A comparison of barbell kinematics and kinetics during successful and unsuccessful snatch attempts among elite male weightlifters

- in cases of unsuccessful lifts with backward barbell drops -

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1. Introduction

Thank you for permission to filming at 2019WWC in Pattaya, Thailand. This tournament has more players than ever before and has not been analyzed. Therefore, as a sequel to previously submitted papers (*“A Biomechanical Comparison of Successful and Unsuccessful Snatch Attempts among Elite Male Weightlifters”), here are the analysis results comparing successful and unsuccessful snatch lift for 2017WWC and 2017JWC. Previously submitted papers were intended for attempts where the barbell was dropped forward in unsuccessful snatch, but this report is intended for attempts where the barbell was dropped BACKWARD. By combining the two results, it will be very beneficial data.

Without authorization and guidance from IWF, our research would not have been possible. We profusely thank the IWF.

*Nagao H, Kubo Y, et al. A Biomechanical Comparison of Successful and Unsuccessful Snatch Attempts among Elite Male Weightlifters. Sports; 7, 151, 2019.

2. Methods

2.1 Procedures

Snatch attempts were recorded using a digital video camera(ILCE-7M3, SONY, Japan) operating at 60 Hz with a shutter speed of 1/500 sec. To obtain the real-space two-dimensional position coordinates of the barbell trajectory in the sagittal plane, the left end of the barbell was digitized to obtain the position coordinates in the camera space. The Speedede-Up Robust Features method was used for automatic digitizing. The barbell plate diameter (0.45 m) was used as the reference to calibrate the barbell's real-space position coordinates from the camera-space position coordinates.

2. Methods

2.2 Subject

The data in this study included successful and unsuccessful snatch lifts achieved at the same weights in the same lifter (JWC2017,Tokyo and WWC2017,USA), ***in the case of the unsuccessful lift due to a backward barbell drop.*** The nationalities, categories (junior or senior), weight categories, and barbell weights are listed in Table.

Name	Nation	category	Class	Snatch [kg]
TRAN-Le-Quoc-Toan	VIE	senior	56	119
CHIANG-Nien-En	TPE	junior	62	110
HORST-Jacob-Christian	USA	junior	62	110
NONDARA-Pongsakorn	THA	junior	62	112
BALAM-NAAL-Maximiliano	MEX	junior	62	113
HIGUITA-BARRERA-Luis-Fernando	COL	junior	62	126
URUMOV-Vladimir-Marinov	BUL	senior	62	125
TAKAO-Hiroaki	JPN	senior	62	126
ALHUMAYD-Mahmoud-Mohammed-S	KSA	senior	69	138
MCTAGGART-Cameron-David	NZL	junior	77	130
MAKEYEV-Mikhail	KAZ	junior	77	140
KIM-Sungmin	KOR	junior	77	147
CHIANG-Tsung-Han	TPE	senior	77	137
LOBSI Pornchai	THA	senior	77	151
MATA-PEREZ-Andres-Eduardo	ESP	senior	77	154
ROSA-DA-SILVA-Welisson	BRA	senior	85	140
SANTAVY-Boady-Robert	CAN	junior	94	160
MARUMOTO-Hiroto	JPN	junior	105	142
MOCHIDA-Ryunosuke	JPN	senior	105	165
VINCI-Alessandro	ITA	junior	105	138
			Mean	134.2

senior: n=9

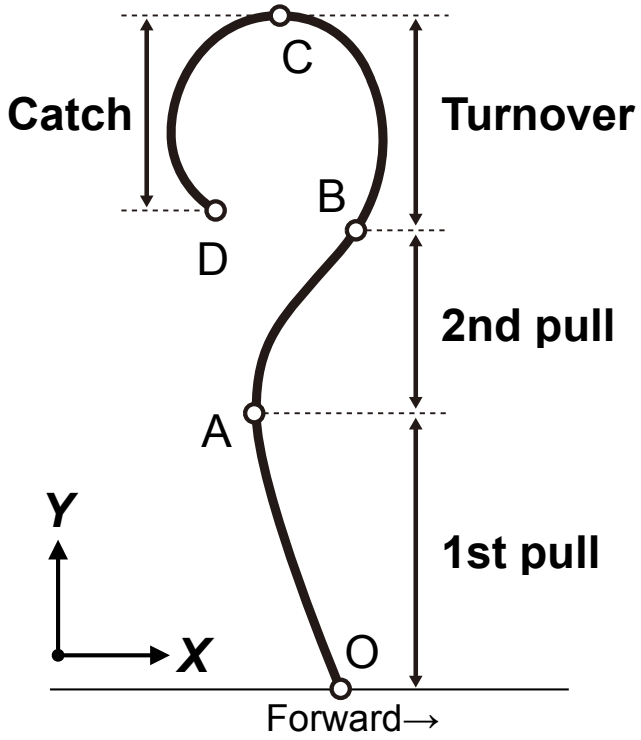
junior: n=11

TOTAL: n=20

2. Methods

2.3 Definition of the phases and events of the snatch lift

the snatch lift phases (1st pull, 2nd pull, Turnover and Catch phase)
were defined according to the barbell trajectory



Event point

O: start position

A: most backward position before Peak vertical velocity

B: peak vertical velocity

C: maximum height

D: catch position

The “start position” was defined as the time when the *y*-axis component of the barbell position (barbell height) was ≥0.225 m, and the *y*-axis component of the barbell velocity was ≥0.01 m/s.

The “catch position” was defined as the time when the *y*-axis component of the barbell velocity was closest to 0 m/s after the height of the barbell reached the maximum.

