IAAF World Championships
LONDON 2017

BIOMECHANICAL REPORT

FOR THE

IAAF World Championships
LONDON 2017

Triple Jump Men's

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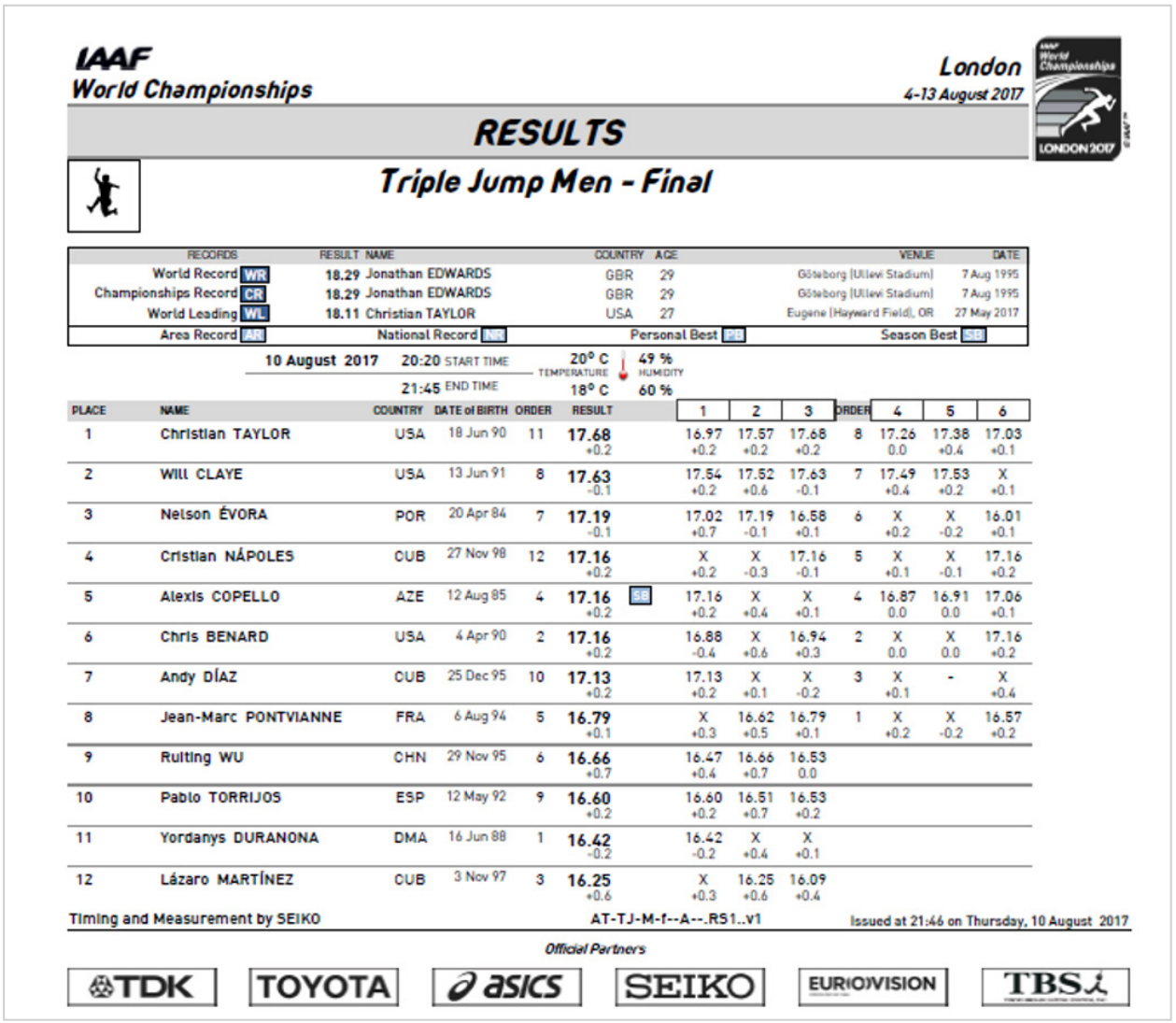
INTRODUCTION

The men's triple jump finals took place on the night of August 10th in warm and still weather conditions. Coming into the final, Christian Taylor and Will Claye, both of the USA, were strong contenders given their season leading performances. The final was a battle between the two Americans for the gold. Taylor's third round jump of 17.68 metres in response to Claye's jump of 17.63 metres was enough to win him the gold medal. Claye's jump was enough to secure the silver medal position. Portugal's Nelson Évora earned the bronze medal with a third round jump of 17.19 metres.



IAAF World Championships — London 4-13 August 2017

RESULTS

Triple Jump Men - Final

RECORDS	RESULT	NAME	COUNTRY	AGE	VENUE	DATE
World Record WR	18.29	Jonathan EDWARDS	GBR	29	Göteborg (Ullevi Stadium)	7 Aug 1995
Championships Record CR	18.29	Jonathan EDWARDS	GBR	29	Göteborg (Ullevi Stadium)	7 Aug 1995
World Leading WL	18.11	Christian TAYLOR	USA	27	Eugene (Hayward Field), OR	27 May 2017

Area Record AR | National Record NR | Personal Best PB | Season Best SB

10 August 2017 — 20:20 START TIME — 20° C TEMPERATURE — 49 % HUMIDITY

21:45 END TIME — 18° C — 60 %

PLACE	NAME	COUNTRY	DATE of BIRTH	ORDER	RESULT		1	2	3	ORDER	4	5	6
1	Christian TAYLOR	USA	18 Jun 90	11	17.68 +0.2		16.97 +0.2	17.57 +0.2	17.68 +0.2	8	17.26 0.0	17.38 +0.4	17.03 +0.1
2	Will CLAYE	USA	13 Jun 91	8	17.63 -0.1		17.54 +0.2	17.52 +0.6	17.63 -0.1	7	17.49 +0.4	17.53 +0.2	X +0.1
3	Nelson ÉVORA	POR	20 Apr 84	7	17.19 -0.1		17.02 +0.7	17.19 -0.1	16.58 +0.1	6	X +0.2	X -0.2	16.01 +0.1
4	Cristian NÁPOLES	CUB	27 Nov 98	12	17.16 +0.2		X +0.2	X -0.3	17.16 -0.1	5	X +0.1	X -0.1	17.16 +0.2
5	Alexis COPELLO	AZE	12 Aug 95	4	17.16 +0.2	SB	17.16 +0.2	X +0.4	X +0.1	4	16.87 0.0	16.91 0.0	17.06 +0.1
6	Chris BENARD	USA	4 Apr 90	2	17.16 +0.2		16.88 -0.4	X +0.6	16.94 +0.3	2	X 0.0	X 0.0	17.16 +0.2
7	Andy DÍAZ	CUB	25 Dec 95	10	17.13 +0.2		17.13 +0.2	X +0.1	X -0.2	3	X +0.1	-	X +0.4
8	Jean-Marc PONTVIANNE	FRA	6 Aug 94	5	16.79 +0.1		X +0.3	16.62 +0.5	16.79 +0.1	1	X +0.2	X -0.2	16.57 +0.2
9	Ruiting WU	CHN	29 Nov 95	6	16.66 +0.7		16.47 +0.4	16.66 +0.7	16.53 0.0				
10	Pablo TORRIJOS	ESP	12 May 92	9	16.60 +0.2		16.60 +0.2	16.51 +0.7	16.53 +0.2				
11	Yordanys DURANONA	DMA	16 Jun 88	1	16.42 -0.2		16.42 -0.2	X +0.4	X +0.1				
12	Lázaro MARTÍNEZ	CUB	3 Nov 97	3	16.25 +0.6		X +0.3	16.25 +0.6	16.09 +0.4				

Timing and Measurement by SEIKO — AT-TJ-M-f--A--.RS1..v1 — Issued at 21:46 on Thursday, 10 August 2017

Official Partners

TDK TOYOTA asics SEIKO EURO)VISION TBS

METHODS

Seven vantage locations for camera placement were identified and secured. These locations were situated in the stand along the back straight in line with the runway. A calibration procedure was conducted before and after each competition. A rigid cuboid calibration frame was positioned on the run up area multiple times over discrete predefined areas along the runway to ensure an accurate definition of a volume within which athletes were achieving running their last two steps before the take-off board and their hop, step and jump.

