IAAF World Indoor Championships
BIRMINGHAM 2018
1–4 MARCH

BIOMECHANICAL REPORT

FOR THE

IAAF

WORLD INDOOR CHAMPIONSHIPS 2018

Long Jump Women

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INTRODUCTION

The women's long jump took place on the afternoon of Sunday 4th March. It was Moguenara-Taroum who was contesting for first place with Ivana Španovic in the first two rounds. However, from round 4 it was a battle between Španovic and the previous World Indoor Champion, Brittney Reese. It was Španovic who emerged victorious with a jump of 6.96 metres defeating Reese into second place. In the end Moguenara-Taroum's second round effort of 6.85 metres was enough to clinch the bronze medal by four centimetres from Quanesha Burks.

IAAF World Indoor Championships — Birmingham (GBR) 1-4 March 2018

RESULTS

Long Jump Women - Final

RECORDS	RESULT	NAME	COUNTRY	AGE	VENUE	DATE
World Indoor Record WIR	7.37	Heike DRECHSLER	GDR	24	Wien	13 Feb 1988
Championship Record CR	7.23	Brittney REESE	USA	26	Istanbul (Ataköy Arena)	11 Mar 2012
World Leading WL	6.96	Ivana ŠPANOVIC	SRB	28	Birmingham	4 Mar 2018

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

4 March 2018 15:27 START TIME

16:52 END TIME

PLACE	NAME	COUNTRY	DATE of BIRTH	ORDER	RESULT		1	2	3	ORDER	4	5	6
1	Ivana ŠPANOVIC	SRB	10 May 90	13	**6.96**	WL	6.89	6.74	X	8	6.96	-	-
2	Brittney REESE	USA	9 Sep 86	12	**6.89**	SB	6.76	6.61	6.77	5	6.89	6.72	6.64
3	Sosthene MOGUENARA-TAROU	GER	17 Oct 89	10	**6.85**	SB	6.59	6.85	X	7	6.31	6.23	6.30
4	Quanesha BURKS	USA	15 Mar 95	9	**6.81**	PB	6.81	6.51	6.71	6	6.78	X	6.70
5	Malaika MIHAMBO	GER	3 Feb 94	8	**6.64**		6.43	6.40	6.55	2	X	6.64	
6	Khaddi SAGNIA	SWE	20 Apr 94	11	**6.64**		6.64	X	6.40	4	6.45	4.23	
7	Christabel NETTEY	CAN	2 Jun 91	1	**6.63**	SB	6.49	6.63	6.49	3	6.45	6.44	
8	Ksenija BALTA	EST	1 Nov 86	6	**6.57**		6.46	6.48	6.26	1	6.50	6.57	
9	Alina ROTARU	ROU	5 Jun 93	5	**6.41**		X	6.37	6.41				
10	Maryna BEKH	UKR	18 Jul 95	2	**6.37**		X	6.37	6.35				
11	Lauma GRIVA	LAT	27 Oct 84	4	**6.34**		6.18	6.34	6.28				
12	Éloyse LESUEUR	FRA	15 Jul 88	3	**6.34**		6.26	6.34	6.20				
13	Jessamyn SAUCEDA	MEX	22 May 89	7	**5.99**	SB	5.95	5.93	5.99				

Timing and Measurement by SEIKO   AT-LJ-W-f--A--.RS1..v1   Issued at 16:53 on Sunday, 04 March 2018

Official Partners

METHODS

Five vantage locations for camera placement were identified and secured. These locations were situated in the stand along the home 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 completed their last three steps before take-off until landing.

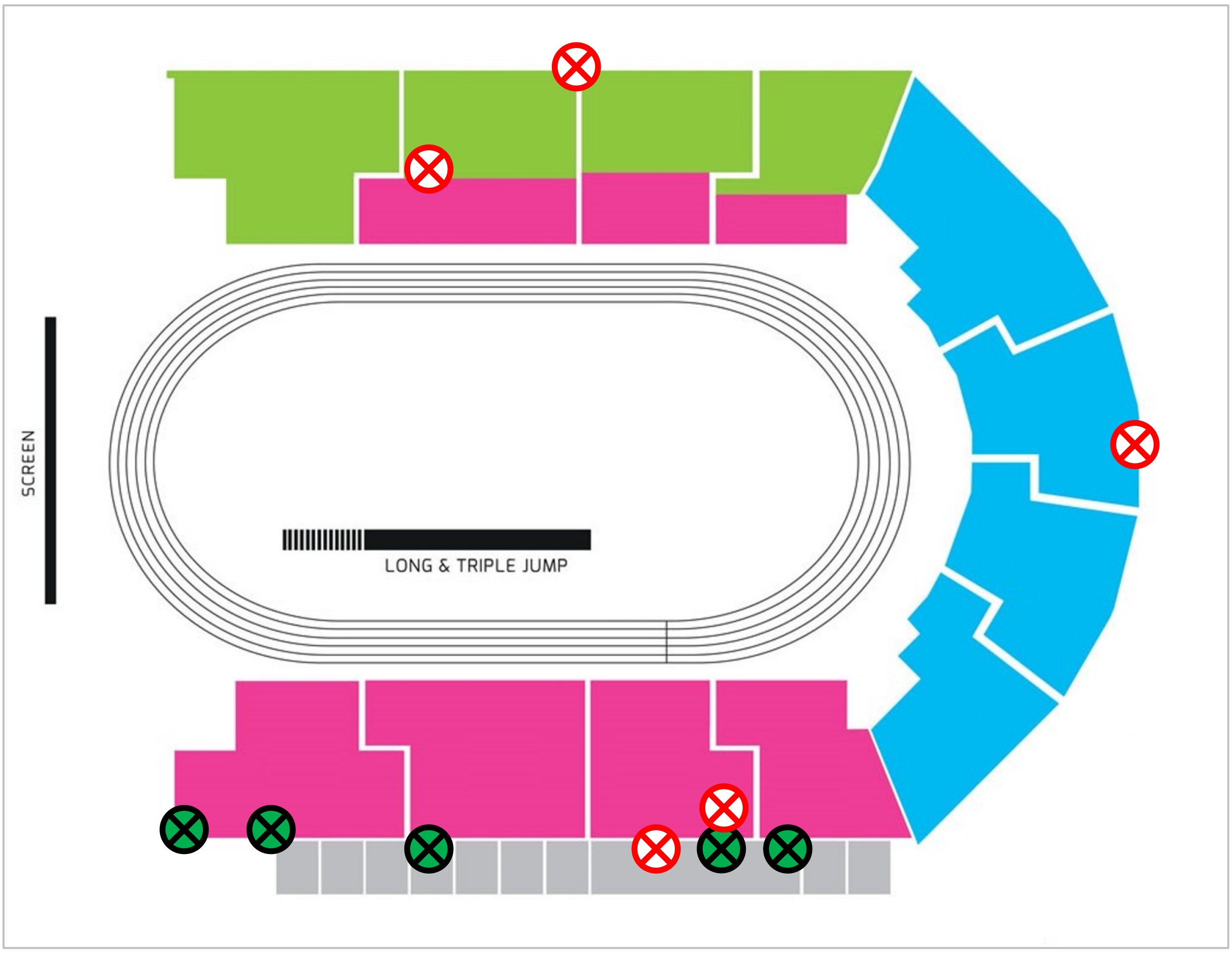


Figure 1. Camera layout for the women's long jump indicated by green-filled circles.

Seven cameras were used to record the action during the long jump final. Three Sony PXW-FS5 cameras operating at 200 Hz (shutter speed: 1/1750; ISO: 2000-400; FHD: 1920x1080 px) were used to capture the motion of athletes as they moved through the calibrated area of the run-up and take-off. Four Sony RX10 M3 cameras operating at 100 Hz (shutter speed: 1/1000; ISO: 2000-3600; FHD: 1920x1080 px) were positioned strategically along the runway with two of these being paired with a Sony PXW-FS5 camera each as a precaution against the unlikely event of data capture loss. The other two Sony RX10 M3 cameras were positioned to focus on the landing pit to capture the instant of landing.