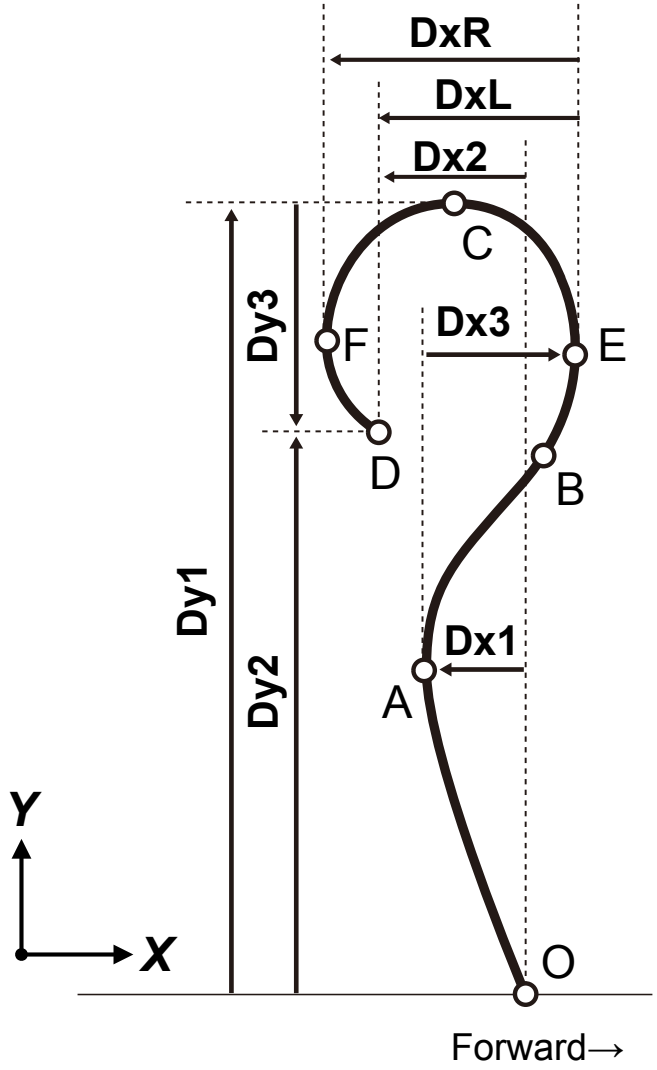
2. Methods

2.4 Barbell kinematics parameters

Symbol	Unit	Definition
Barbell vertical direction variable		
Dy1	[m]	Start position to maximum height
Dy2	[m]	Start position to the catch position
Dy3	[m]	Maximum height to the catch position (drop distance)
pVy+_1st	[m/s]	Maximum vertical linear velocity in the 1st pull phase
pVy+_2nd	[m/s]	Maximum vertical linear velocity in the 2nd pull phase
pVy-	[m/s]	Minimum vertical linear velocity in the catch phase (drop velocity)
pFy_1st	[N]	Maximum vertical linear force in the 1st pull phase
pFy_2nd	[N]	Maximum vertical linear force in the 2nd pull phase
pPy_1st	[W]	Maximum vertical linear power in the 1st pull phase
pPy_2nd	[W]	Maximum vertical linear power in the 2nd pull phase
pFy%height	[%]	Height of peak vertical force position normalized by the maximum height
Barbell horizontal direction variable		
Dx1	[m]	Start position to the most backward position before the turnover phase
Dx2	[m]	Start position to the catch position
Dx3	[m]	Most backward position before the turnover phase to the most forward position
DxL	[m]	Most forward position in the 2nd pull phase to the catch position
DxR	[m]	Most forward position in the 2nd pull phase to the most backward position
pVx+	[m/s]	Maximum horizontal linear velocity in the forward direction
pVx-	[m/s]	Maximum horizontal linear velocity in the backward direction
pFx+	[N]	Maximum horizontal linear force in the forward direction
pFx-	[N]	Maximum horizontal linear force in the backward direction

2. Methods

2.4 Barbell kinematics parameters (image)



Event point

O: start position

A: most backward position before Peak vertical velocity

B: peak vertical velocity

C: maximum height

D: catch position

E: most forward position in the 2nd pull phase

F: most backward position

2. Methods

2.5 Statistics

Paired t-tests were used to compare all barbell variables between successful and unsuccessful snatch lifts. Levene's test was used to check the equality of means assumptions associated with the chosen statistic. The magnitude of the differences was determined via calculation of Cohen's d effect size. The magnitude of the effect sizes was interpreted as small (~0.2), medium (~0.5), and large (~0.8) (*Cohen, J. 1988). The level of significance was set at $p < 0.05$ for all statistical tests performed.