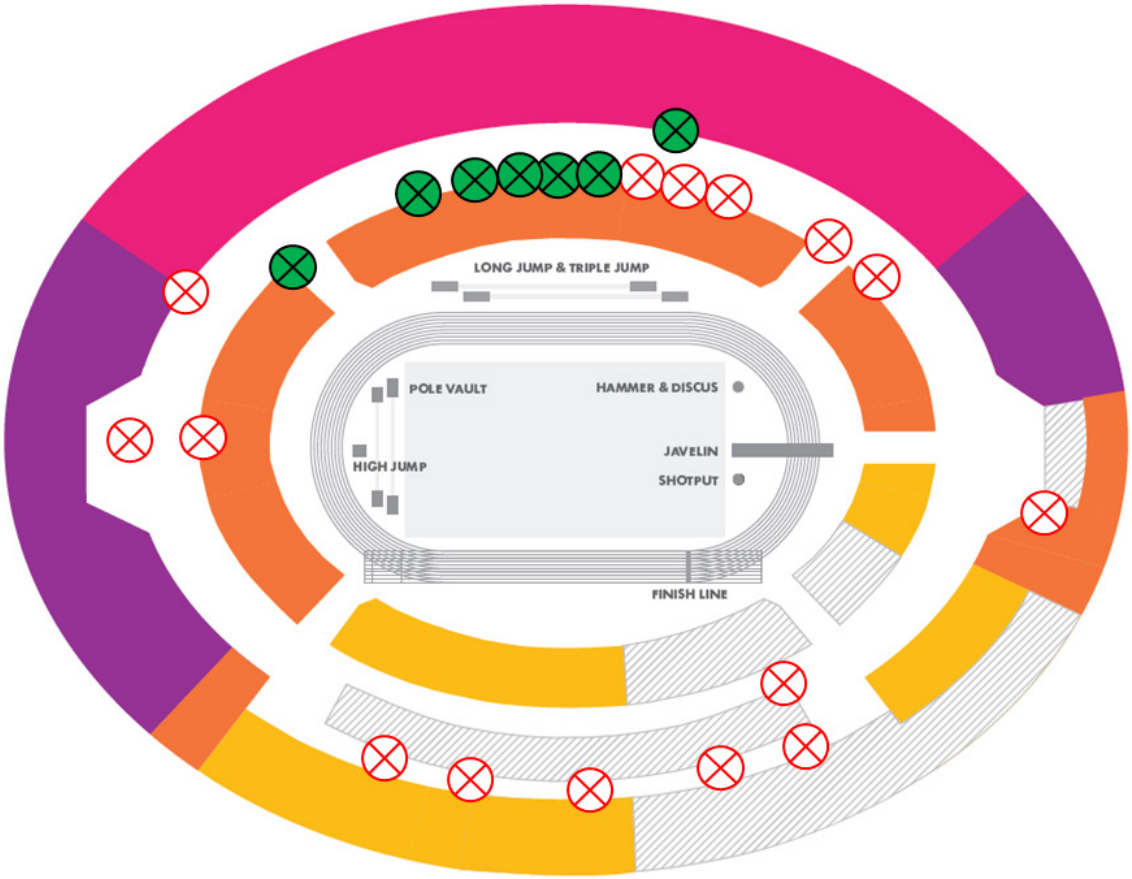


Figure 1. Camera locations within the stadium for the men's triple jump final (shown in green).

Nine cameras were used to record the action during the triple jump final. Three Sony PXW-FS5 cameras operating at 200 Hz (shutter speed: 1/1750; ISO: 2500; FHD: 1920x1080 px) were used to capture the motion of athletes as they were moving through the calibrated area of the run-up to the take-off board. Six Canon EOS 700D cameras operating at 60 Hz (shutter speed: 1/1000; ISO: 1600; SHD: 1280x720 px) were positioned in line with the runway to capture the kinematics of the hop, step and jump sections of the triple jump including landing. These cameras operated in pairs to capture these zones of movement for the athletes.

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. Digitising started 15 frames before the beginning of the step and completed 15 frames after to provide padding during filtering. Each file was first digitised frame by frame and upon completion adjustments were made as necessary using the points over frame method, where each point (e.g. right knee joint) was tracked through the entire sequence. 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 repeated digitising of one jump 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 (CM). 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.

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

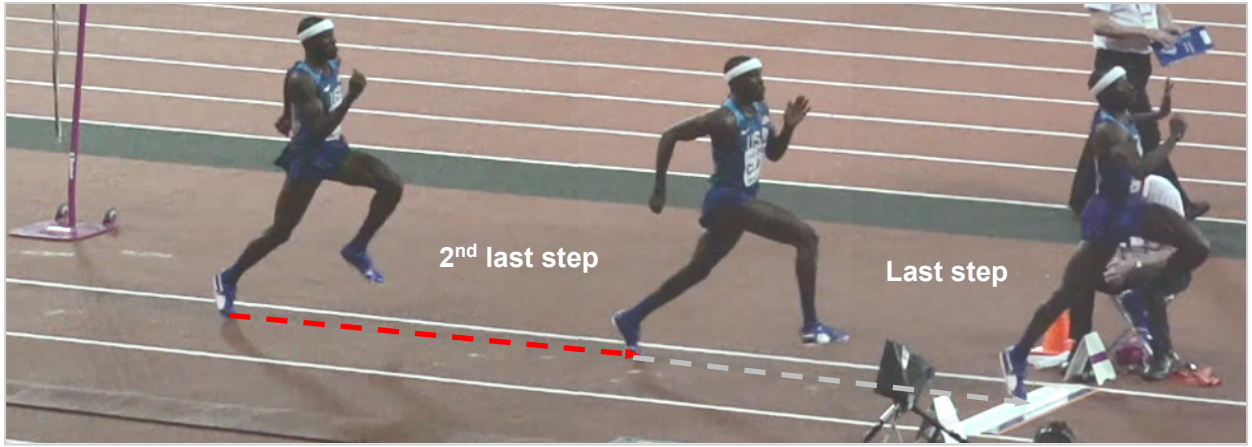


Figure 3. The last two steps before the take-off board in the triple jump.

Table 1. Definition of variables analysed in the triple jump final.

Variable	Definition
Official distance	The official distance published in the results.
Effective distance	The distance from the foot tip at take-off to the mark in the sand that is closest to the take-off board.
Take-off loss	The distance from the foot tip (take-off foot) to the front edge of the take-off board.
Step length (2nd last and last step before take-off board)	The length of the second-last and last approach steps before the take-off board measured from the foot tip in each step to the next foot tip.
Step length (hop, step and jump)	The length of the hop, step and jump as measured from the foot tip in each step to the next foot tip.
Relative step length (hop, step and jump)	The percentage length of the hop, step and jump relative to the effective distance.
Velocity (2nd last and last step before take-off, hop, step and jump)	The mean horizontal (anteroposterior) centre of mass (CM) velocity of the athlete measured during the last two steps before the take-off board as well as the hop step and jump. The horizontal velocity was also measured at the instant of take-off of the hop, step and jump.
Vertical velocity (hop, step and jump)	The athlete's vertical CM velocity at the instant of take-off of the hop, step and jump.
Change in horizontal velocity (hop, step and jump)	The difference between the horizontal velocity at take-off for the hop, step and jump, relative to the value at toe-off of the preceding step.
Contact time (hop, step and jump)	The time spent in contact during the support phase of the hop, step and jump.
Trunk angle	The angle of the trunk relative to the horizontal and considered to be 90° in the upright position measured at touchdown (TD) and take-off (TO) of the hop, step and jump contact

	phases. This was also measured at instant of landing.
Take-off angle	The angle of the athlete's CM at take-off relative to the horizontal of the hop, step and jump.
Knee angle	The angle between the thigh and lower leg and considered to be 180° in the anatomical standing position. This was measured when it reached its minimum during contact of the hop, step and jump. It was also measured at the instant of landing.
Thigh angle of swing leg	The angle of the thigh of the swinging leg measured from the horizontal at take-off of the hop, step and jump.
Thigh angular velocity of swing leg	The mean angular velocity of the thigh of the swinging leg from initial contact to take-off of the hop, step and jump.
CM lowering (hop, step and jump)	The reduction in CM height from take-off of the last step to the minimum CM height during the contact phases of the hop, step and jump.
Hip angle	The angle between the trunk and thigh and considered to be 180° in the anatomical standing position. This was measured at the instant of landing.
Landing distance	The distance from the athlete's heel to the centre of mass at the first contact in the pit.
Landing loss	The distance between the first contact point in the sand and the point to which the measurement was made. A value of zero indicates no landing loss.

