereas 3 steps leaves about 4.30 m for the hurdle clearance. Athletes of the XIXth century can now hurdle over lighter barriers with a smoother technique, resulting in a shorter clearance of about 3.60 m.

Interview of the medallists

Andy Pozzi, Jarret Eaton and Aurel Manga accepted to explain what they try to do technically and mentally in the different parts of the 60m hurdle race. Their precious testimony allows to put in context the row measurements and findings, and find where the personal experience of the athletes is matching or not or with the scientific observations.

ANDY POZZI (GBR) 1st 7.46 s

1.91 m, 83 kg.

Before the start "I like to be relaxed, I'll mentally rehearse my start a couple of times but I'll also be taking in the atmosphere of the stadium".

On the blocks "In the set position, my mind is completely empty and I'm ready to react to any sound."

Start to 1st hurdle "In the first steps I'm thinking about being precise in order to get a good first clearance and setting up my race. Because I run 7 steps to the first hurdle, I try to focus on strong ground contacts to make sure I am in the best possible position by the time I reach the first hurdle."

Over the hurdles "I'm trying to keep my body position high to give me a good sprinting position off the hurdle. In the final, I knew after hitting Hurdle 2 that I was slightly behind the race so I focused on really attacking the subsequent hurdles aggressively but ensuring I had good clearances and didn't hit any more hurdles"

On Birmingham's final "Throughout the World Indoors, I was very controlled at the start because I felt I had missed some preparation there due to injury but this set up my races really well. The control here meant that I could really pick up speed from Hurdle 3 to the finish line. In the final, I pushed a bit harder at the start which is why I hit Hurdle 2 heavily as I was too close from carrying a higher velocity but thankfully, I was able to recover closing the race really strongly."

JARRET EATON (USA) 2nd 7.47 s

1.95 m, 85 kg.

Before the start "I try to be empty and calm, feeling confident, having my head blanked and relaxed.".

On the blocks "I'm waiting for the gun. The slightest noise would make me react. I'm trying to be aggressive while pushing out in a straight line instead of stepping side to side. I want to be efficient in my actions."

Start to 1st hurdle "I try to drive and keep my head down for 2-3 steps before I look up and find the hurdle. I think I'm really good at my acceleration and driving to the first hurdle which gives me momentum. The start of my race has been a strength of mine."

Over the hurdles "I'm trying to keep my trail leg tight and keep my arms moving while I run through the hurdles. I can improve by keeping my hips high while I go into the hurdle and making sure that in my technique, I am nice and tall going through the hurdles."

On Birmingham's final "After crossing the line, I couldn't remember anything of the race! When I'm running it's like an autopilot in a plane. If there's a mistake or a hurdle hit, my conscience is back and I'm correcting the mistake."

AUREL MANGA (FRA) 3rd 7.54

1.90 m, 89 kg.

Before the start “My race is already visualised before getting in the starting-blocks. In Birmingham, the race was recalled after a false start, so I was afraid to make one myself. I’m consistent from the start to finish, the aspect I need to improve is my self-confidence.”.

On the blocks “The start is all about instinct. Early in the training season, I work on technical details with my coach, but the closer we get to the competition, the less technical cues we use. My blocks are always set the same way, the front blocks 2 feet from the line, the rear blocks 3 feet.”

Start to 1st hurdle “Leaving the blocks is a liberation. I drop off everything. I usually work on having the first 3 steps quite long. I switched from 8 to 7 steps in the U23 category. With 8 steps, I used to come too close to the hurdles. So I began to move the blocks back and start 1 feet away from the start line, and finally I made the change to 7 steps.”

Over the hurdles “I use cues, key words, since 2016, but never the same ones. It depends on the championships. In 2017 the cue was Smooth, then during World Champs, it was Door. This year it is the word Closed. I can’t remember what it was for Birmingham! These words give me the right aim, the right intention I’m trying to get at. I try to have a progressive acceleration through each interval, not hitting fast splits too early.”

On Birmingham’s final “I think I hit the first hurdle, I felt it during the race, and I touched the 3rd one but I only saw that one the video replay. I remember I leaned on the tape without knowing what was my ranking position.”

Interestingly, all three medallists insist on the mental aspect of the start of the race, at least during the competition. All the technical work on the start has been achieved beforehand at practice, visualisation seems to play an important role as well, so that the hurdler has nothing to think about on the blocks, and instead is calling his emotions. There is a tension between the aim to be calm and aggressive. It should be seen as paradoxical, rather complementary, as the ability to discharge the energy at the highest intensity is conditioned by a state of relaxation. In the acceleration phase to the first hurdle, it’s possible to try to connect the biomechanical findings with the description of the hurdlers. For example, the parallel between Pozzi’s words on his first steps “strong ground contacts” and the fact that his first 3 contact times are the shortest and his flight times are the longest among the finalists, covering a longer distance (4.74 m) in the process compared to the other medallists. Eaton’s impression of a good start is backed up by the split times (Table 21) and his description of driving head down can be traced in the Figure 9 with the lowest CM projection angle out of the blocks and sharp trunk inclination at take-off for each of the first steps (angle alpha, Table 14). Pozzi’s mistake at hurdle 2 is measurable as his interval goes from 1.03 s to 1.05 s before finding the right rhythm again with 0.99 s. Same for Manga at hurdle 1 with a relatively slow first interval (1.06 s, table 20), however his race format was well applied as each of his units are getting faster and was as fast as Pozzi in the last unit and the fastest of all finalists between the last hurdle and the finish line.

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