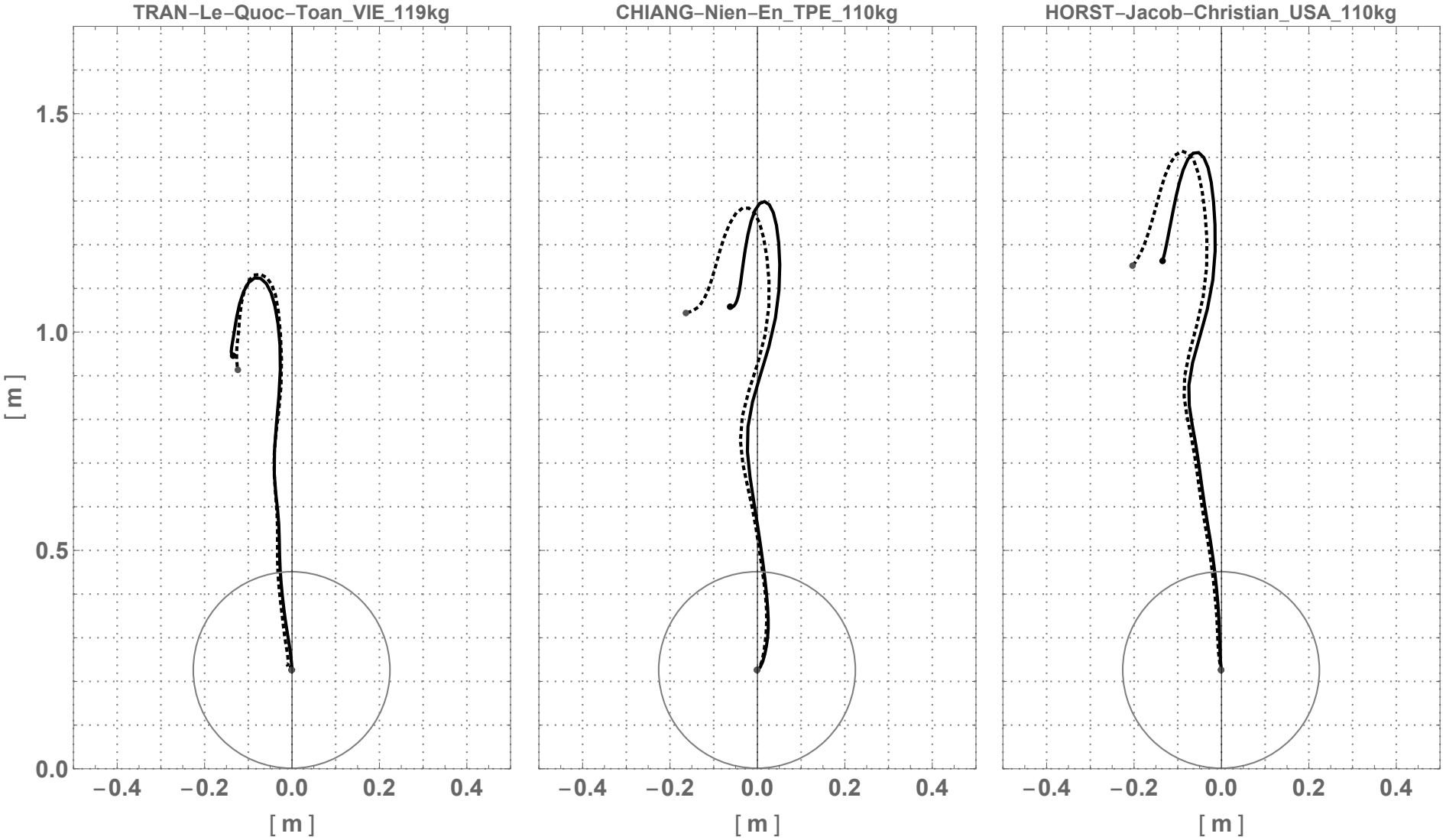
[*] Cohen, J. Statistical Power for the Behavioral Sciences; Erlbaum: Hillsdale, NJ, USA, 1988.