Note: *CM = centre of mass.*

RESULTS

Overall analysis

Table 2 below provides the official recorded distance of each athlete along with its comparison with their personal and season best. Copello was the only athlete to jump a season's best, improving on his previous best by 6 centimetres.

Table 2. Competition results in comparison with athletes' personal bests (PB) and season's bests (SB) for 2017 (before World Championships).

Athlete	Rank	Official distance (m)	SB (2017) (m)	Comparison with SB (m)	PB (m)	Comparison with PB (m)
TAYLOR	1	17.68	18.11	−0.43	18.21	−0.53
CLAYE	2	17.63	17.91	−0.28	17.91	−0.28
ÉVORA	3	17.19	17.20	−0.01	17.74	−0.55
BENARD	4	17.16	17.48	−0.32	17.48	−0.32
COPELLO	5	17.16	17.10	0.06	17.68	−0.52
NÁPOLES	6	17.16	17.27	−0.11	17.27	−0.11
DÍAZ	7	17.13	17.40	−0.27	17.40	−0.27
PONTVIANNE	8	16.79	17.13	−0.34	17.13	−0.34
WU	9	16.66	17.18	−0.52	17.18	−0.52
TORRIJOS*	10	16.60	16.96	−0.36	17.04	−0.44
DURANONA	11	16.42	17.02	−0.60	17.20	−0.78
MARTÍNEZ	12	16.25	17.07	−0.82	17.24	−0.99

Note: *Negative values represent a shorter jump in the World Championship final compared with the PB and SB.*

**Each athlete's best jump was analysed, except for Torrijos, whose second-best attempt was analysed.*

Table 3 provides some distance characteristics of each athlete's best jumps in relation to their effective distance and distance lost at the take-off board. The smallest loss at the take-off board was by Duranona with no loss, and the largest loss was by Martínez with a loss of 17 centimetres. The mean loss was 7 centimetres. Table 4 below shows the step lengths of each finalist for the last two steps before the take-off board, the hop, step and jump.

Table 3. Distance characteristics of the individual best jumps.

Athlete	Analysed attempt	Official distance (m)	Effective distance (m)	Take-off loss (m)
TAYLOR	3	17.68	17.79	0.11
CLAYE	3	17.63	17.74	0.11
ÉVORA	2	17.19	17.21	0.02
BENARD	6	17.16	17.21	0.05
COPELLO	1	17.16	17.18	0.02
NÁPOLES	3	17.16	17.17	0.01
DÍAZ	1	17.13	17.15	0.02
PONTVIANNE	3	16.79	16.94	0.15
WU	2	16.66	16.74	0.08
TORRIJOS	3	16.53	16.65	0.12
DURANONA	1	16.42	16.42	0.00
MARTÍNEZ	2	16.25	16.42	0.17

Table 4. Step length data for the two steps before the take-off board and the hop, step and jump.

Athlete	2nd last (m)	Last (m)	Hop (m)	Step (m)	Jump (m)
TAYLOR	2.37	2.11	5.83	5.56	6.40
CLAYE	2.46	2.30	6.11	5.33	6.30
ÉVORA	2.11	2.03	6.15	5.14	5.92
BENARD	2.48	2.36	6.22	5.11	5.88
COPELLO	2.50	2.31	5.89	5.29	6.00
NÁPOLES	2.40	2.43	6.00	5.28	5.89
DÍAZ	2.32	2.31	6.25	4.83	6.07
PONTVIANNE	2.25	2.20	5.80	4.94	6.20
WU	2.29	2.49	5.99	4.09	6.66
TORRIJOS	2.23	2.13	5.94	4.88	5.83
DURANONA	2.40	2.38	6.15	4.78	5.49
MARTÍNEZ	2.42	2.15	5.93	4.60	5.89

Note: *The hop, step and jump distances were provided by deltatre.*

Table 5 and Figure 4 illustrate the contribution of the hop, step and jump (relative percentage) to the effective distance. Table 4 also shows the technique used by each athlete (classified as either hop- or jump-dominated if the difference in relative percentage of the hop and jump was greater than 2%).

Table 5. Relative percentage of the hop, step and jump to overall effective distance and the technique employed.

Athlete	Hop (%)	Step (%)	Jump (%)	Technique
TAYLOR	32.8	31.3	36.0	Jump-dominated
CLAYE	34.4	30.0	35.5	Balanced
ÉVORA	35.7	29.9	34.4	Balanced
BENARD	36.1	29.7	34.2	Balanced
COPELLO	34.3	30.8	34.9	Balanced
NÁPOLES	34.9	30.8	34.3	Balanced
DÍAZ	36.4	28.2	35.4	Balanced
PONTVIANNE	34.2	29.2	36.6	Jump-dominated
WU	35.8	24.4	39.8	Jump-dominated
TORRIJOS	35.7	29.3	35.0	Balanced
DURANONA	37.5	29.1	33.4	Hop-dominated
MARTÍNEZ	36.1	28.0	35.9	Balanced

Note: *Percentages might not add up to 100% because of rounding.*

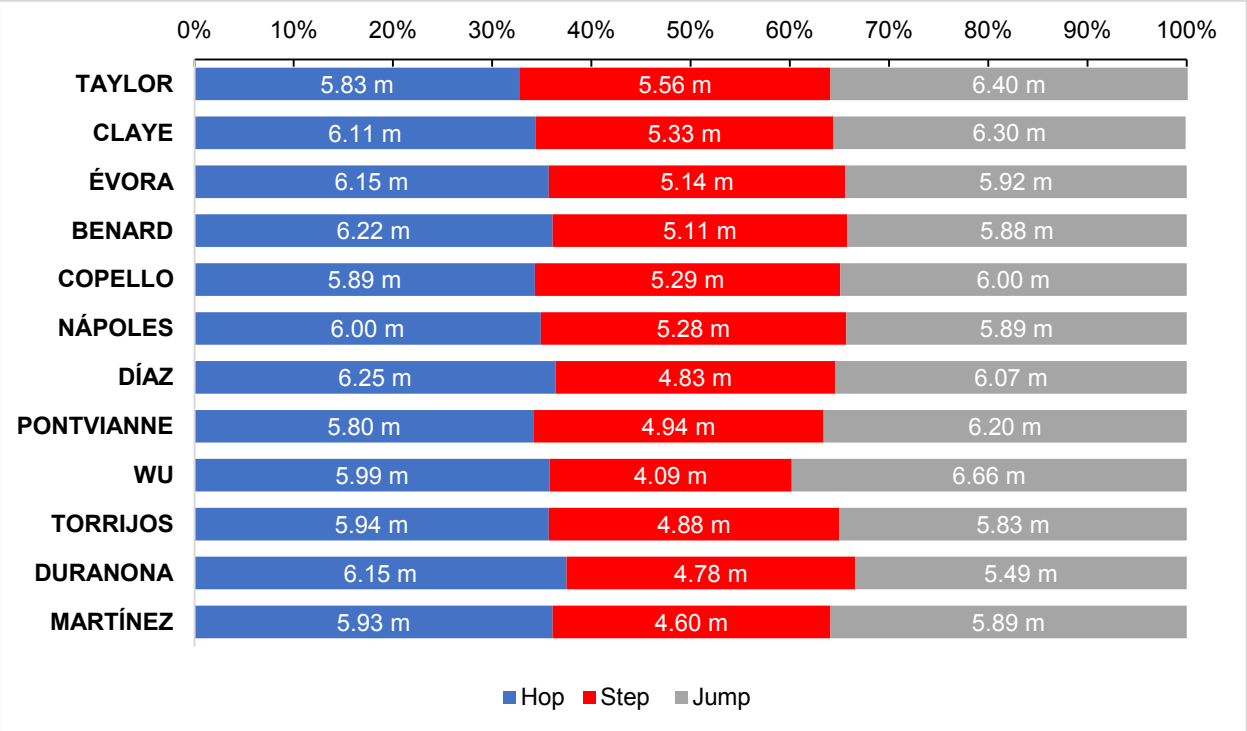
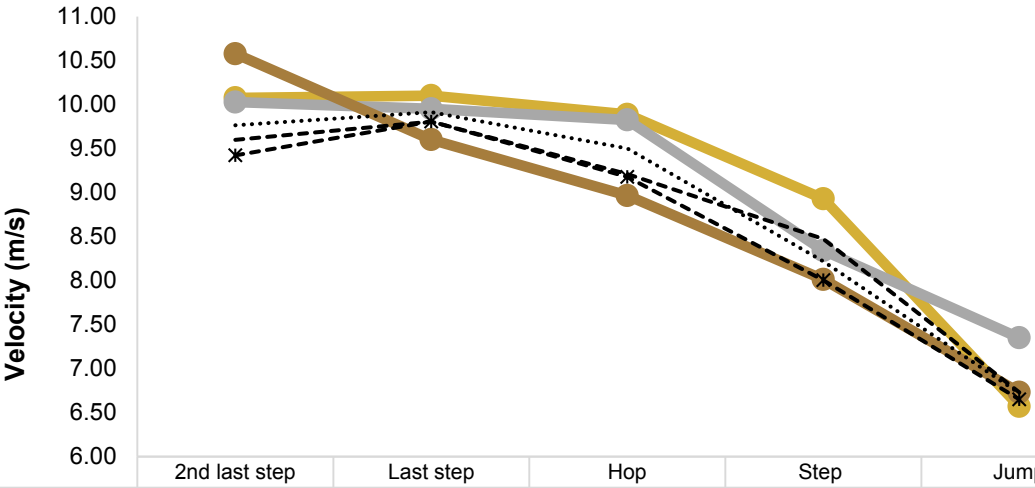