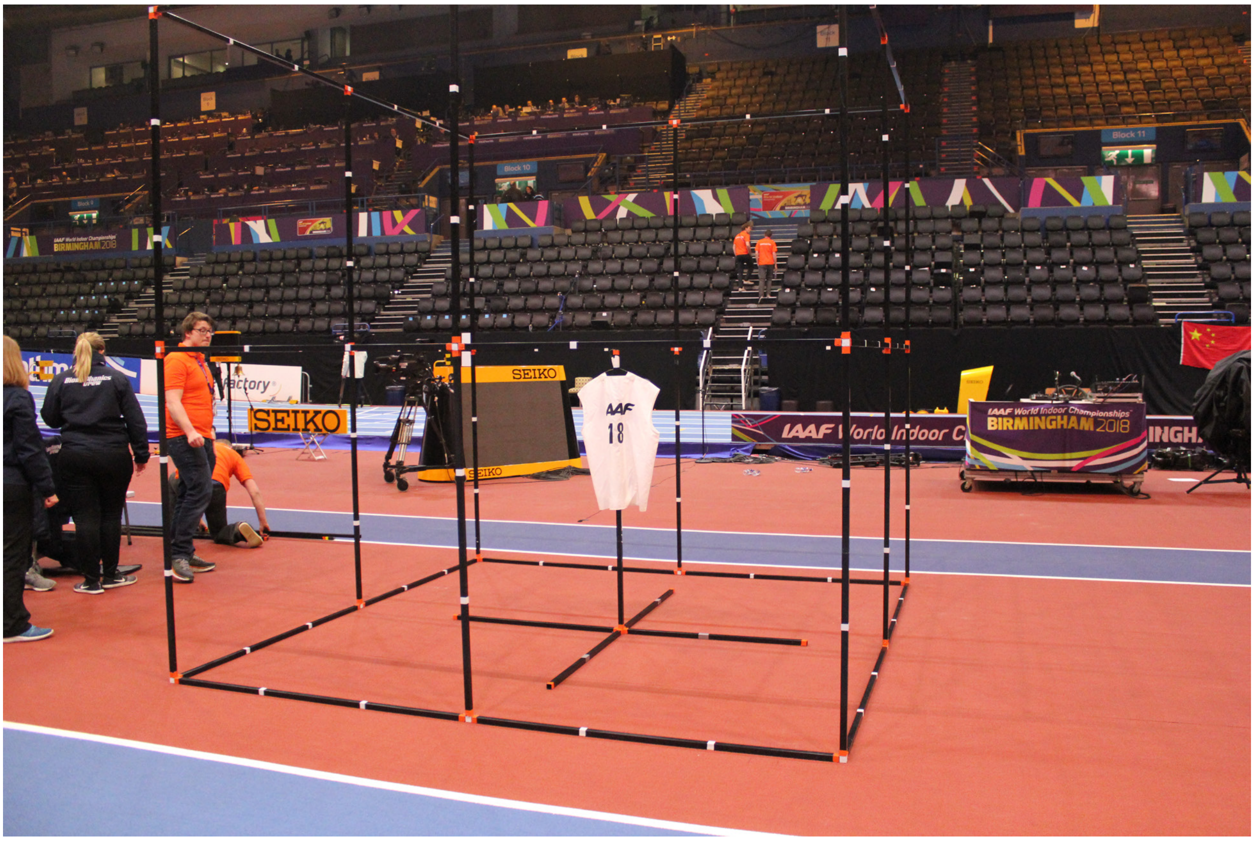


Figure 2. The calibration frame was constructed and filmed before and after the competition.

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.

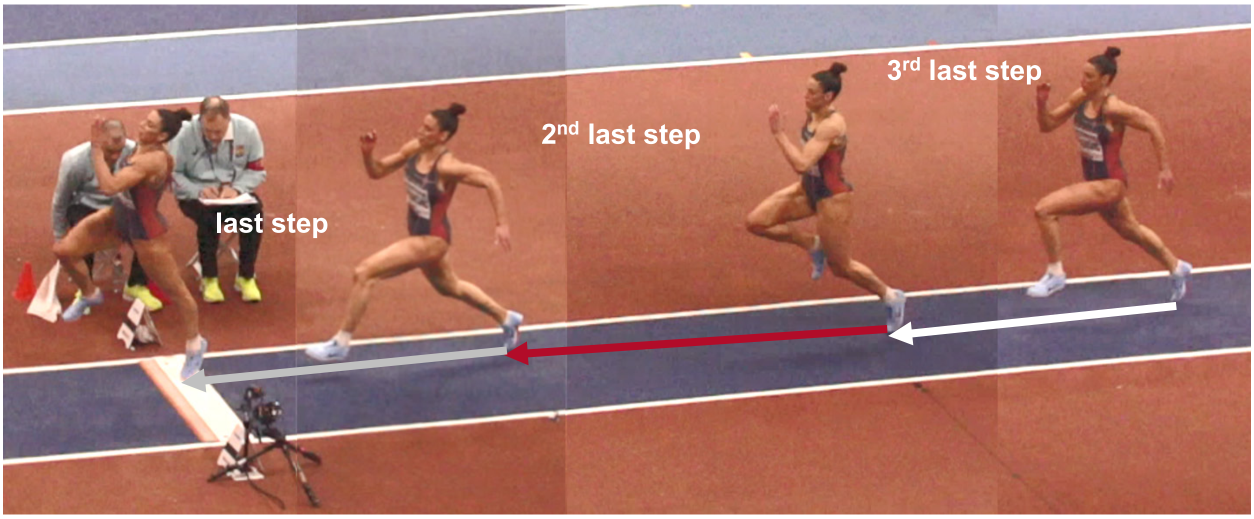


Figure 3. Last three steps in the approach phase of the long jump.

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

Variable	Definition
Official distance	The official distance published in the results.
Effective distance	The distance measured from the tip of the foot at take-off to the take-off board plus the official distance.
Take-off loss	The distance from the foot tip (take-off foot) to the front edge of the take-off board.
Step length (3rd last, 2nd last, last)	The length of the third-to-last, second-last and last approach steps measured from the foot tip in each step to the next foot tip.
Change in step length (3rd last / 2nd last and 2nd last / last)	The percentage difference in length between each step and the previous step.
Velocity (3rd last step, 2nd last step, last step)	The mean horizontal (anteroposterior direction) velocity of the athlete measured during each of the last three steps before take-off.
Horizontal velocity at take-off	The athlete's horizontal centre of mass (CM) velocity (anteroposterior direction) at the instant of take-off.
Vertical velocity at take-off	The velocity in the vertical direction of the athlete's CM at the instant of take-off.
Loss in horizontal velocity	The change in horizontal velocity from touchdown (TD) on the board to take-off from the board.
CM lowering	The reduction in CM height from take-off of the last step to the minimum CM height during contact with the board.
Contact time (last three steps)	The time spent in contact during the support phase of the last three steps.
Trunk lean angle	The angle of the trunk relative to the horizontal at the instant of touchdown and take-off and considered to be 0° in the upright position. A negative value indicates they are behind the upright position and a positive value indicates they are in front of the upright position.
Take-off angle	The angle of the athlete's CM at take-off from the board relative to the horizontal.

Body inclination angle	The angle of a line between the athlete's CM and contact foot relative to the vertical at the instant of touchdown and take-off.
Knee angle	The angle between the thigh and lower leg and considered to be 180° in the anatomical standing position. This was measured at TD on the board and when it reached its minimum on the take-off board.
Knee range of motion	The change in knee angle from TD on the board to its minimum while on the take-off board.
Knee angular velocity	The mean rate of change of the knee angle from touchdown on the board to reaching its minimum on the board.
Thigh angle of swing leg	The angle of the thigh of the swinging leg measured from the horizontal at take-off.
Thigh angular velocity of swing leg	The mean angular velocity of the thigh of the swinging leg from initial contact to take-off from the board.
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 shows the official best distance of each athlete alongside a comparison with their personal and season's bests. The mean jump distance was 6.57 metres and the mean difference compared with their season's bests was −0.10 metres and compared with their personal bests was −0.29 metres.

Table 2. Competition results in comparison with athletes' personal bests (PB) and season's bests (SB) for 2018 (before World Championships).

Athlete	Rank	Official distance (m)	SB (2018) (m)	Comparison with SB (m)	PB (m)	Comparison with PB (m)
ŠPANOVIC	1	6.96	6.93	0.03	7.24	−0.28
REESE	2	6.89	6.88	0.01	7.23	−0.34
MOGUENARA-TAROUM	3	6.85	6.83	0.02	6.86	−0.01
BURKS	4	6.81	6.73	0.08	6.80	0.01
MIHAMBO	5	6.64	6.72	−0.08	6.72	−0.08
SAGNIA	6	6.64	6.92	−0.28	6.92	−0.28
NETTEY	7	6.63	6.62	0.01	6.99	−0.36
BALTA	8	6.57	6.63	−0.06	6.87	−0.30
ROTARU	9	6.41	6.48	−0.07	6.74	−0.33
BEKH	10	6.37	6.67	−0.30	6.71	−0.34
GRĪVA	11	6.34	6.52	−0.18	6.53	−0.19
LESUEUR	12	6.34	6.69	−0.35	6.90	−0.56
SAUCEDA	13	5.99	-	-	6.74	−0.75

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

Table 3 shows some distance characteristics of each athlete's best jumps in relation to their effective distance and distance lost at the take-off board. The mean loss at the take-off board was 0.086 metres.

Table 3. Distance characteristics of the individual best jumps.