3. Results

3.1 Barbell Trajectory

——— : successful

- - - - - - : unsuccessful

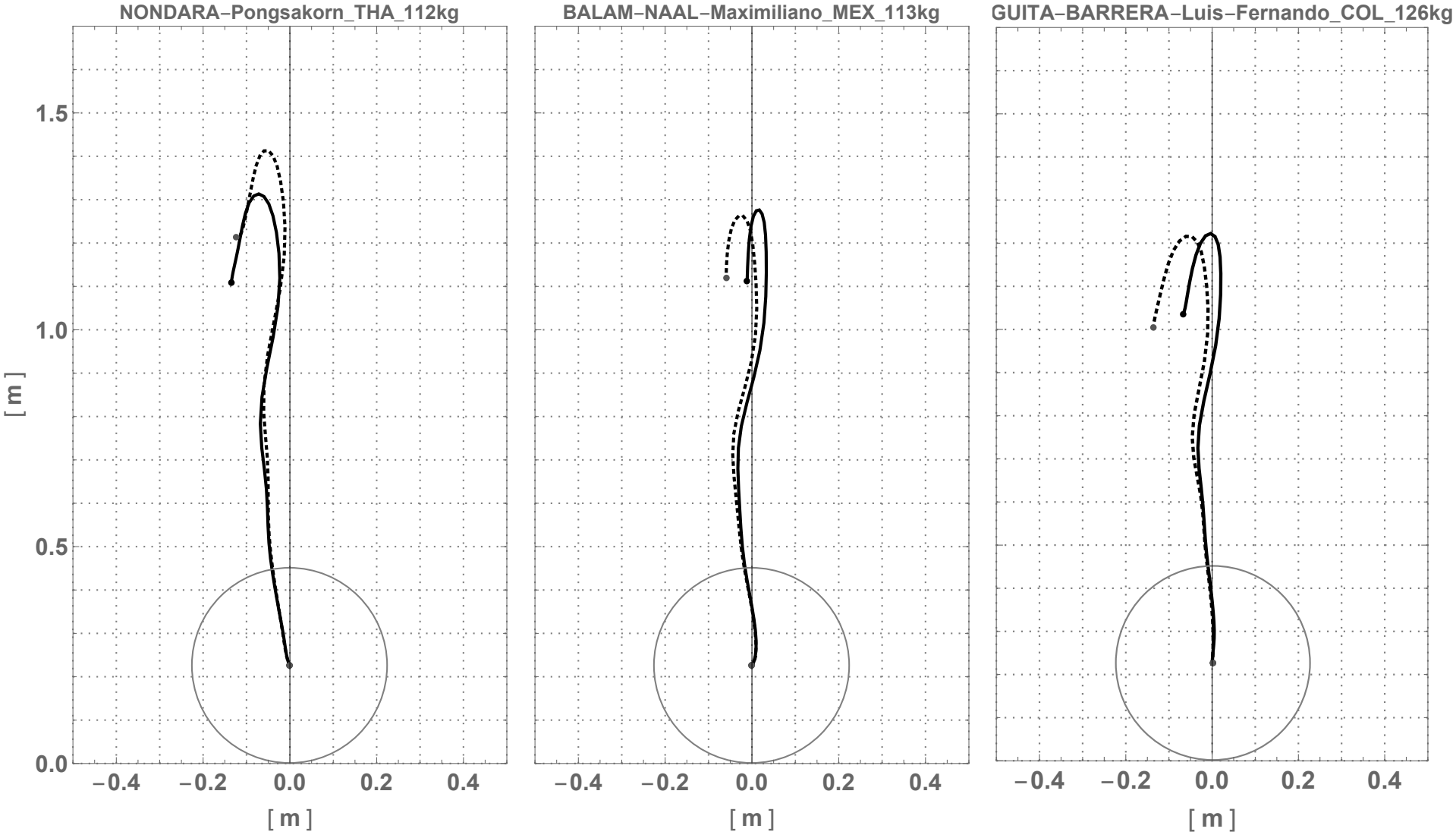


3. Results

3.1 Barbell Trajectory

——— : successful

- - - - - - : unsuccessful

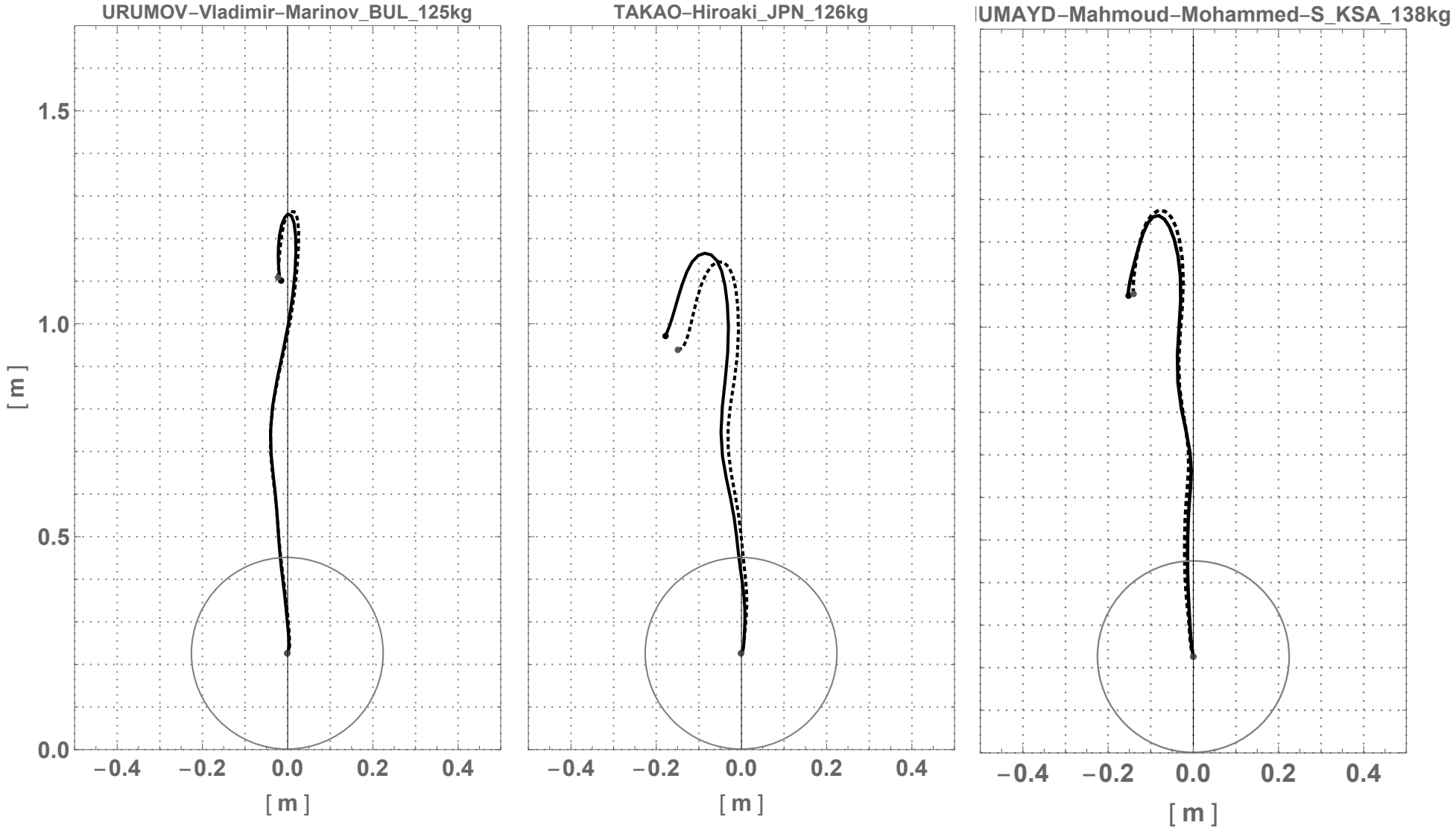


3. Results

3.1 Barbell Trajectory

——— : successful

- - - - - - : unsuccessful

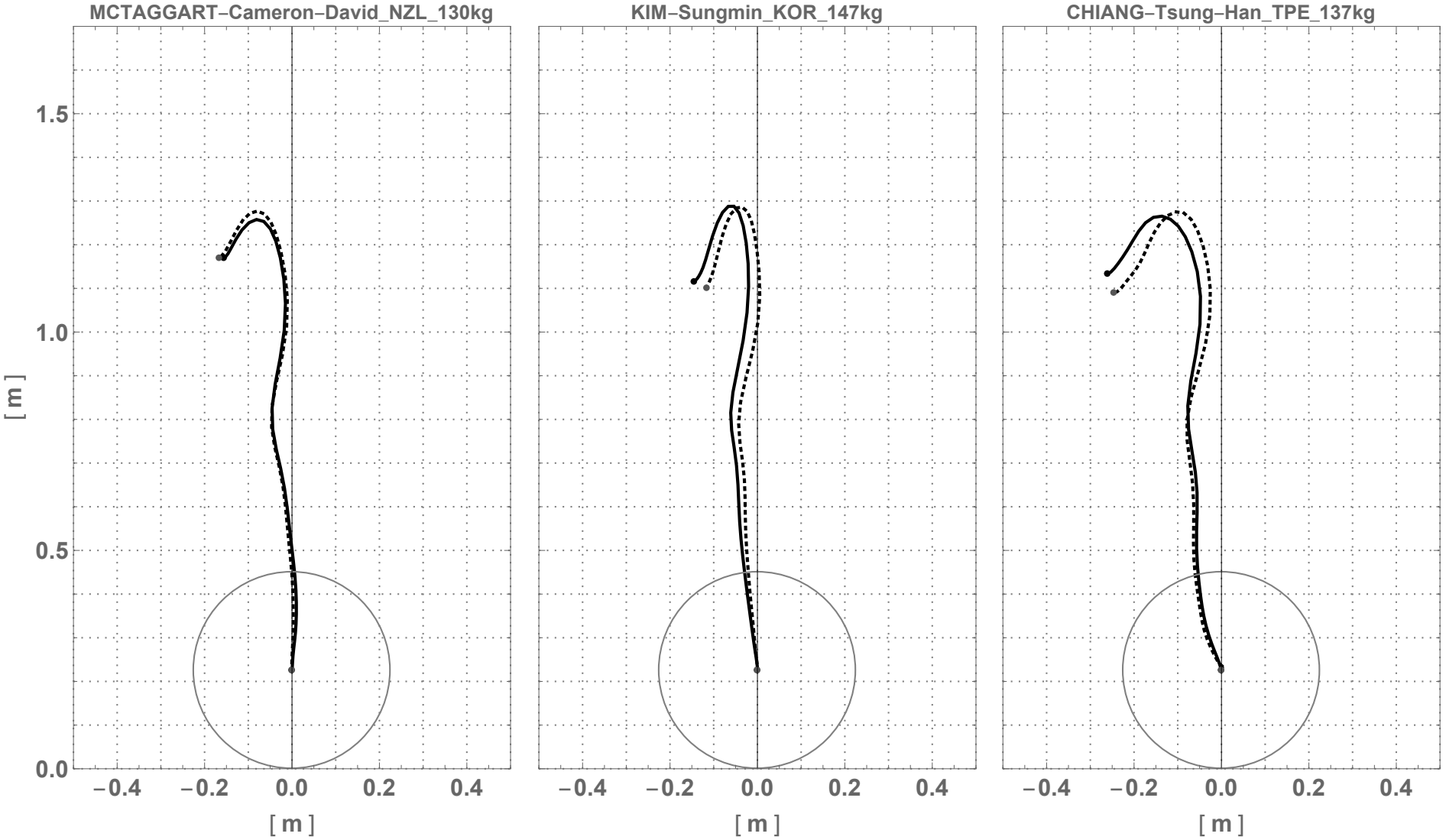


3. Results

3.1 Barbell Trajectory

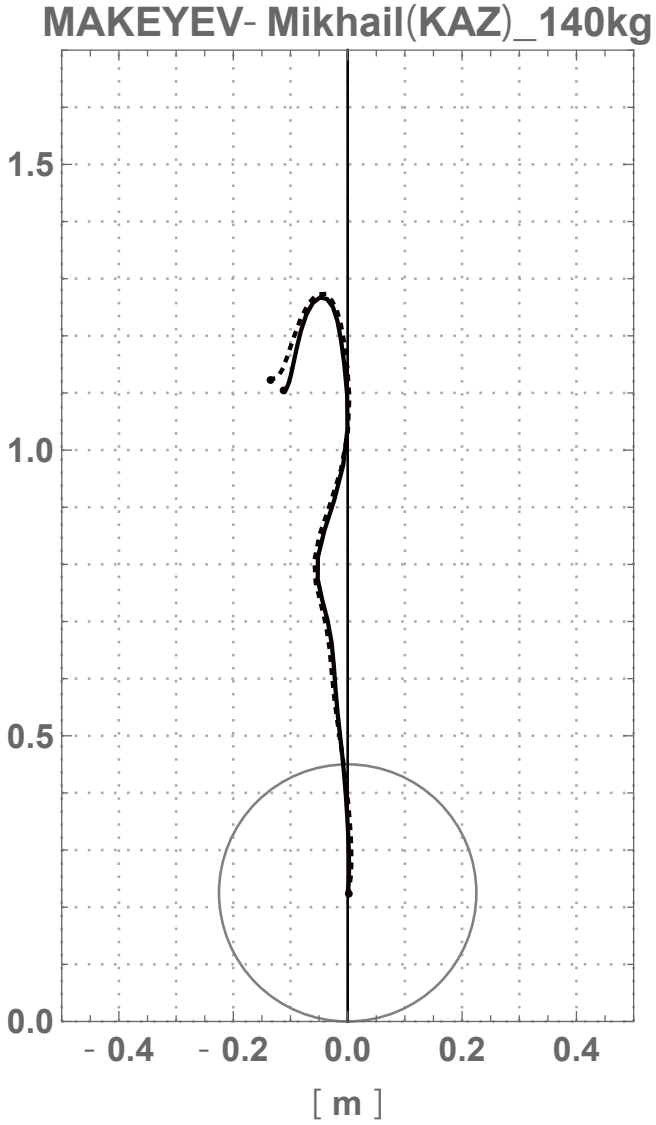
——— : successful

- - - - - - : unsuccessful



3. Results

3.1 Barbell Trajectory



——— : successful

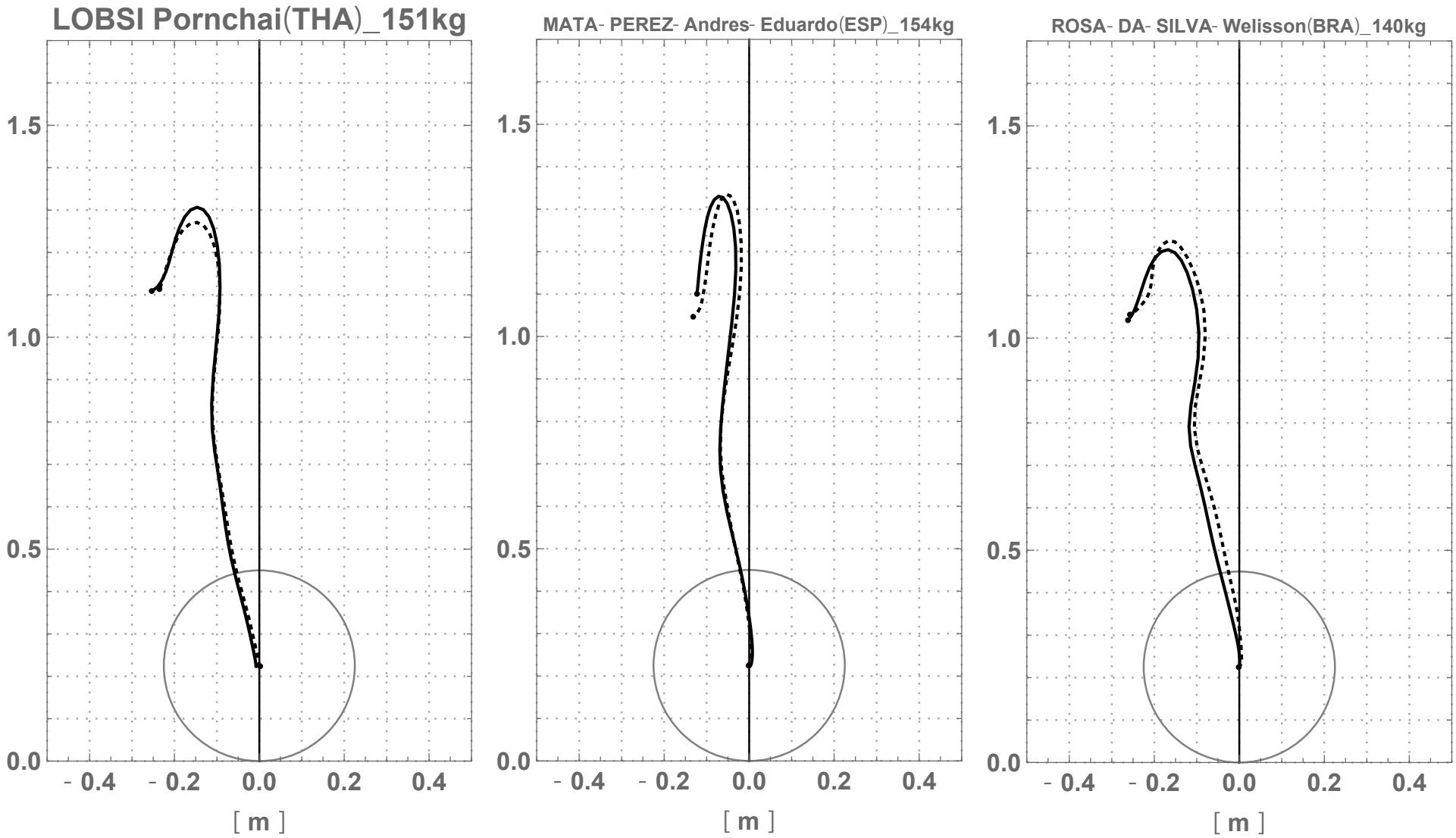
- - - - - - : unsuccessful

3. Results

3.1 Barbell Trajectory

——— : successful

- - - - - - : unsuccessful

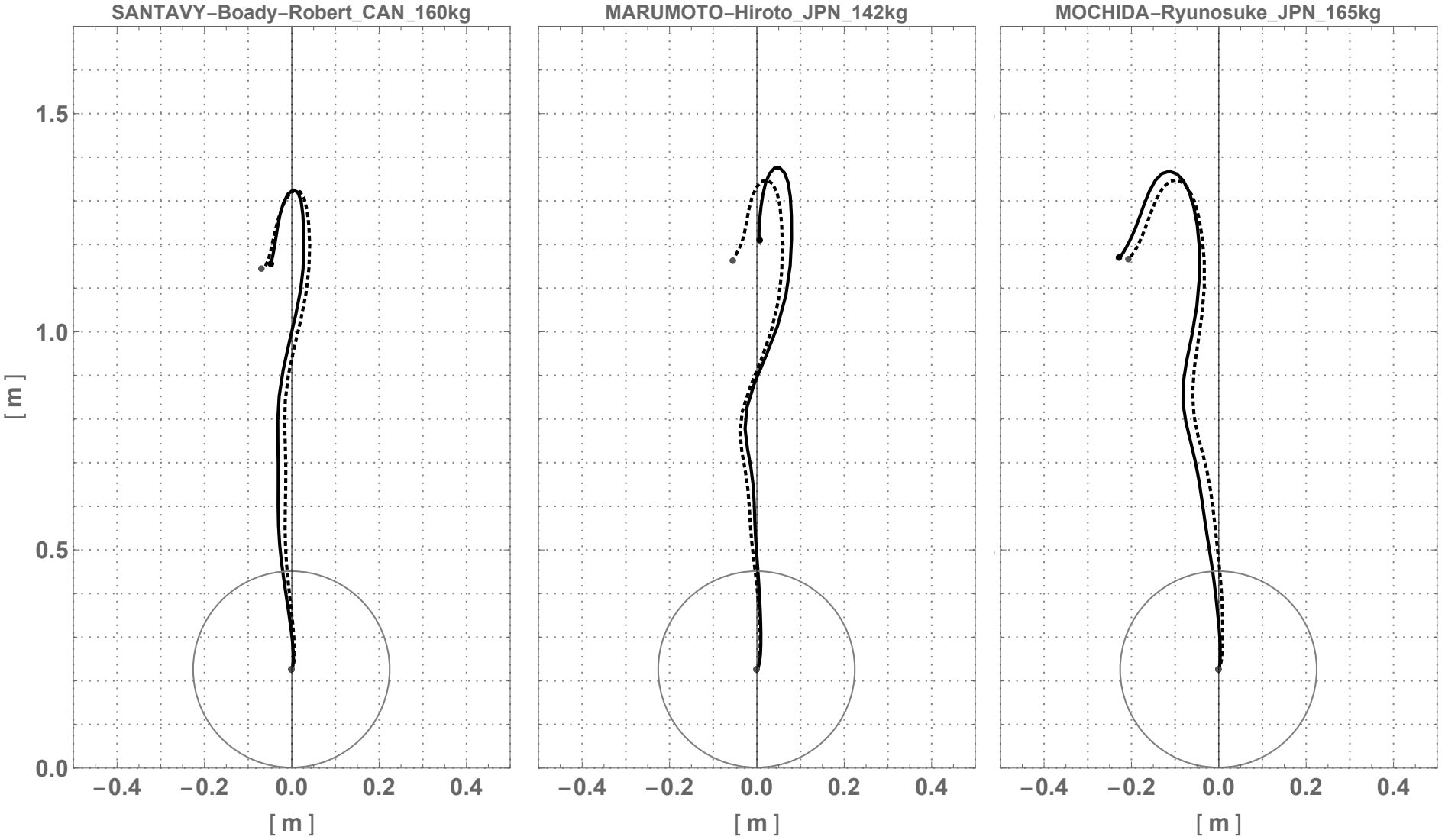


3. Results

3.1 Barbell Trajectory

—— : successful

- - - - - - : unsuccessful

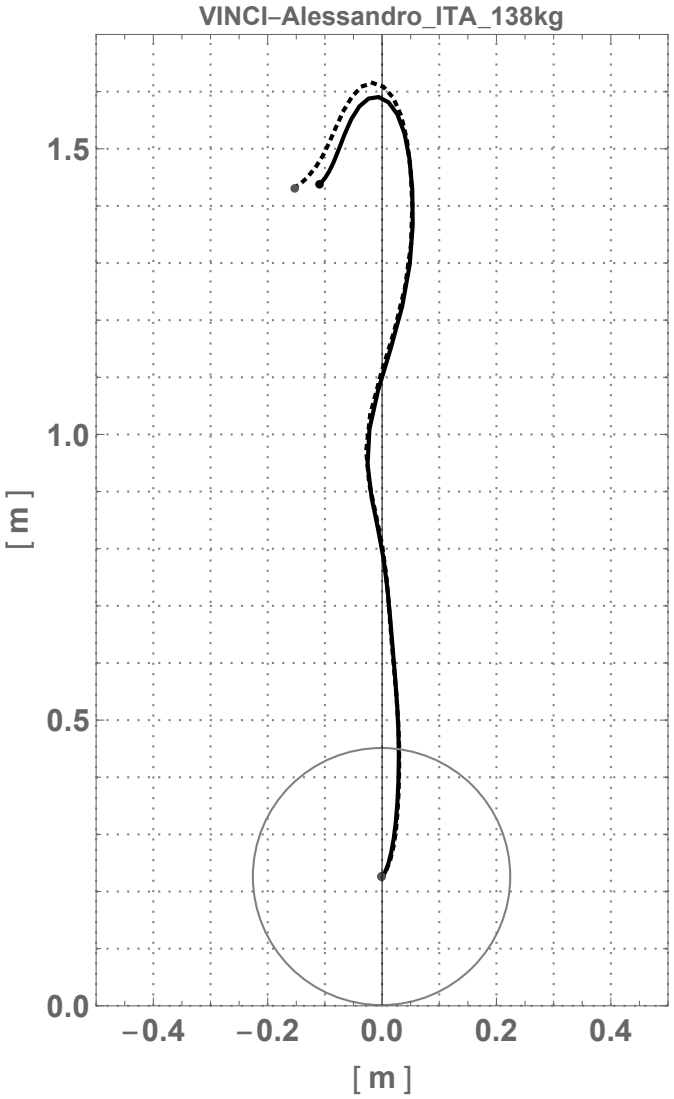


3. Results

3.1 Barbell Trajectory

——— : successful

- - - - - - : unsuccessful