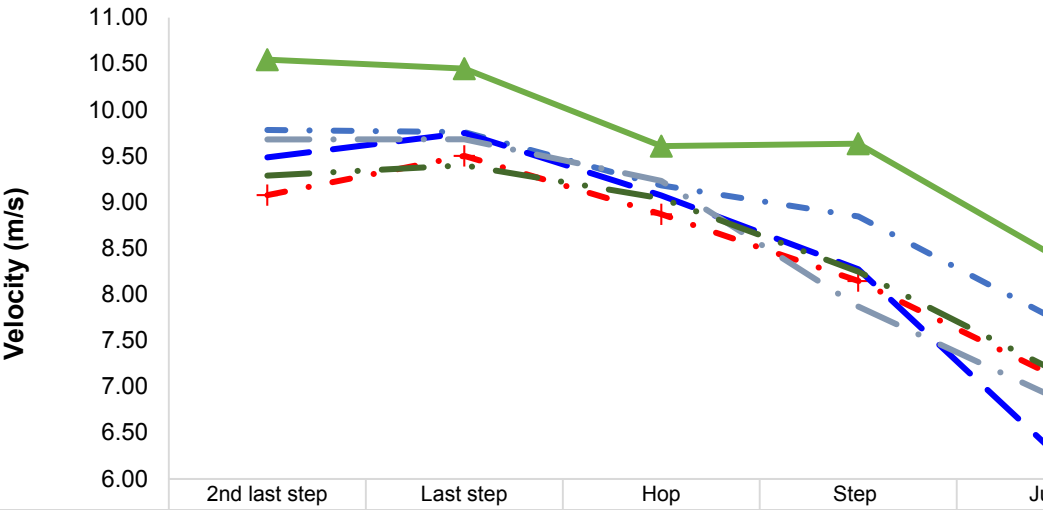
Figure 4. Relative percentage of hop, step and jump lengths (relative to effective distance) along with step length in metres.

Figures 5 and 6 show the change in velocities across the two steps before the take-off board, the hop, the step and jump. The mean horizontal velocity for the second-last step before the take-off board was 9.78 m/s and the last step before the take-off board was 9.81 m/s. The mean horizontal velocity for the hop was 9.30 m/s, the step was 8.42 m/s and the jump was 7.03 m/s.



	2nd last step	Last step	Hop	Step	Jump
TAYLOR	10.08	10.10	9.89	8.93	6.57
CLAYE	10.03	9.95	9.83	8.34	7.35
ÉVORA	10.58	9.60	8.97	8.01	6.73
BENARD	9.76	9.91	9.50	8.22	6.72
COPELLO	9.60	9.81	9.21	8.47	6.73
NÁPOLES	9.42	9.81	9.18	8.00	6.65

Figure 5. Change in horizontal velocity of the two steps before the take-off board and the hop, step and jump for the top 6 finishers.



	2nd last step	Last step	Hop	Step	Jump
DÍAZ	9.08	9.50	8.87	8.15	7.11
PONTVIANNE	9.78	9.76	9.18	8.84	7.73
WU	10.55	10.45	9.61	9.63	8.41
TORRIJOS	9.49	9.75	9.07	8.27	6.28
DURANONA	9.68	9.68	9.23	7.87	6.88
MARTÍNEZ	9.29	9.40	9.04	8.25	7.17

Figure 6. Change in horizontal velocity of the two steps before the take-off board and the hop, step and jump for the bottom 6 finishers.

***Note**: The velocities in Figures 5 and 6 include contact and flight of each phase.*

Figures 7, 8 and 9 show the contact and flight times for hop, step and jump, respectively. The medallists are highlighted in their respective medal colours. Table 6 on the next page shows the step times for the two steps before the take-off board, the hop, step and jump.

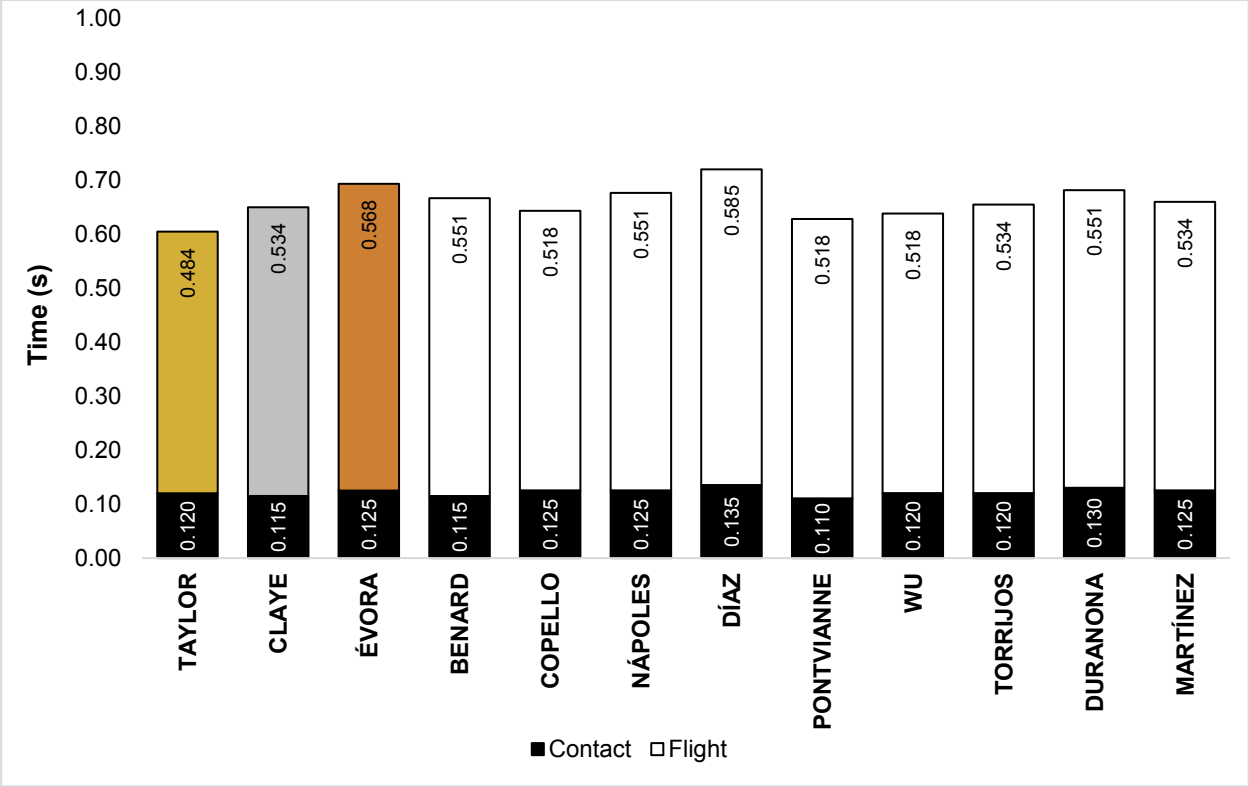


Figure 7. Contact and flight times for the hop phase of the triple jump for all finalists.