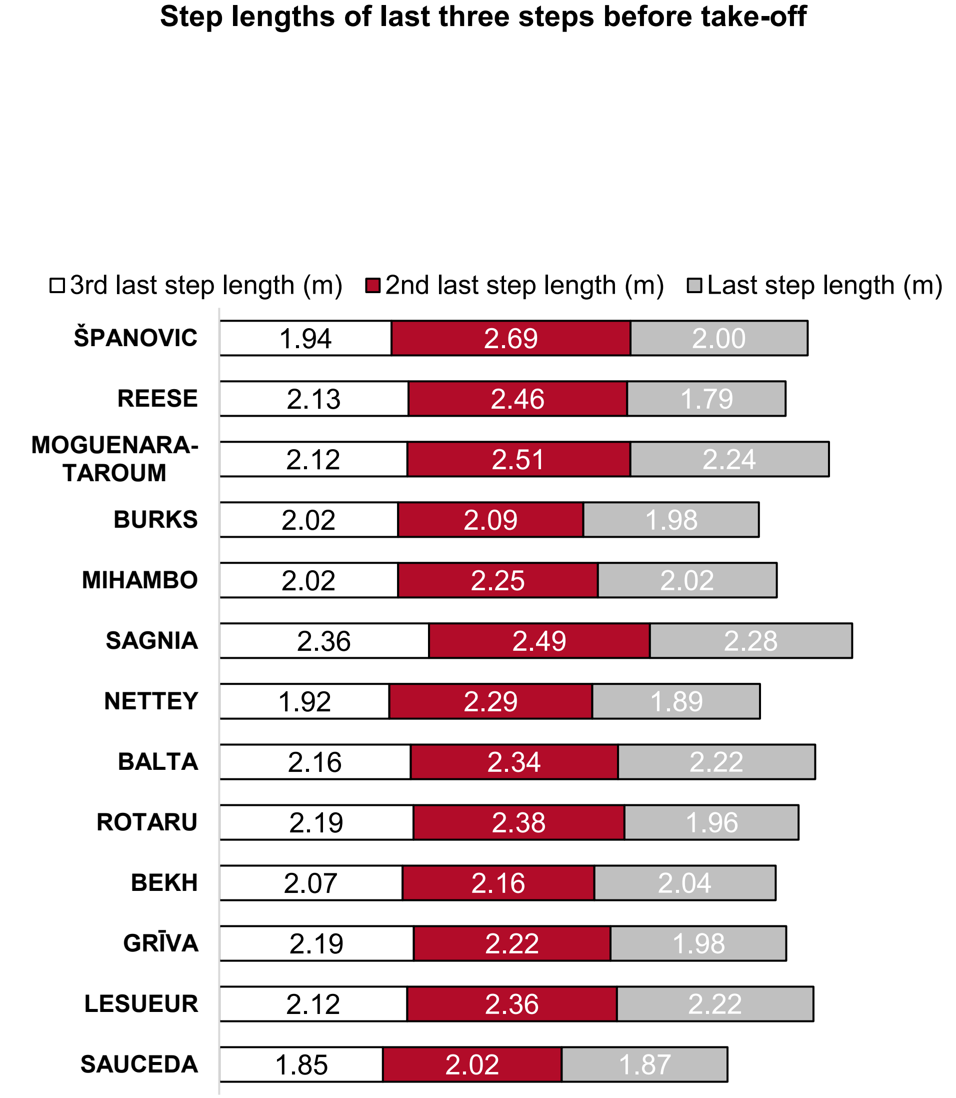
Athlete	Analysed attempt	Official distance (m)	Effective distance (m)	Take-off loss (m)
ŠPANOVIC	4	6.96	7.046	0.086
REESE	4	6.89	6.972	0.082
MOGUENARA-TAROUM	2	6.85	6.866	0.016
BURKS	1	6.81	6.948	0.138
MIHAMBO	5	6.64	6.715	0.075
SAGNIA	1	6.64	6.757	0.117
NETTEY	2	6.63	-	-
BALTA	5	6.57	6.575	0.005
ROTARU	3	6.41	6.544	0.134
BEKH	2	6.37	6.424	0.054
GRĪVA	2	6.34	6.371	0.031
LESUEUR	2	6.34	6.496	0.156
SAUCEDA	3	5.99	6.130	0.140

Note: *The take-off distances were provided by deltatre and there was no value recorded for Nettey.*

Approach phase analysis

Table 4 shows the step lengths of each finalists during their last three steps before the take-off board. The percentage change in step length from the third- to second-last, and in the second-last to last steps, is also presented. The mean change from the third-last to second-last step was an increase of 12%. The mean change from the second-last to last step was a decrease of 12%.

Table 4. Step length characteristics of the last three steps in each individual's best jump.



	Change in step length	
	3^{rd} last / 2^{nd} last (%)	2^{nd} last / last (%)
ŠPANOVIC	+39	−26
REESE	+15	−27
MOGUENARA-TAROUM	+19	−11
BURKS	+4	−5
MIHAMBO	+12	−10
SAGNIA	+5	−8
NETTEY	+19	−17
BALTA	+8	−5
ROTARU	+9	−17
BEKH	+5	−5
GRĪVA	+1	−11
LESUEUR	+11	−6
SAUCEDA	+9	−7

Table 5 shows the step time of the last three steps for each athlete. Figures 4-6 show the flight and contact times of each of those last three steps to the take-off board. The mean contact time for the third-last step was 0.105 seconds, for the second-last step was 0.113 seconds and the for the last step was 0.122 seconds. The mean flight time for the third-last step was 0.112 seconds, for the second-last step was 0.136 seconds and the for the last step was 0.075 seconds.

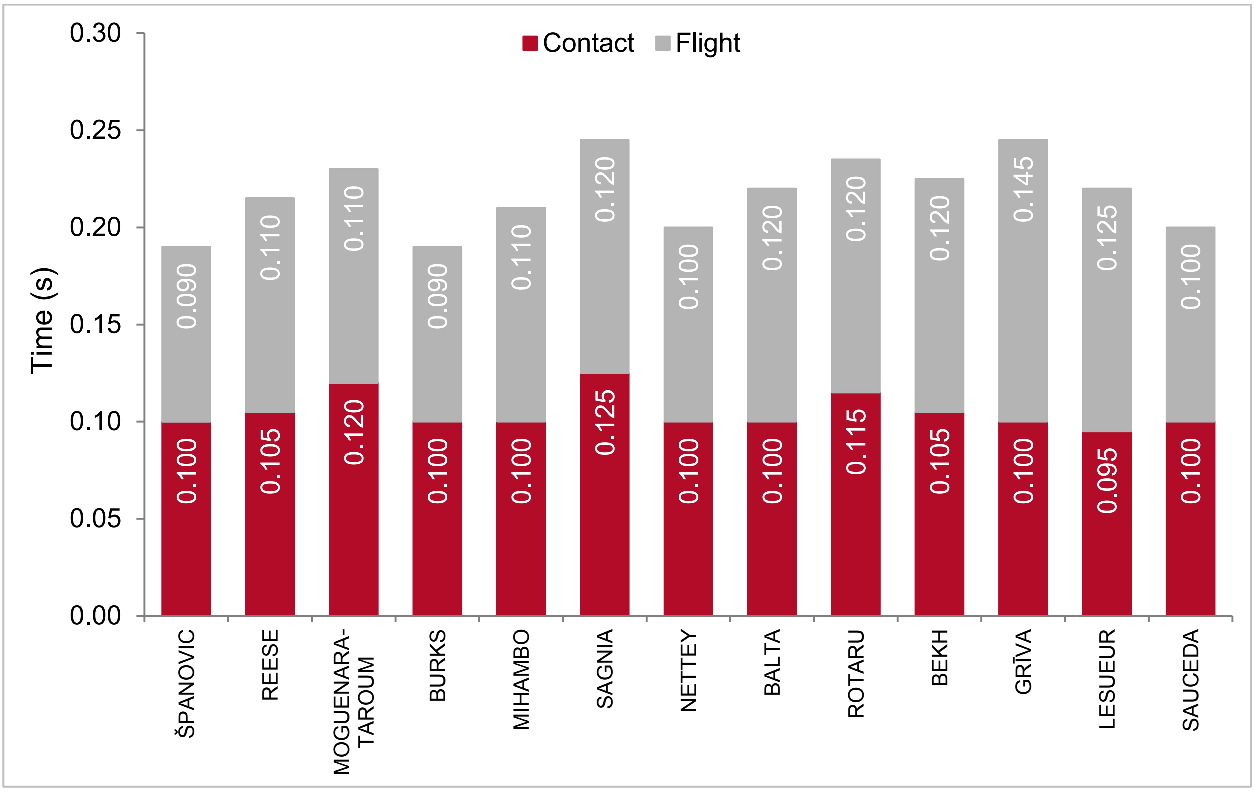


Figure 4. Contact and flight times for each finalist during the third-last step in their approach to the take-off board.

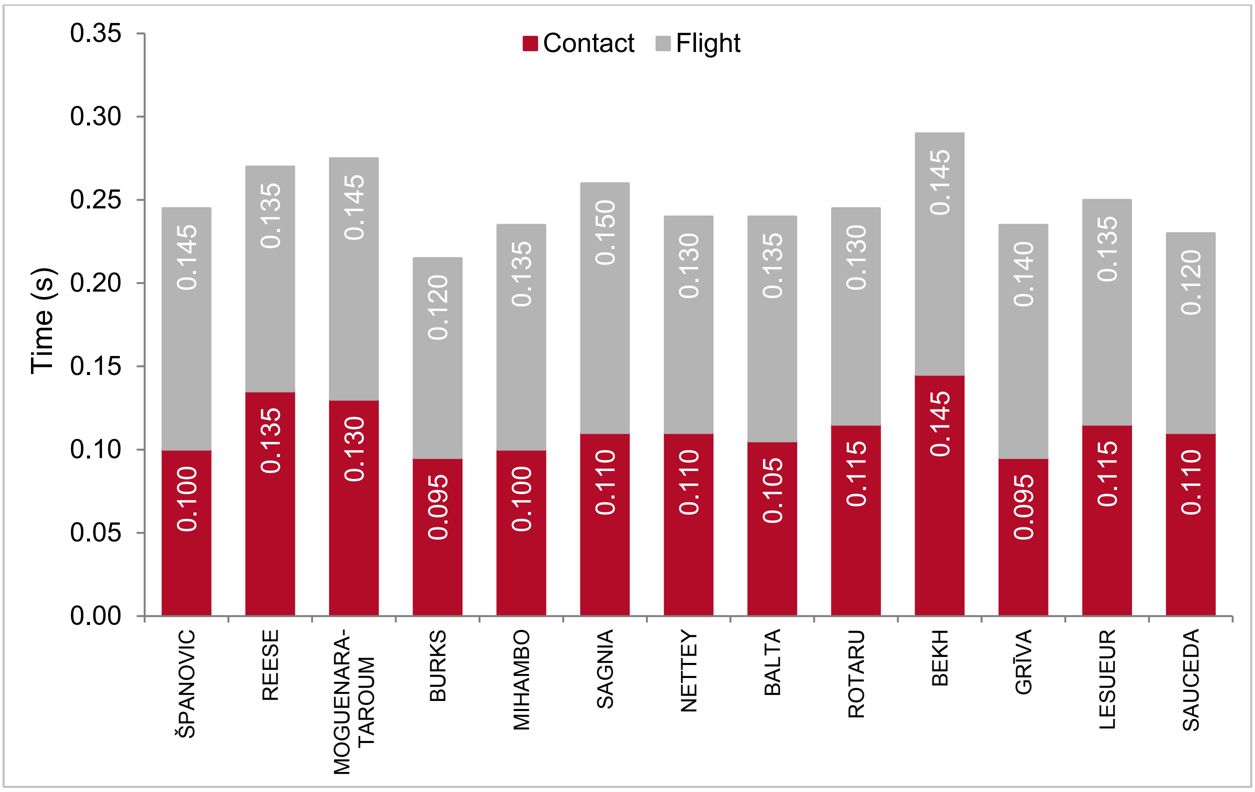


Figure 5. Contact and flight times for each finalist during the second-last step in their approach to the take-off board.