3. Results

3.2 Results of statistical analysis of barbell parameter

variable			unit	successful	unsuccessful	p-value	Effect size
Dy1			[m]	1.30 ± 0.10	1.30 ± 0.10	0.316	0.030
Dy2			[m]	1.12 ± 0.10	1.11 ± 0.11	0.176	0.071
Dy3	*	†	[m]	0.18 ± 0.04	0.19 ± 0.04	0.030	0.266
pVy_1st			[m/s]	0.99 ± 0.11	0.99 ± 0.09	0.476	0.007
pVy_2nd		†	[m/s]	1.97 ± 0.11	1.94 ± 0.14	0.088	0.217
pVy-		†	[m/s]	-0.85 ± 0.10	-0.87 ± 0.09	0.071	0.238
pFy_1st			[N]	1837 ± 281	1841 ± 287	0.422	0.015
pFy_2nd	*	†	[N]	2048 ± 323	1962 ± 300	0.027	0.276
pPy_1st			[W]	321 ± 92	310 ± 86	0.271	0.116
pPy_2nd	*	†	[W]	1219 ± 330	1087 ± 338	0.045	0.396
pFy%height			[%]	61.2 ± 9.1	61.6 ± 9.0	0.434	0.044
Dx1			[m]	0.06 ± 0.03	0.05 ± 0.03	0.239	0.084
Dx2			[m]	0.13 ± 0.08	0.14 ± 0.06	0.188	0.070
Dx3			[m]	0.05 ± 0.02	0.05 ± 0.02	0.379	0.028
DxL	**	†	[m]	0.12 ± 0.05	0.14 ± 0.04	0.004	0.376
DxR	**	†	[m]	0.13 ± 0.06	0.15 ± 0.05	0.006	0.318
pVx+			[m/s]	0.38 ± 0.17	0.39 ± 0.16	0.099	0.110