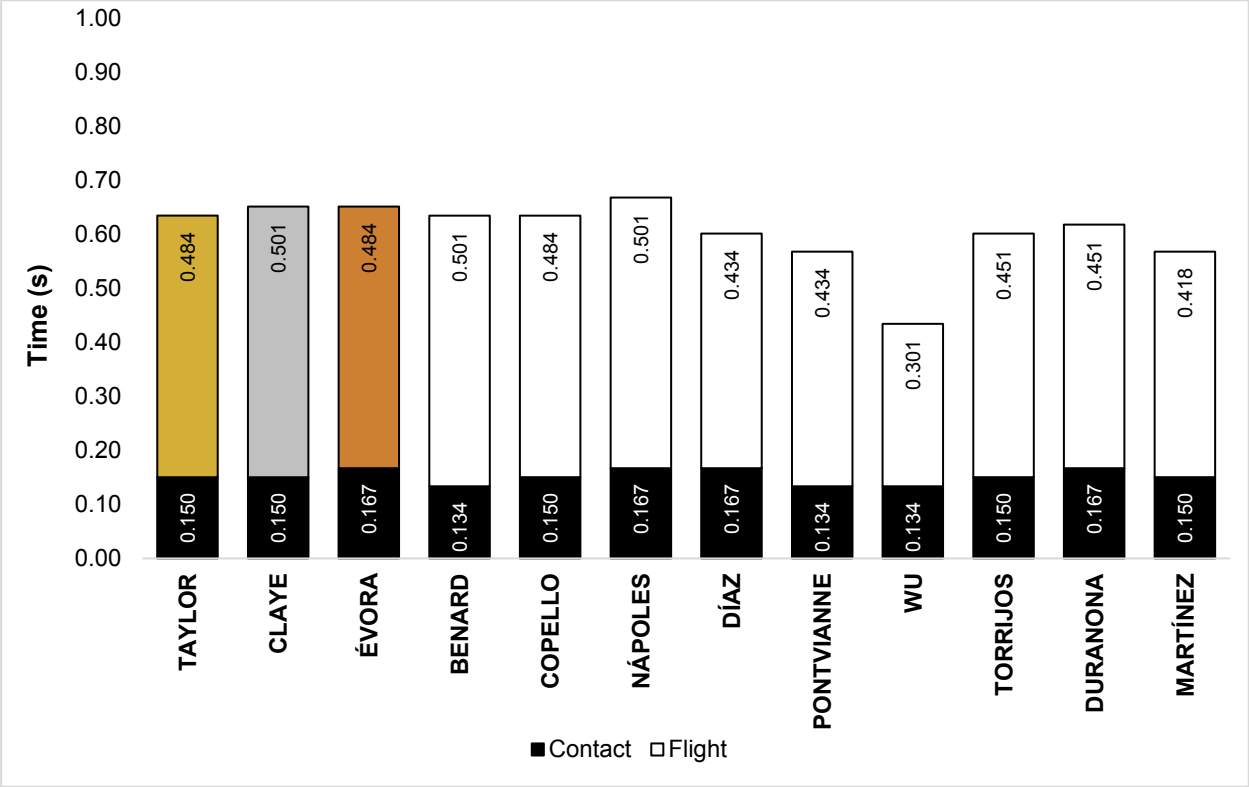


Figure 8. Contact and flight times for the step phase of the triple jump for all finalists.

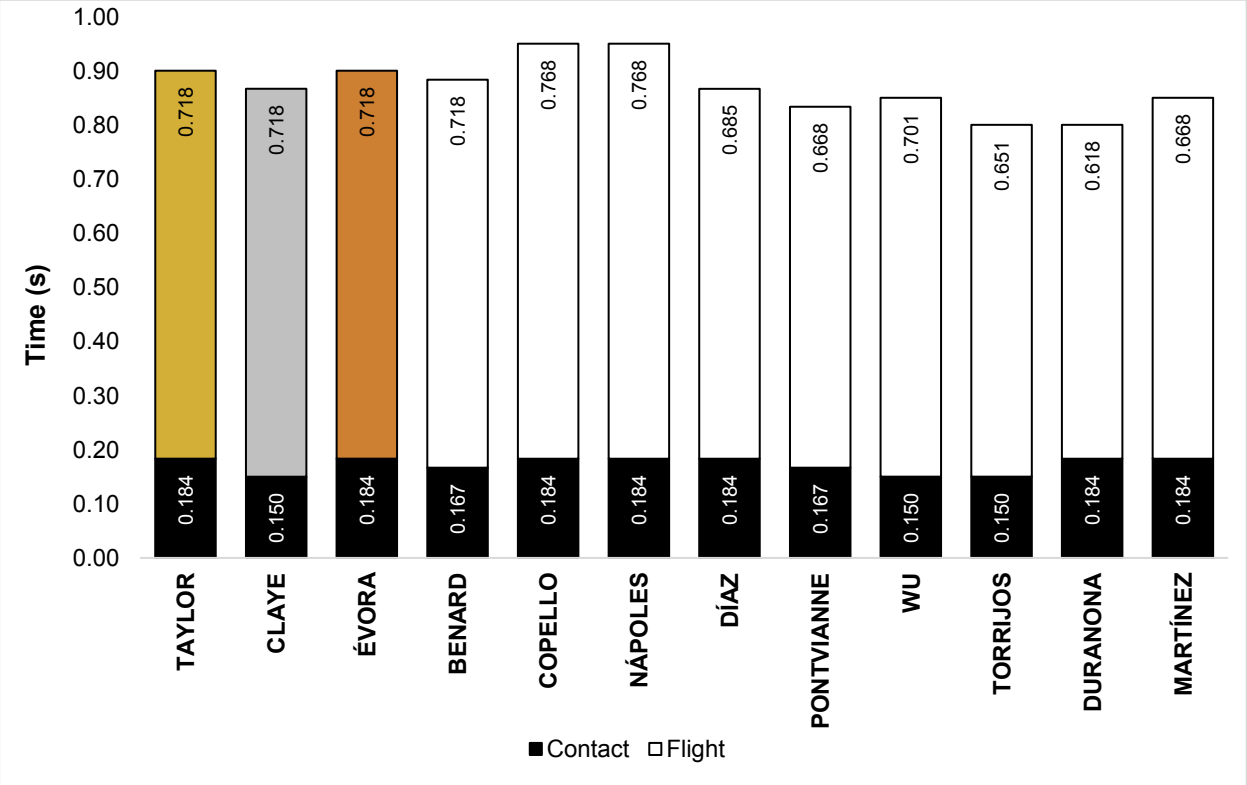


Figure 9. Contact and flight times for the jump phase of the triple jump for all finalists.

Table 6. Step times for the two steps before the take-off board and the hop, step and jump.