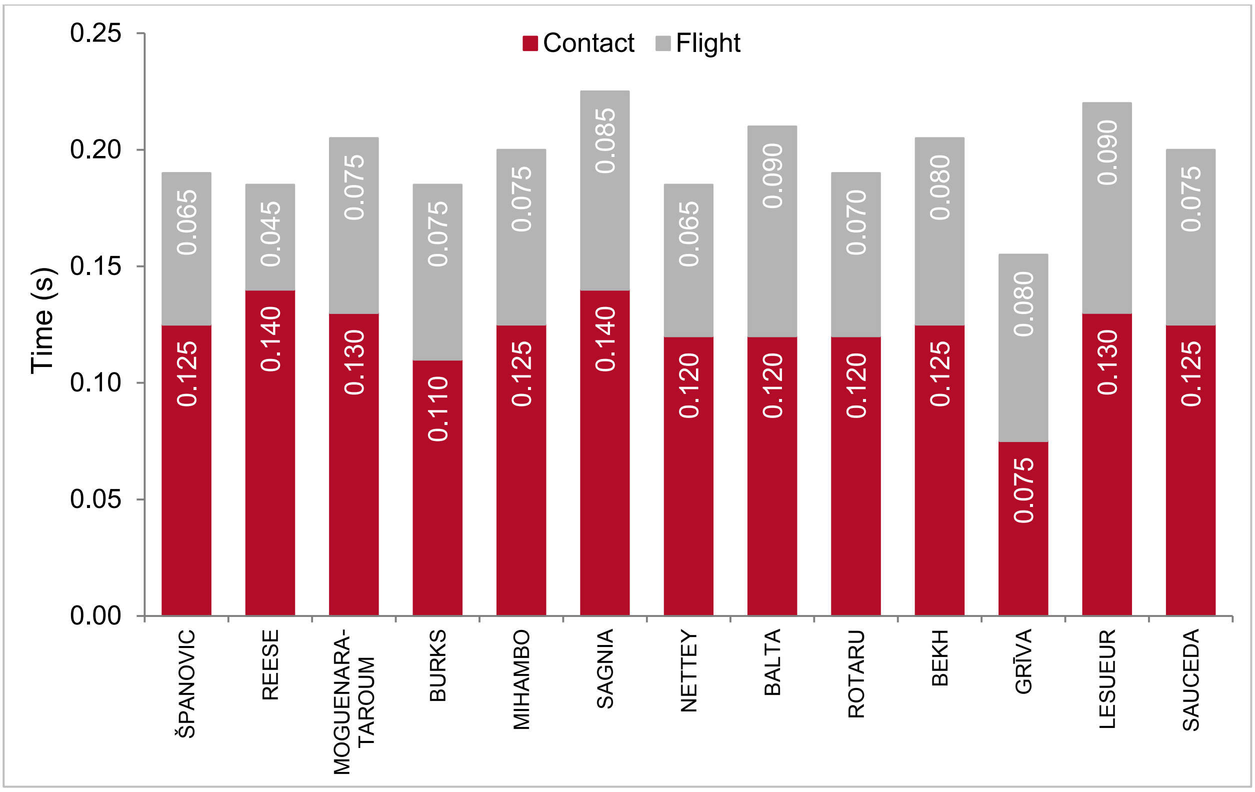
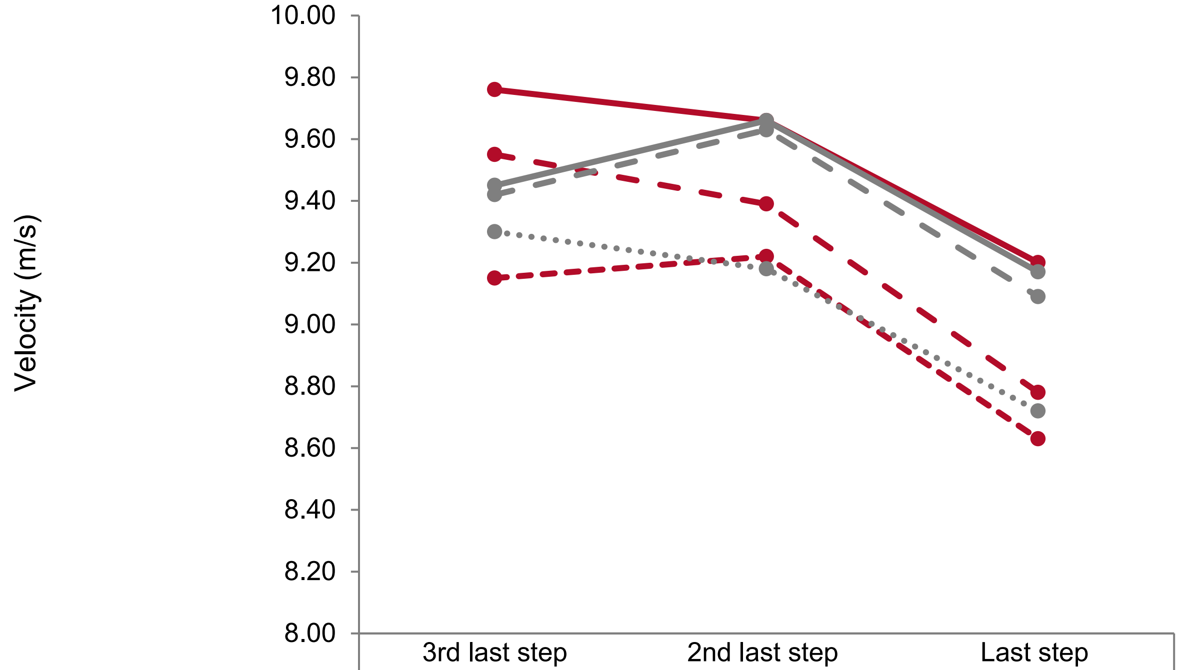


Figure 6. Contact and flight times for each finalist during the last step in their approach to the take-off board.

Table 5. Step times of the last three steps to the take-off board.

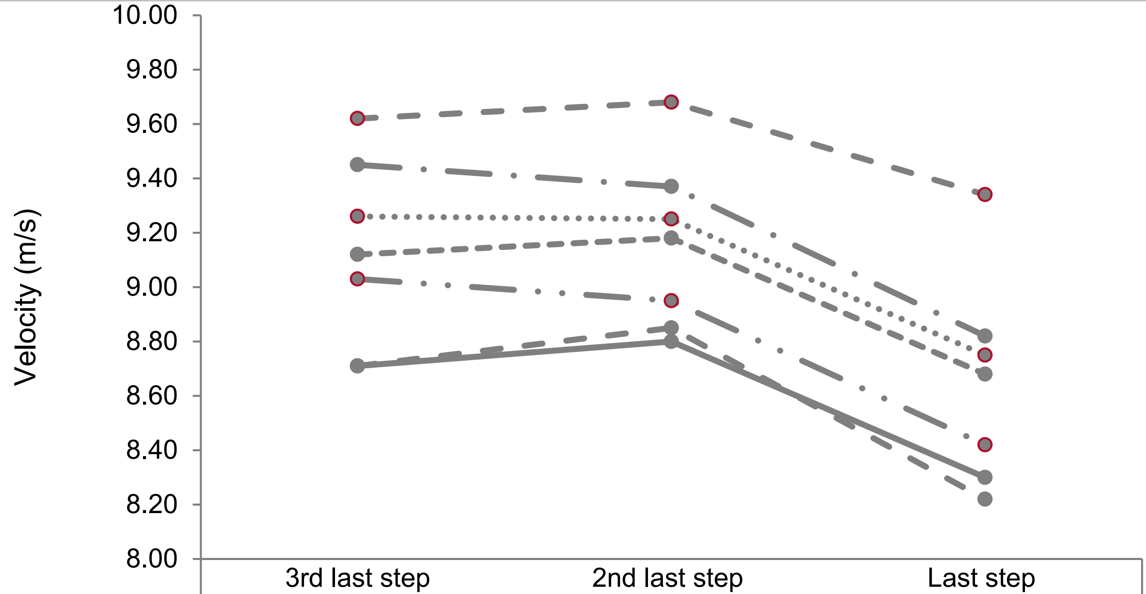
	3rd last step	2nd last step	Last step
ŠPANOVIC	0.190	0.245	0.190
REESE	0.215	0.270	0.185
MOGUENARA-TAROUM	0.230	0.275	0.205
BURKS	0.190	0.215	0.185
MIHAMBO	0.210	0.235	0.200
SAGNIA	0.245	0.260	0.225
NETTEY	0.200	0.240	0.185
BALTA	0.220	0.240	0.210
ROTARU	0.235	0.245	0.190
BEKH	0.225	0.290	0.205
GRĪVA	0.245	0.235	0.155
LESUEUR	0.220	0.250	0.220
SAUCEDA	0.200	0.230	0.200

On the following page, Figures 7 and 8 show the horizontal velocities for the last three steps for all finalists. The mean change in velocity from the third-last to second-last step was an increase of 0.2 m/s. The mean change in velocity from the second-last to last step was a reduction of 0.63 m/s.



	3rd last step	2nd last step	Last step
ŠPANOVIC	9.76	9.66	9.20
REESE	9.55	9.39	8.78
MOGUENARA-TAROUM	9.15	9.22	8.63
BURKS	9.45	9.66	9.17
MIHAMBO	9.42	9.63	9.09
SAGNIA	9.30	9.18	8.72

Figure 7. Change in horizontal velocity during the last three approach steps for the top six finishers.