Athlete	2nd last (s)	Last (s)	Hop (s)	Step (s)	Jump (s)
TAYLOR	0.230	0.175	0.604	0.634	0.902
CLAYE	0.245	0.195	0.649	0.651	0.868
ÉVORA	0.200	0.180	0.693	0.651	0.902
BENARD	0.235	0.210	0.666	0.635	0.885
COPELLO	0.260	0.205	0.643	0.634	0.952
NÁPOLES	0.250	0.210	0.676	0.668	0.952
DÍAZ	0.235	0.210	0.720	0.601	0.869
PONTVIANNE	0.220	0.200	0.628	0.568	0.835
WU	0.210	0.215	0.638	0.435	0.851
TORRIJOS	0.225	0.185	0.654	0.601	0.801
DURANONA	0.255	0.215	0.681	0.618	0.802
MARTÍNEZ	0.235	0.205	0.659	0.568	0.852

Hop, step and jump analysis

Table 7 shows the horizontal and vertical velocities of the take-off for the hop, step and jump phases. Table 8 shows the change in CM height for the hop, step and jump.

Table 7. Horizontal and vertical velocities at take-off of the hop, step and jump.

	Hop		Step		Jump	
Athlete	Horizontal velocity (m/s)	Vertical velocity (m/s)	Horizontal velocity (m/s)	Vertical velocity (m/s)	Horizontal velocity (m/s)	Vertical velocity (m/s)
TAYLOR	9.85	2.77	8.52	2.35	6.34	2.43
CLAYE	9.16	2.66	8.77	2.37	7.09	2.91
ÉVORA	8.84	2.88	7.85	2.75	6.26	2.75
BENARD	8.94	3.25	7.81	2.18	6.84	3.46
COPELLO	9.81	2.90	7.92	2.08	6.86	3.22
NÁPOLES	9.32	2.91	8.40	2.94	5.94	3.31
DÍAZ	9.04	3.23	8.31	2.44	6.96	2.64
PONTVIANNE	9.30	2.98	7.70	1.87	7.55	2.65
WU	9.77	2.40	8.66	1.15	8.57	2.95
TORRIJOS	9.54	2.99	8.16	2.37	7.28	2.60
DURANONA	9.13	2.98	7.33	2.34	6.65	2.21
MARTÍNEZ	9.25	3.13	8.86	2.23	6.50	2.66

***Note**: These instantaneous velocities for the phases have been captured at different frame rates. This should be considered when examining these velocities along with those in Figures 5 and 6.*

Table 8. CM height lowering during the hop, step and jump.

Athlete	Hop (cm)	Step (cm)	Jump (cm)
TAYLOR	1	26	18
CLAYE	6	30	16
ÉVORA	2	31	15
BENARD	2	21	19
COPELLO	7	31	18
NÁPOLES	5	25	18
DÍAZ	4	32	13
PONTVIANNE	4	27	11
WU	4	28	10
TORRIJOS	4	28	15
DURANONA	6	30	13
MARTÍNEZ	1	30	14

The change in horizontal velocity between these phases is shown in Figure 10 below. The mean change in horizontal velocity between the hop and the previous step was −0.75 m/s, between the hop and step was −1.12 m/s and between the step and jump was −1.29 m/s.

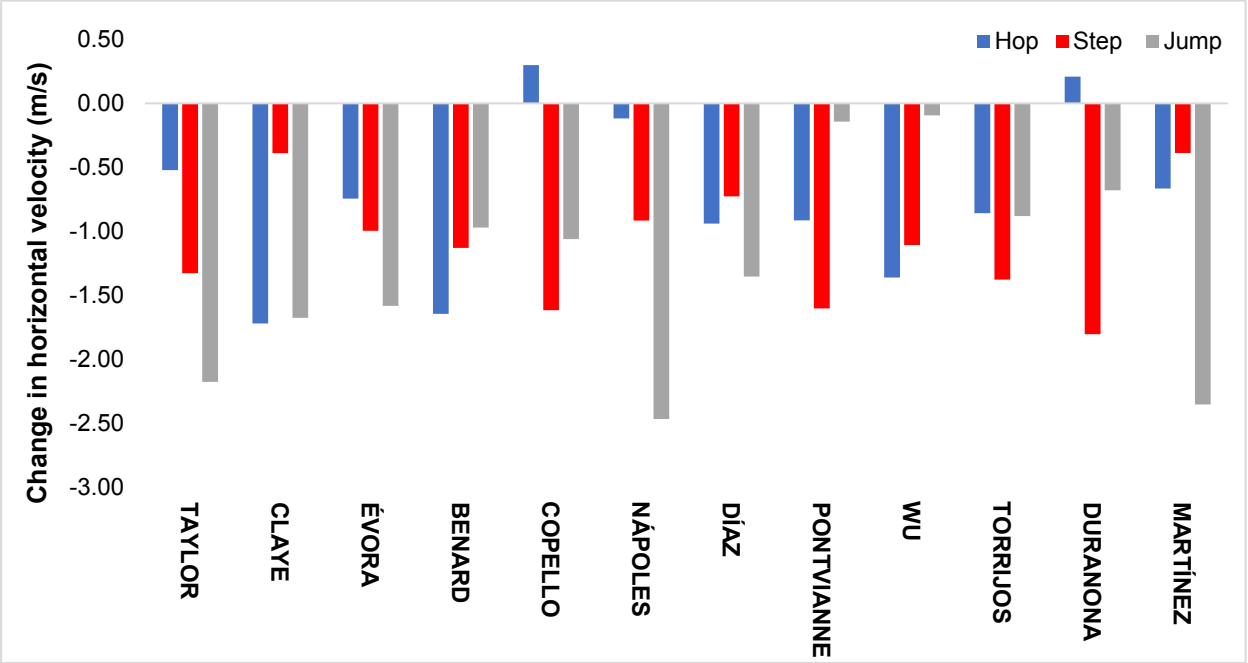
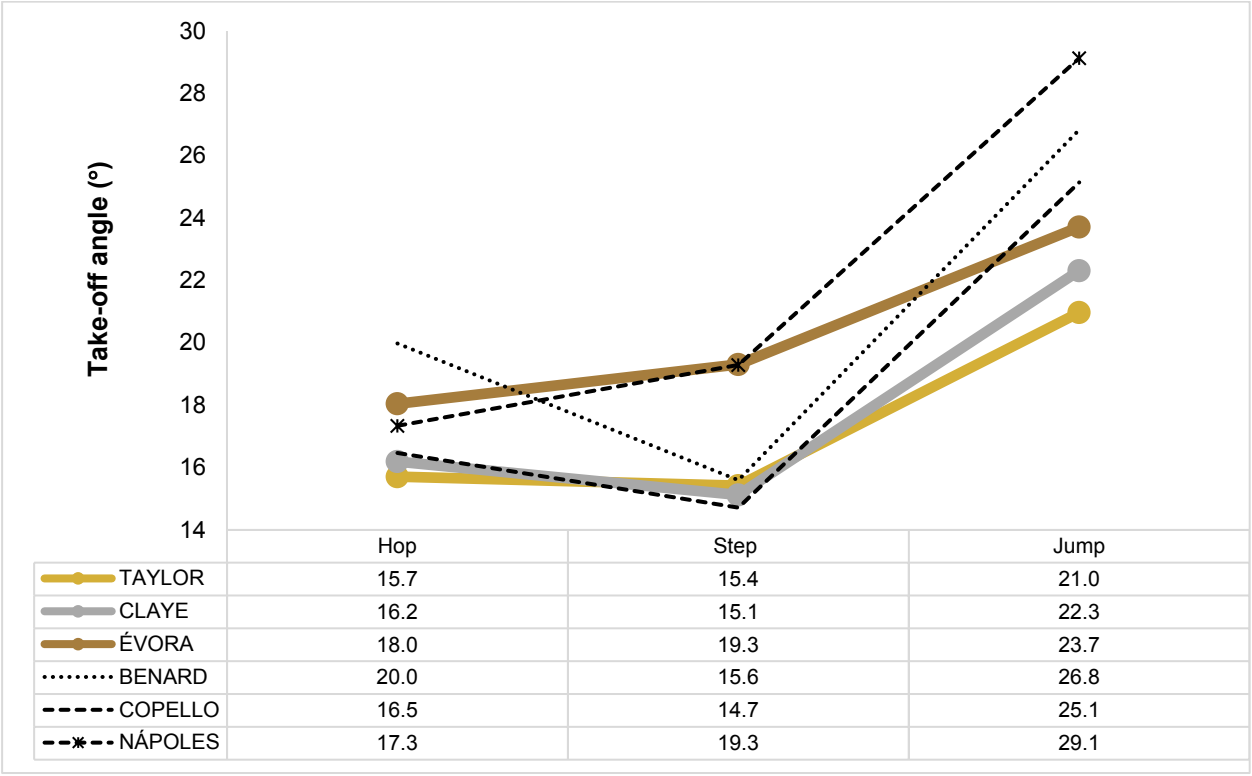


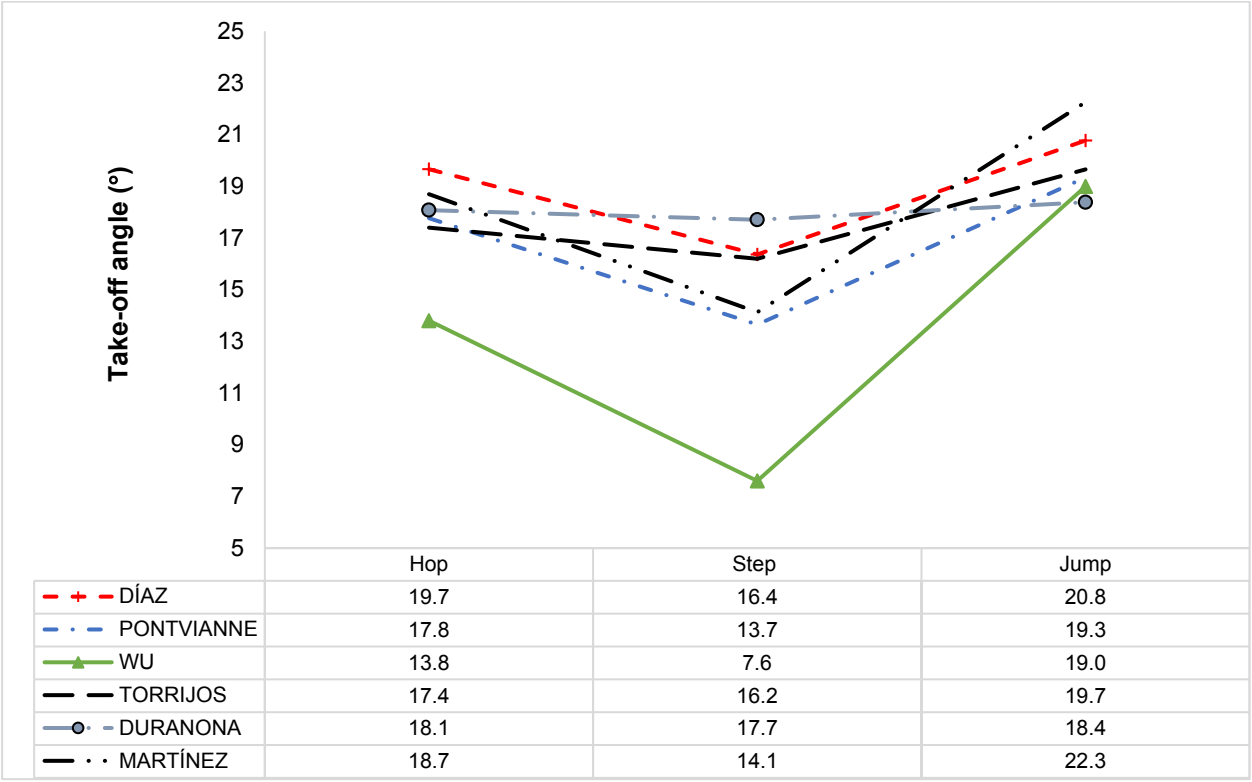
Figure 10. The change in horizontal velocity for the hop, step and jump for each finalist.

Figures 11 and 12 below show the change in take-off angle of the hop, step and jump take-off phases. The mean take-off angle for the hop was 17.4°, for the step was 15.4° and for the jump was 22.3°.



	Hop	Step	Jump
TAYLOR	15.7	15.4	21.0
CLAYE	16.2	15.1	22.3
ÉVORA	18.0	19.3	23.7
BENARD	20.0	15.6	26.8
COPELLO	16.5	14.7	25.1
NÁPOLES	17.3	19.3	29.1

Figure 11. Take-off angle in the hop, step and jump for the top 6 finalists.



	Hop	Step	Jump
DÍAZ	19.7	16.4	20.8
PONTVIANNE	17.8	13.7	19.3
WU	13.8	7.6	19.0
TORRIJOS	17.4	16.2	19.7
DURANONA	18.1	17.7	18.4
MARTÍNEZ	18.7	14.1	22.3

Figure 12. Take-off angle in the hop, step and jump for the bottom 6 finalists.

Table 9 below presents the minimum knee angle during the contact phases of the hop, step and jump. Table 10 shows the change in trunk angle from touchdown to take-off of the hop, step and jump.

Table 9. Minimum knee angle during the contact phases of hop, step and jump.

Athlete	Hop (°)	Step (°)	Jump (°)
TAYLOR	151.5	125.1	135.6
CLAYE	144.1	120.0	126.4
ÉVORA	128.1	129.7	128.9
BENARD	133.1	141.6	136.8
COPELLO	146.1	119.1	131.0
NÁPOLES	119.7	130.2	137.0
DÍAZ	115.9	129.6	131.1
PONTVIANNE	139.4	137.7	120.8
WU	143.6	133.4	129.1
TORRIJOS	148.2	128.5	133.9
DURANONA	127.7	121.3	133.9
MARTÍNEZ	128.3	124.2	127.4

Table 10. Changes in trunk angle during touchdown (TD) and take-off (TO) of the hop, step and jump.

	Hop		Step		Jump	
Athlete	TD (°)	TO (°)	TD (°)	TO (°)	TD (°)	TO (°)
TAYLOR	87.8	83.4	89.1	85.6	92.7	75.1
CLAYE	88.3	89.1	87.5	84.2	92.4	74.8
ÉVORA	92.6	90.2	89.0	80.2	89.9	69.8
BENARD	93.3	93.9	94.4	84.9	86.3	86.3
COPELLO	89.1	89.4	84.9	85.6	88.1	72.1
NÁPOLES	88.5	80.9	89.3	80.8	95.8	76.4
DÍAZ	89.9	79.6	85.9	77.7	89.2	78.1
PONTVIANNE	86.4	91.0	93.7	83.3	98.2	85.0
WU	90.8	92.6	92.2	85.8	88.8	80.3
TORRIJOS	85.1	87.6	94.6	77.1	81.1	79.3
DURANONA	88.0	96.3	94.8	79.1	91.0	68.0
MARTÍNEZ	92.3	86.7	88.8	90.7	91.4	76.5

Table 11 shows the thigh angle (relative to the horizontal plane) at take-off along with the thigh angular velocity of the swing leg during the contact phase of the hop, step and jump. The mean thigh angle for the hop, step and jump was −22.6°, −25.7° and −20.3°, respectively. The mean thigh angular velocity of the swing leg for the hop, step and jump was 516 °/s, 350 °/s and 346 °/s, respectively.

Table 11. Thigh angle at take-off and mean thigh angular velocity of the swing leg (during the contact phase) for the hop, step and jump.