	3rd last step	2nd last step	Last step
NETTEY	9.45	9.37	8.82
BALTA	9.62	9.68	9.34
ROTARU	9.12	9.18	8.68
BEKH	9.03	8.95	8.42
GRĪVA	8.71	8.85	8.22
LESUEUR	9.26	9.25	8.75
SAUCEDA	8.71	8.80	8.30

Figure 8. Change in horizontal velocity during the last three approach steps for the bottom seven finishers.

Take-off analysis

Table 6 shows the velocity components of the CM at take-off along with the loss in horizontal velocity during contact with the take-off board. The mean horizontal velocity at TO was 7.94 m/s, while the mean vertical velocity at TO was 3.22 m/s. The mean change in horizontal velocity was −1.60 m/s. The mean take-off angle was 22.1°. Figure 9 shows the relationship between the horizontal (anteroposterior) and vertical velocity at take-off.

Table 6. CM angle at take-off and velocities (horizontal, vertical and resultant) during the final step and at take-off.

Athlete	Horizontal velocity at TO (m/s)	Vertical velocity at TO (m/s)	Change in horizontal velocity (TD – TO) (m/s)	Resultant velocity at TO (m/s)	TO angle (°)
ŠPANOVIC	8.46	3.10	−1.60	9.01	20.1
REESE	8.44	3.18	−0.83	9.02	20.6
MOGUENARA-TAROUM	7.61	3.61	−1.82	8.42	25.4
BURKS	8.48	3.38	−1.52	9.13	21.7
MIHAMBO	8.39	3.05	−1.23	8.93	20.0
SAGNIA	7.34	3.68	−2.26	8.21	26.6
NETTEY	7.74	3.46	−1.79	8.48	24.1
BALTA	8.39	2.96	−1.62	8.90	19.4
ROTARU	7.90	3.38	−1.79	8.59	23.2
BEKH	7.50	3.23	−1.75	8.17	23.3
GRĪVA	7.27	3.26	−1.69	7.97	24.1
LESUEUR	7.99	2.31	−1.47	8.32	16.1
SAUCEDA	7.68	3.20	−1.40	8.32	22.6

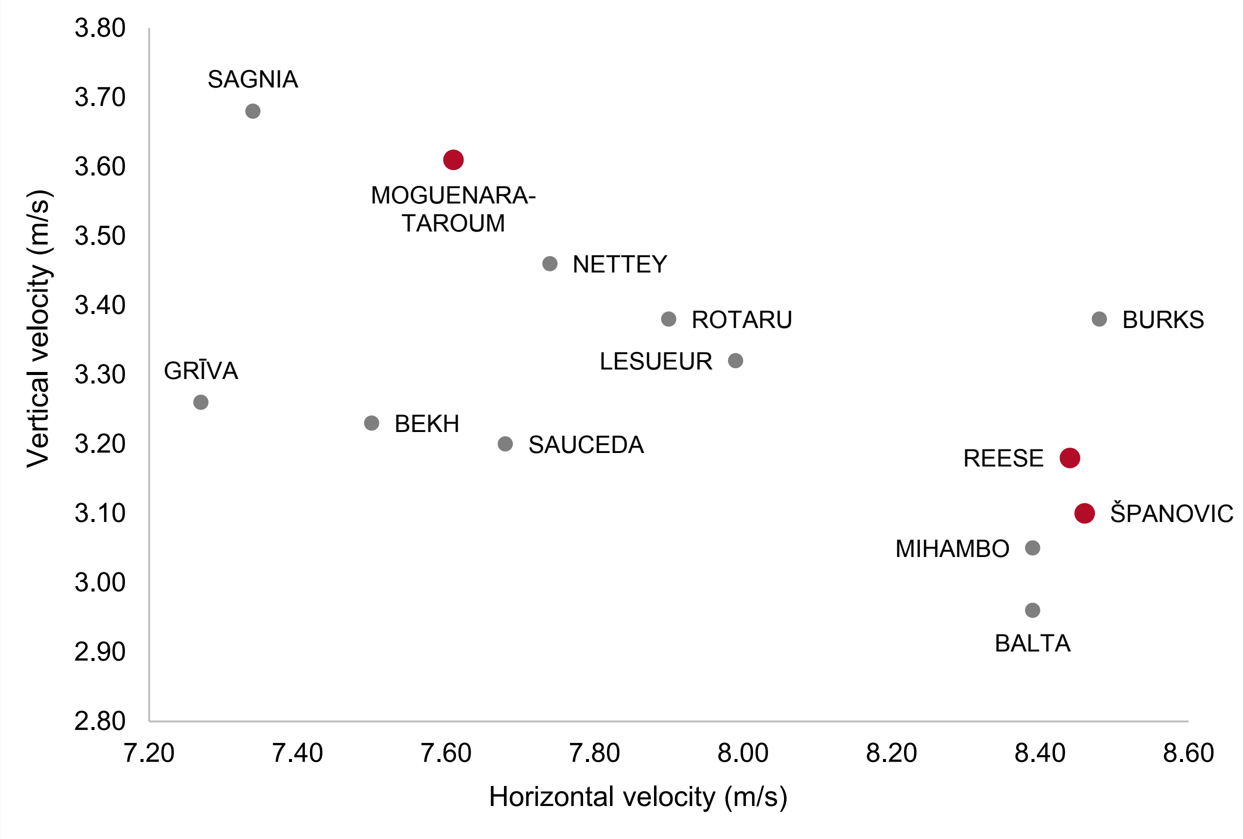


Figure 9. Scatterplot of horizontal (anteroposterior) vs. vertical velocity at take-off for all finalists.

The angles of the trunk and body inclination angle at touchdown on the board and take-off from the board are presented in Table 7. The mean trunk angle at touchdown was −7.4°, and at take-off was 1.0°. The mean body inclination angle at touchdown was −35.6°, while its value at take-off was 18.8°. The change in this angle from touchdown to take-off was 54.3°. The angle of the lead thigh at take-off was −7.1°.

Table 7. Angular data of the trunk and swinging leg for each athlete's individual best jump.

Athlete	Body inclination angle at TD (°)	Body inclination angle at TO (°)	Trunk angle at TD (°)	Trunk angle at TO (°)	Lead thigh angle at TO (°)	Mean lead thigh angular velocity (°/s)
ŠPANOVIC	−35.3	21.4	−3.8	2.9	−21.1	631
REESE	−37.9	23.7	−1.6	7.3	−6.4	651
MOGUENARA -TAROUM	−37.9	16.1	−6.7	−3.9	−18.1	533
BURKS	−35.1	19.4	−6.7	−1.4	−2.1	694
MIHAMBO	−33.4	23.4	−3.4	3.8	−13.8	566
SAGNIA	−39.0	16.0	−18.5	0.9	−3.4	575
NETTEY	−36.5	17.0	−6.2	−0.8	−10.7	640
BALTA	−34.9	20.2	−6.4	−1.5	−10.2	533
ROTARU	−34.8	17.7	−14.9	−8.3	11.8	771
BEKH	−35.6	18.1	−9.8	−5.9	0.0	463
GRĪVA	−32.7	15.8	−6.8	−4.4	−2.0	645
LESUEUR	−34.9	18.0	−5.0	−3.0	−3.2	605
SAUCEDA	−34.2	17.5	−6.2	1.5	−13.5	537

Note: *A negative body inclination angle indicates that the CM is behind the foot at contact. A negative lead thigh angle means the thigh is below the horizontal. A negative trunk angle indicates that trunk is extended beyond the upright position while a positive trunk angle indicates the trunk angle is flexed beyond the upright position.*

Table 8 displays the knee angle at touchdown (TD) and the minimum knee angle achieved on the board. The mean knee angle at TD on the board was 166.0° while the mean minimum knee angle on the board was 139.2°. The mean knee range of motion was 26.8°. The mean rate of change of this knee angle was −481 °/s. The mean lowering of the CM height was 4 centimetres.

Table 8. Characteristics of the contact leg on the take-off board and the CM vertical displacement during the final step.

Athlete	Knee angle at TD (°)	Minimum knee angle (°)	Knee range of motion (°)	Mean knee angular velocity (°/s)	CM lowering (cm)
ŠPANOVIC	167.9	144.1	23.8	−595	2
REESE	160.0	123.6	36.4	−662	1
MOGUENARA-TAROUM	160.2	137.5	22.7	−349	4
BURKS	167.0	143.0	24.0	−600	3
MIHAMBO	166.1	138.8	27.3	−496	5
SAGNIA	174.5	141.6	32.9	−506	5
NETTEY	165.1	133.3	31.8	−530	3
BALTA	164.2	140.1	24.1	−438	4
ROTARU	168.9	138.6	30.3	−505	4
BEKH	165.0	145.2	19.8	−305	9
GRĪVA	170.7	146.7	24.0	−440	6
LESUEUR	164.9	142.0	22.9	−416	3
SAUCEDA	163.1	134.5	28.6	−409	2

Note: *Negative angular velocity values for the knee indicate the knee is flexing as this is the period from touchdown to reaching their minimum knee angle.*

Landing analysis

Table 9 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 Moguenara-Taroum at 0.24 metres. Five other athletes also recorded a loss on landing. The mean hip angle at landing was 90.1°. The mean knee angle was 133.7°, while the mean trunk angle was 5.7°. Figure 10 shows the landing distance by each athlete. The mean landing distance was 0.59 metres.

Table 9. Landing characteristics in the women's long jump final.

Athlete	Hip angle (°)	Knee angle (°)	Trunk angle (°)	Landing loss (m)
ŠPANOVIC	92.2	139.3	−8.8	0.10
REESE	100.7	132.4	−5.2	0.00
MOGUENARA-TAROUM	102.2	149.0	5.3	0.24
BURKS	62.5	132.1	30.8	0.00
MIHAMBO	69.1	129.0	18.1	0.17
SAGNIA	70.1	110.0	12.5	0.00
NETTEY	87.3	132.4	12.3	0.07
BALTA	79.2	153.9	24.4	0.12
ROTARU	100.3	113.4	−6.5	0.07
BEKH	96.3	118.2	−8.2	0.03
GRĪVA	91.0	122.6	2.9	0.00
LESUEUR	110.5	146.9	−0.8	0.00
SAUCEDA	109.6	158.9	−2.5	0.12

***Note**: A negative trunk angle indicates that trunk is extended beyond the upright position while a positive trunk angle indicates the trunk angle is flexed beyond the upright position.*

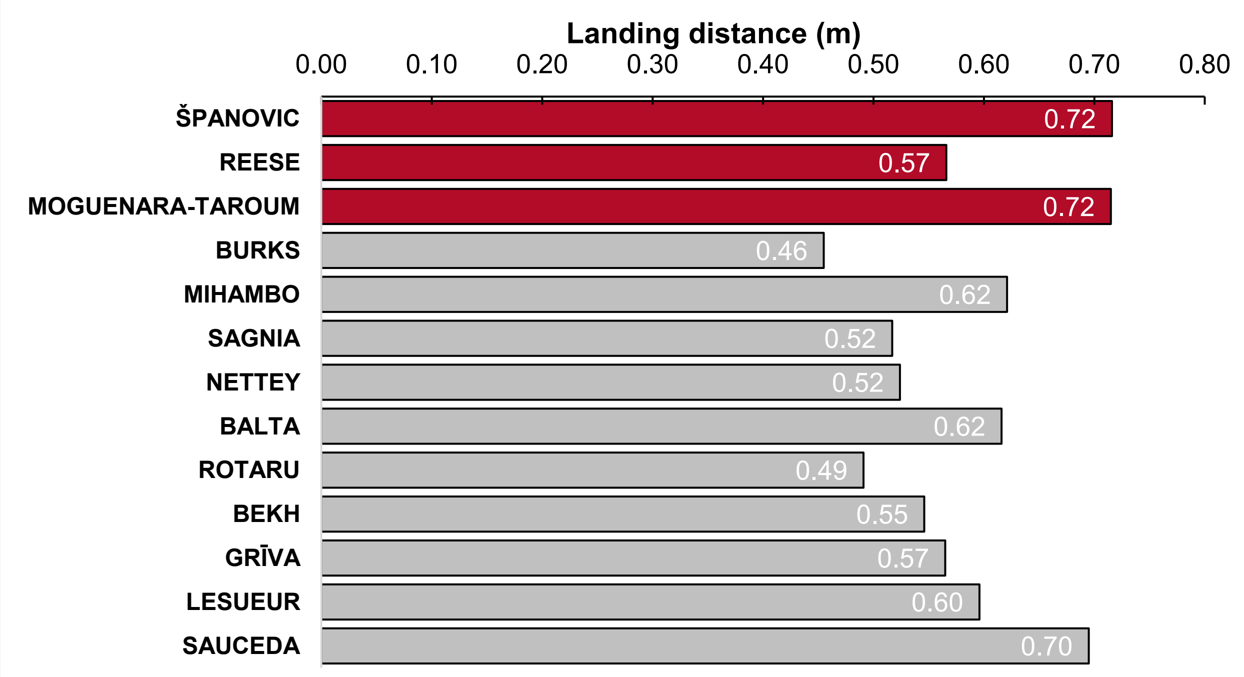


Figure 10. The landing distances for each finalist in the women's long jump.

CM trajectories (vertical)

Figures 11-15 on the following pages show the changes in the height of the CM from toe-off of the last step until take-off from the board. These data have been normalised to the height of the CM at toe-off of the last step.

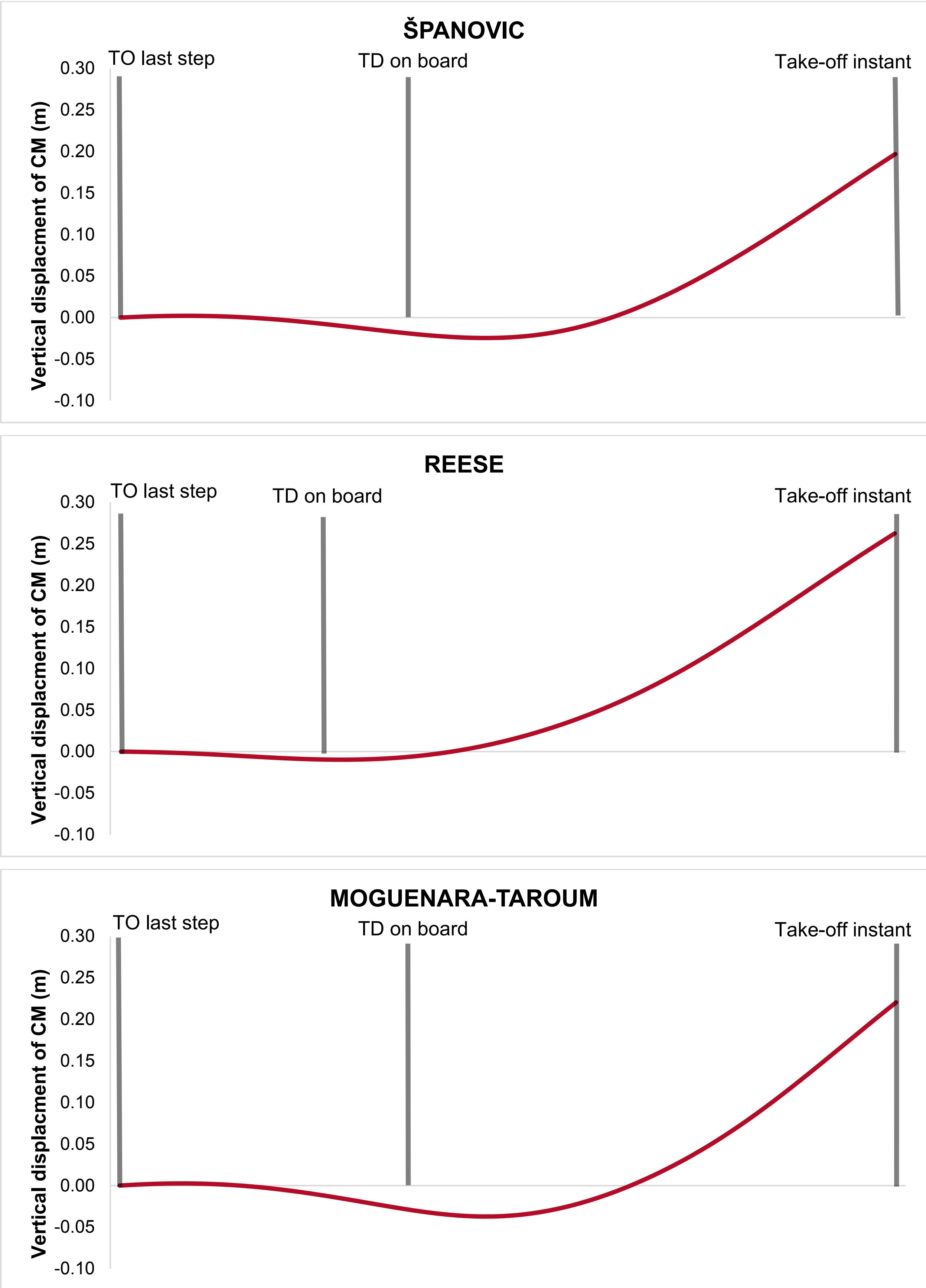


Figure 11. Change in the height of the CM from touchdown (TD) of the last step until the instant of take-off from the board for the medallists.