	Hop		Step		Jump	
Athlete	Thigh angle (°)	Mean thigh angular velocity (°/s)	Thigh angle (°)	Mean thigh angular velocity (°/s)	Thigh angle (°)	Mean thigh angular velocity (°/s)
TAYLOR	−24.3	439	−16.9	392	−12.7	351
CLAYE	−21.5	542	−16.9	337	−27.5	277
ÉVORA	−26.7	528	−30.5	331	−14.1	326
BENARD	−22.1	505	−28.8	372	−27.4	333
COPELLO	−15.1	582	−28.6	346	−22.4	347
NÁPOLES	−26.9	445	−19.5	355	−11.8	360
DÍAZ	−20.1	530	−22.7	372	−23.0	322
PONTVIANNE	−23.4	556	−39.5	241	−11.1	434
WU	−18.0	538	−29.2	363	−24.6	407
TORRIJOS	−34.3	436	−24.4	358	−37.4	279
DURANONA	−14.8	573	−17.2	378	−15.9	367
MARTÍNEZ	−24.1	570	−34.7	312	−15.1	337

Note: *A negative lead thigh angle means the thigh is below the horizontal.*

Landing analysis

Table 12 shows the angles of the trunk, hip and knee on landing with the sand. The loss in landing is also shown. The largest landing loss was by Copello at 0.26 metres. Six other athletes also recorded a loss on landing. The mean hip angle at landing was 78.4°. The mean knee angle was 131.2°, while the mean trunk angle was 64.6°. Figure 13 shows the landing distance by each athlete. The mean landing distance was 0.50 metres.

Table 12. Landing characteristics in the men's triple jump final.

Athlete	Hip angle (°)	Knee angle (°)	Trunk angle (°)	Landing loss (m)
TAYLOR	81.6	128.5	71.7	0.02
CLAYE	69.9	163.7	30.7	0.11
ÉVORA	83.7	124.5	66.9	0.00
BENARD	61.3	114.4	66.9	0.06
COPELLO	72.1	101.3	78.9	0.26
NÁPOLES	83.6	121.2	74.9	0.21
DÍAZ	95.7	131.9	60.6	0.00
PONTVIANNE	64.7	141.0	60.2	0.00
WU	69.7	134.2	50.9	0.18
TORRIJOS	79.3	136.8	80.2	0.10
DURANONA	64.0	115.8	62.3	0.00
MARTÍNEZ	115.4	161.3	71.0	0.00

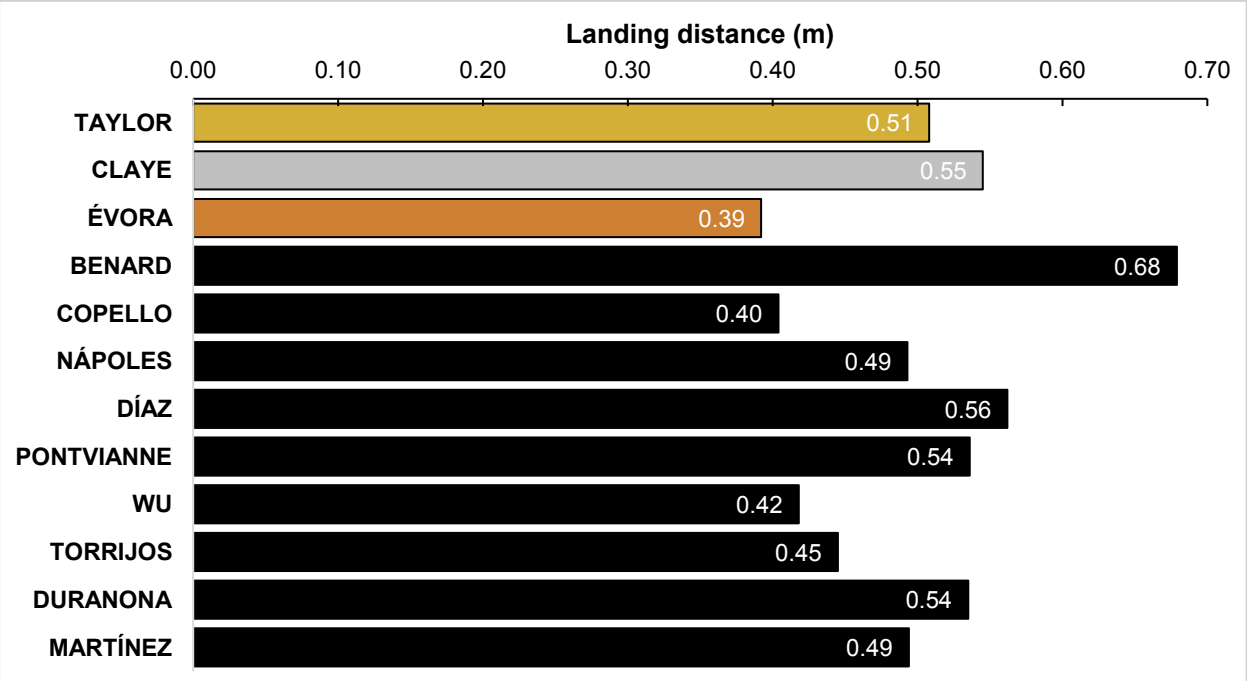


Figure 13. The landing distances for each finalist in the men's triple jump.

COACH'S COMMENTARY

Unlike other field events, in which a single, maximal effort is required, success in the triple jump demands a series of two submaximal efforts and one maximal effort. In these efforts, athletes must trade-off the maintenance of horizontal velocity against the generation of vertical velocity in the hop, step and jump.

During the phases of hop, step and jump some athletes favour different approaches in terms of effort distribution. Most of the finalists were considered to have a "balanced" technique but Taylor displayed a "jump-dominated" technique as he is known to have, along with two others (Pontvianne and Wu). Duranona was the only finalist have a "hop-dominated" technique. Where Taylor had the biggest gain relative to the other finalists was in the step and jump distances. He had the longest step (5.56 metres) and second-longest jump (6.40 metres).

The run-up to the take-off board is obviously important for creating speed. The mean velocities of the second-last and last step before the take-off board were 9.78 m/s and 9.81 m/s, respectively. Interestingly, the gold medallist was the only athlete to exceed 10 m/s in the last step before the take-off board, apart from the ninth-placed Wu. Taylor had the highest hop velocity of all the finalists at 9.89 m/s and even though he lost some velocity to the take-off of the hop (Table 7), he had the highest value for the step distance at 5.56 metres (Figure 4).

In the hop, step and jump it is important for the athlete to maintain a stable, upright body position overall from contact with the ground to take-off from the ground to avoid any loss in overall velocity because of over rotation. In the men's final, it was apparent that there was a relationship (correlation of −0.63) between the change in trunk angle during the hop support phase and the subsequent loss in velocity to the step. In general, those who tended to flex their trunk (angle less than 90°) more during the hop contact had a smaller loss compared with those who extended their trunk (Table 10). Interestingly, Claye had a very small change in trunk angle (increase of 0.8°) meaning he became slightly more upright and this led to a small loss in horizontal velocity to the step. This might mean the strategy of extending the trunk on contact is a better ploy to prevent an over rotation or loss of control that can lead to potential decreases in horizontal velocity. Interestingly, some athletes choose to bring their trunk back further on initial contact to avoid any loss of control. An example of this is when taking off for the jump phase, the top four finishers had relatively high levels of trunk rotation (Taylor 17.6°, Claye 17.6°, Évora 20.1° and Nápoles 19.4°) during this contact to prevent loss of velocity and also increase the angle of take-off (the mean increase in take-off angle for these athletes between the step and jump was 10.3°). Increasing the extension of the trunk backwards on contact to prevent over rotation is something that the world record holder, Jonathon Edwards, said he prioritised during his record-breaking jump in 1995.

Control on landing is also crucial to maximising the distance achieve in the triple jump. The landing analysis shows that the Claye lost 11 centimetres on landing from falling back. He landed in a position that was very flexed at the trunk (30.7°) compared with the other medallists of Taylor (71.7°) and Évora (66.9°). This loss of control on landing could have cost Claye a gold medal given he was only 5 centimetres back from Taylor overall. The largest loss on landing was by fifth-placed Copello with a loss of 26 centimetres meaning a potential loss of a medal position for him. This is something for him to work on in ensuring that. Perhaps increasing his hip flexion on landing will help him avoid this loss of forward momentum.

CONTRIBUTORS

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Toni Minichiello is a coach for British Athletics. He has worked with a number of elite and senior athletes, most notably Olympic gold medallist and triple World Champion Jessica Ennis-Hill, whom he coached from the age of 15 years old. In 2012, Toni won the BBC Sports Personality of the Year Coach Award. Toni has also been awarded the accolade of UK Sports Coach of the Year and was inducted into the Fellowship of Elite Coaches in 2014.