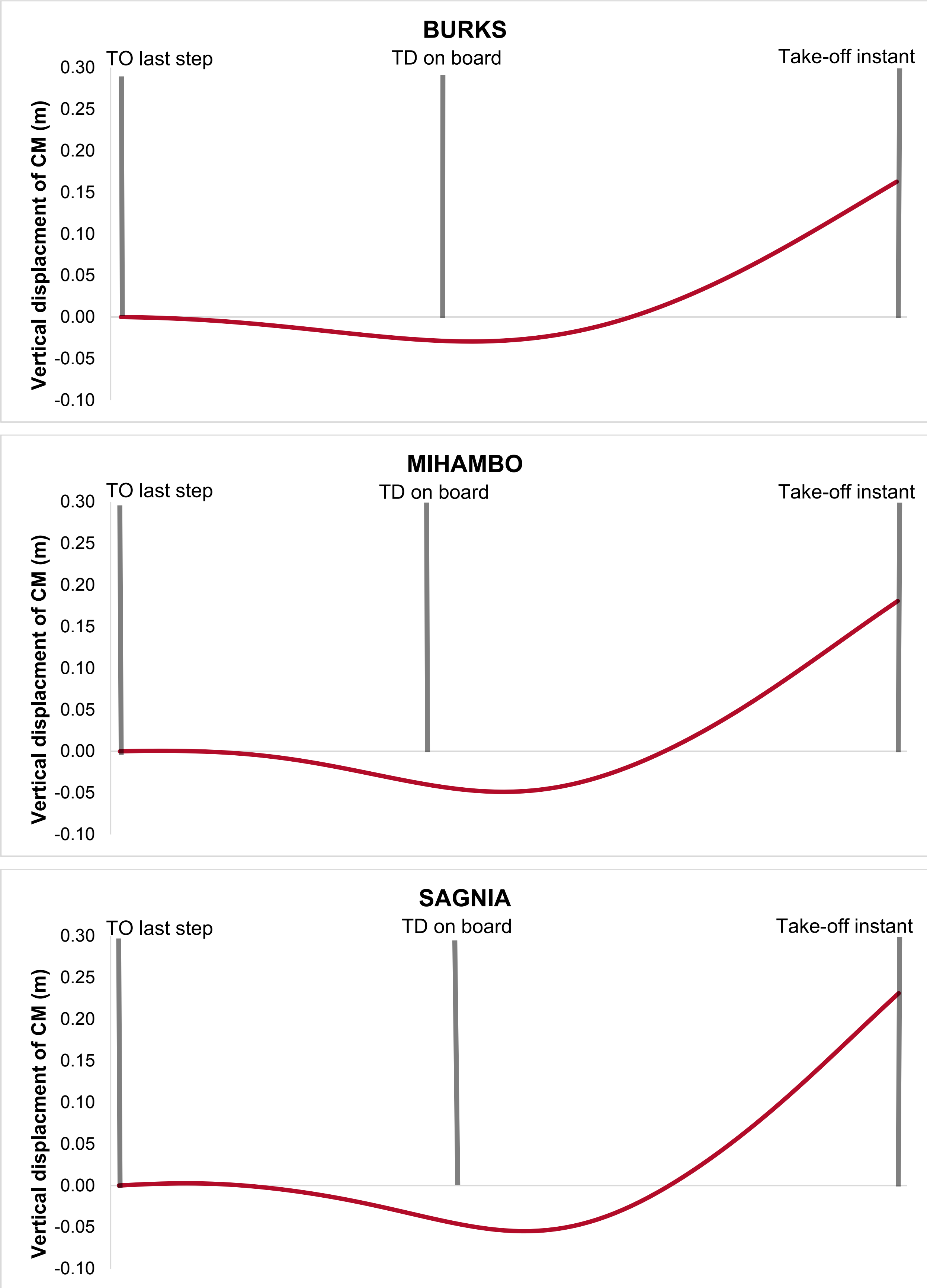


Figure 12. Change in the height of the CM from touchdown (TD) of the last step until the instant of take-off from the board for the fourth, fifth and sixth placed athletes.

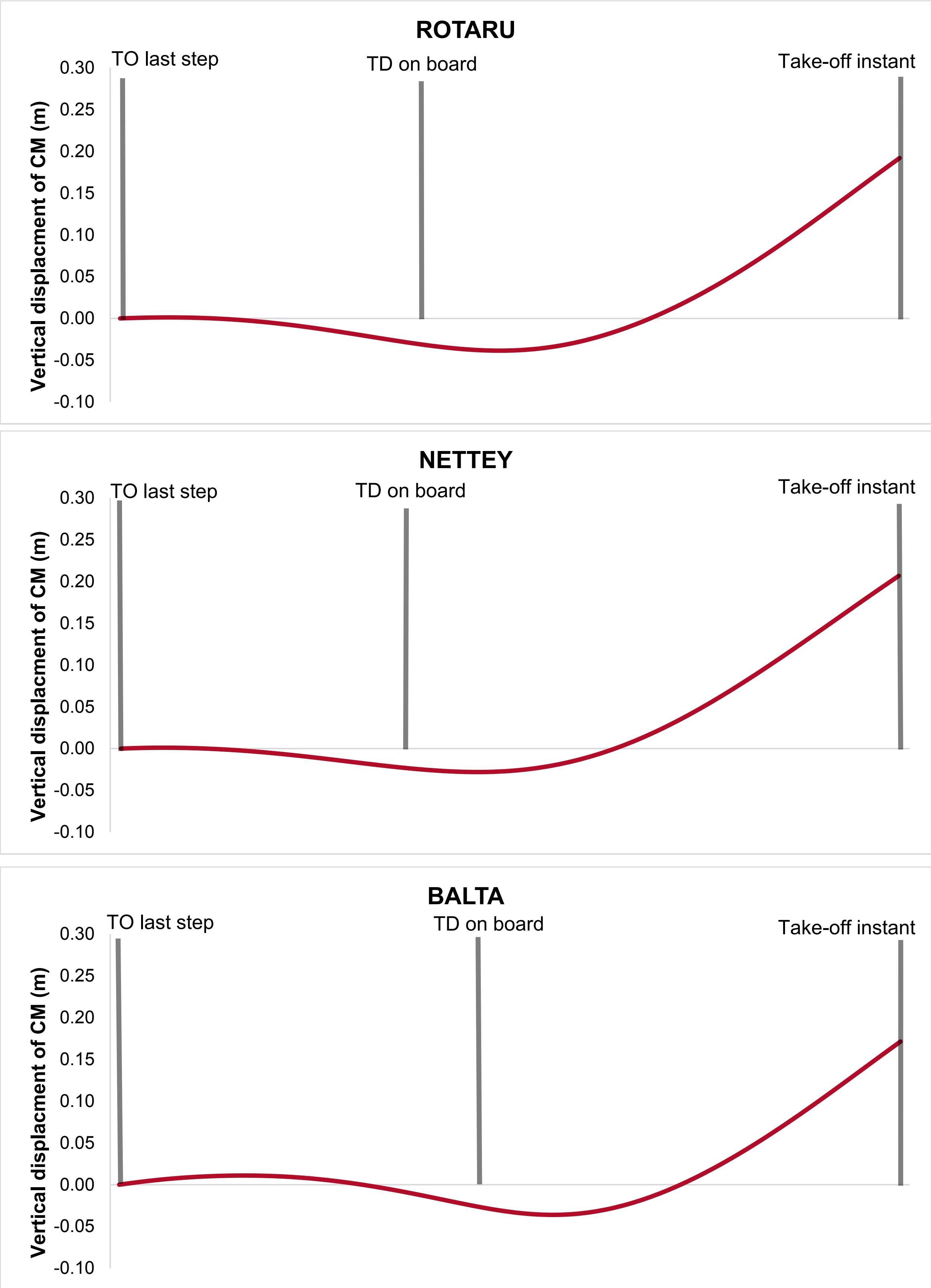


Figure 13. Change in the height of the CM from touchdown (TD) of the last step until the instant of take-off from the board seventh, eighth and ninth placed athletes.

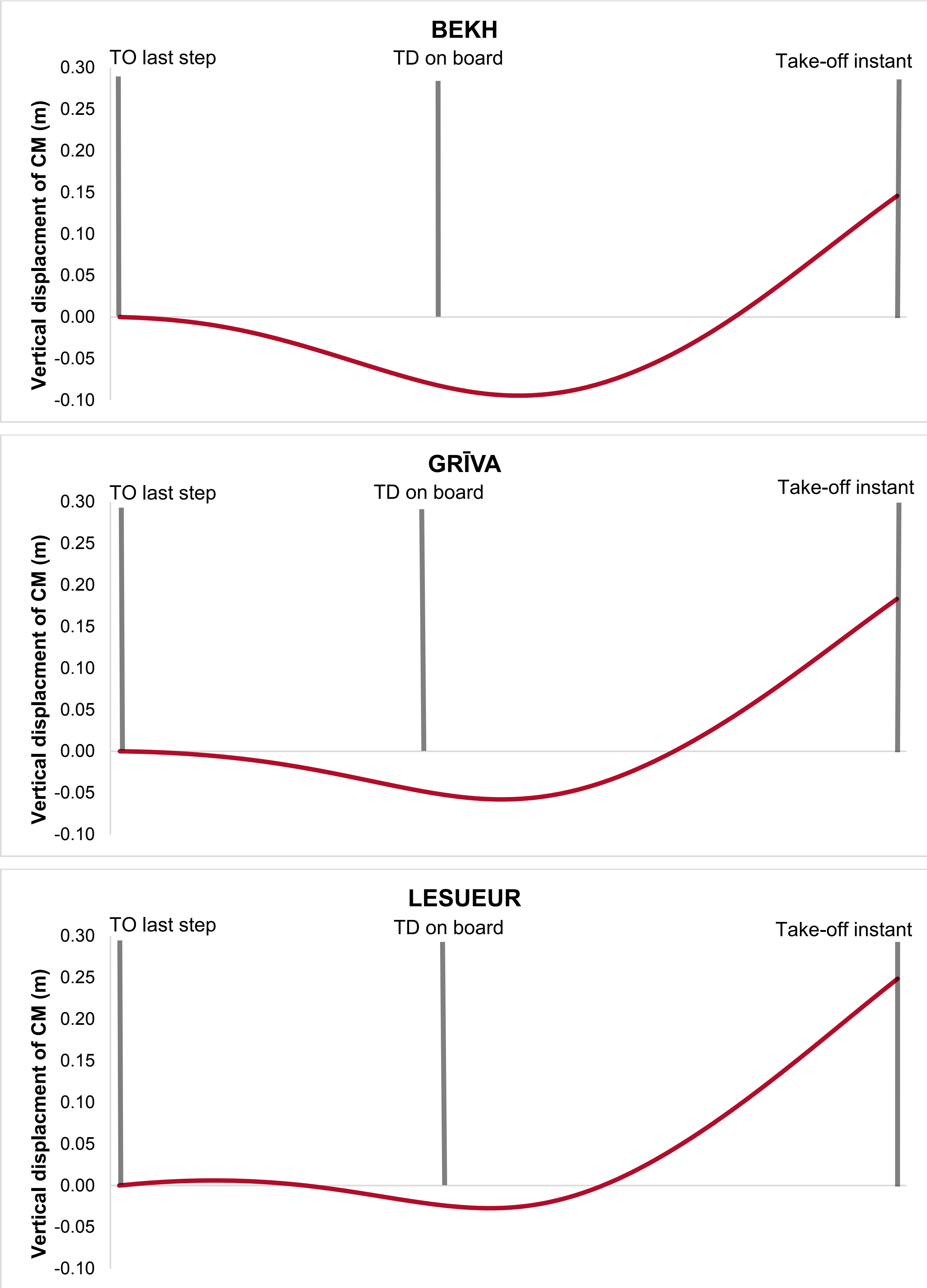


Figure 14. Change in the height of the CM from touchdown (TD) of the last step until the instant of take-off from the board tenth, eleventh and twelfth placed athletes.

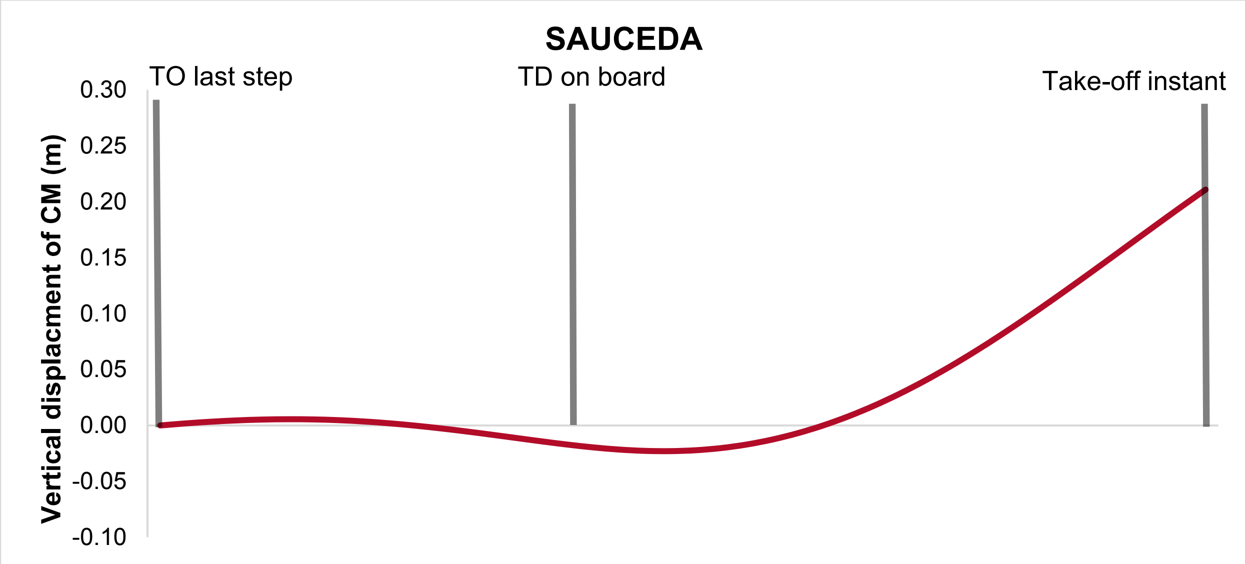


Figure 15. Change in the height of the CM from touchdown (TD) of the last step until the instant of take-off for the thirteenth placed athlete.

COACH'S COMMENTARY

Introduction

The long jump is a simple event in appearance, but the details involved in its execution are much more complex.

The aim is to produce the maximum amount of horizontal velocity in the aim of transfer it during the impulse (we then talk about optimal velocity). This implies a limited loss of velocity on the board; since the potential distance is already determined at take-off, the jump technique (hang, 1 step ½ hitch kick or 1 step ½ hitch kick) allows: 1) a good balance during the flight and 2) an optimum landing.

The commentary of the Birmingham 2018 medallists will be split in two parts:

- Analysis and comparison of the biomechanical findings
- Proposed directions of work for each jumper

Analysis and comparison of the biomechanical findings

<u>Presentation of the athletes:</u>

Ivana Španovic: born in 1990, she excelled in youth categories, becoming world junior champion in 2008. However, she had a late development as she reached 7 m for the first time in 2015, taking world bronze medal. Interestingly, that season, she changed her jumping style, switching from extension to hitch-kick. In 2016, she placed 3rd in Rio Olympics and won the Diamond League. In 2017, she improved to 7.24 m but just missed a medal at the 2017 World Championships.

Brittney Reese: born in 1986, she has an impressive medal collection: Olympic champion in 2012, silver medal in the 2016 Olympics, she is a four-time world champion (2009 to 2017) and two-time winner of the Diamond League. With a 7.31 m PB, she is the best long jumper of the decade.

Sosthene Moguenara-Taroum: born in 1989, she broke the 7 metre barrier in 2013, and set her PB of 7.14 m in 2016, but only took the 10th place at the Rio Olympic Games.

Choice of relevant data

The elements I chose for my analysis are:

- CM trajectory
- Landing distance
- Landing loss
- Mean knee angular velocity (°/s)
- Table 6
- Table 4
- Figure 3,4 5 and 10

a. Comparison of data

Athlete	Official (m)	Landing loss + TO loss (m)	Potential distance (m)
ŠPANOVIC	6.96	0.10 + 0.08	7.14
REESE	6.89	0.00 + 0.08	6.97
MOGUENARA-TAROUM	6.85	0.24 + 0.01	7.10

This table shows the difference between the official and the potential distance for the medallists. It is obvious that the biggest loss of distance for two of them lies in the landing, especially in Moguenara-Taroum who could have been a contender for the gold.

Ivana Španovic

She is the fastest coming on the board: 9.20 m/s on her last step and only lost 0.56 m/s between the 3rd and last steps. In London 2017, her velocity loss was a low as 0.34 m/s for a 6.96 m jump (7.03 m effective). Her take-off angle (20.6°) is similar to Reese, and much lower than Moguenara-Taroum showing a different aim. However, a 0.10 m loss was measured in the landing, meaning that she could have jumped over 7 metres.

Brittney Reese

On the other hand, Reese seems to rely more on the horizontal velocity orientation. In Birmingham 2018, her deceleration is significant (0.77 m/s loss between the 3rd last and the last step, versus 0.56 m/s for Španovic and 0.49 m/s for Moguenara-Taroum), just like in the 2017 London World

Championships the previous year (0.85 m/s for a 7.02 m jump). Yet, she is not seeking a high take-off angle: only 20.6° and a vertical velocity of 3.18 m/s. This trend was even more pronounced in former competitions where she jumped farther: 18.4° and 2.73 m/s in London 2017 for a 7.02 m jump (7.03 m effective), 17.8° and 2.71 m/s for a 7.19 m jump (7.28 m effective) at the 2011 USA championships. With a larger take-off angle of 21° at the 2011 Daegu World Championships, Reese could only jump 6.82 m (6.93 m effective). The parameter Reese seems to rely on is the horizontal velocity at take-off as in Daegu it was only 7.82 m/s, compared to the 8.45 m/s she produced for her 7.19 m jump the same year. The very small lowering of her CM on the board (Figure 10) is typical of triple jumpers, but it was previously already relatively low during the whole-run-up.

Sosthene Moguenara-Taroum

She is the slowest one during her last step before the board, 8.63 m/s, and also has the largest loss of velocity at the end of the run-up. She also displays an atypical style: an acceleration is measured between her 3rd last and 2nd last step (9.15 m/s and 9.22 m/s) and a deceleration at the last step (8.63 m/s). Ideally, we should see a smoother deceleration at this point.

This loss of speed is explained by her aim to increase her take-off angle and vertical velocity: 25.4° and 3.61 m/s, the largest of among the medallists and the 2nd largest of all the jumpers.

Her body inclination angle at TD & TO is −37.9° and 16.1°. Figure 10 (vertical displacement of CM) illustrates these observations.

Potential improvements for these jumpers

Ivana Španovic

With her well-balanced style, she doesn’t really have major changes to focus on, except her landing phase. Indeed, watching the videos of her 6 attempts in Birmingham, we can notice that her farthest jump was the one where she had the minimum loss at landing.

Brittney Reese

She could work on:

1. Reducing the velocity loss on the last steps in order to produce a more efficient impulse
2. Increasing her take-off angle? Would higher velocity at the end of her run-up transfer into different angle?
3. Run with higher hips? Is it advisable to correct it or is it a morphological feature?

Sosthene Moguenara-Taroum

Areas that could be worked on might be:

1. The steadiness and tempo of her run-up. Trying to have a more progressive acceleration would allow her to be more develop more impulse, and reach the board at a higher velocity.
2. Reducing her take-off angle. It can be achieved by a different body position on the last steps (slightly more body leaning), and by limiting the drop of her hips on the board.
3. Her landing technique: 0.24 m are lost there.

Conclusion

Along this analysis of the biomechanical data of the medallists, we found that 2 of them seems to express themselves more through their physical potential rather than optimisation of their technique, whereas Španovic seems to display the best compromise. Still, just like in men’s competition, some precious centimetres are lost in the landing phase.

Two questions come to mind:

- Are women focusing as much as men on technical aspects?
- Should it be necessary to work on adapting other jumping style to the female jumpers in accordance with their physical and morphological features?

CONTRIBUTORS

Dr Catherine Tucker is a Senior Lecturer in Sport and Exercise Biomechanics at Leeds Beckett University. Catherine graduated with First Class Honours in Sport and Exercise Sciences from the University of Limerick and subsequently completed a PhD in sports biomechanics, also at the University of Limerick. Catherine's main research interests centre on the biomechanics of striking movements, particularly golf. She is also interested in movement variability with respect to gait and how it relates to movement outcome / injury reduction.

Dr Athanassios Bissas is the Head of the Biomechanics Department in the Carnegie School of Sport at Leeds Beckett University. His research includes a range of topics but his main expertise is in the areas of biomechanics of sprint running, neuromuscular adaptations to resistance training, and measurement and evaluation of strength and power. Dr Bissas has supervised a vast range of research projects whilst having a number of successful completions at PhD level. Together with his team he has produced over 100 research outputs and he is actively involved in research projects with institutions across Europe.

Triple jump specialist since 2005, Teddy Tamgho is the current world record holder in the discipline. In 2013, he became world champion with 18.04 m and the third man in the history to cross the 18 metre mark. Alongside his athletic career, Teddy has been evolving since 2014 as a coach. He founded his training group 'Team T' and coaches a talented group of 8 athletes including Hugues Zango actual world leading performer (17.58 m) and Rouguy Diallo (14.39 m) former world junior champion.