pVx-			[m/s]	0.40 ± 0.10	0.42 ± 0.08	0.053	0.217
pFx+	*		[N]	787 ± 260	823 ± 257	0.026	0.139
pFx-	*	†	[N]	-651 ± 191	-692 ± 198	0.017	0.210

*: $p < 0.05$
**: $p < 0.01$
†: $d > 0.20$

4. Discussion

- ✓ The results in this study reveal that there were no significant differences in the barbell parameters of Dy1(Maximum barbell height), Dy2(Start position to the catch position) between successful and unsuccessful lifts with backward barbell drop.

  ➡ This result is the same as unsuccessful lifts with frontward barbell drop.
  It follows that the maximum barbell height does not determine the success or failure of the snatch lift if the weight is the lifters' personal best or less.

- ✓ There were significant differences in the barbell parameters of Dy3 (Drop Distance) between successful and unsuccessful lifts with backward barbell drop (successful < unsuccessful).

  ➡ This result is the same as unsuccessful lifts with frontward barbell drop.
  In successful lifts, it can be inferred that the lifter would catch the barbell when its momentum was low by decreasing the drop distance to the catch position after the barbell has reached its maximum height.

4. Discussion

- ✓ The results in this study reveal that there were significant differences in the barbell parameters of DxL and DxR (backward displacement) between successful and unsuccessful lifts with backward barbell drop (successful < unsuccessful).

  ➡ This result is different from the case of unsuccessful lifts with frontward barbell drop. In the case of unsuccessful lifts with frontward barbell drop, successful lift of DxL and DxR were bigger than unsuccessful (*Nagao. et al. 2019). Therefore, barbell backward distance is very important for snatch to succeed.

- ✓ The results in this study reveal that there were significant differences in the barbell parameters of pFx- (Maximal horizontal linear force in the backward direction) between successful and unsuccessful lifts with backward barbell drop (successful < unsuccessful).

  ➡ Therefore, we considered that the peak backward force applied to the barbell and the amount of barbell backward displacement were factors associated with a successful snatch.

*Nagao H, Kubo Y, et al. A Biomechanical Comparison of Successful and Unsuccessful Snatch Attempts among Elite Male Weightlifters. Sports; 7, 151, 2019.

4. Discussion

- **Stone et al. (1998) suggested that lifts with backward displacement of the barbell are also regarded as a positive technique for producing force. However, from the perspective of the successful snatch lift, the amount of backward barbell displacement is in the appropriate range, with neither maximization nor minimization of either parameter. The mean differences in DxL and DxR between successful and unsuccessful lifts were less than the thickness of the shaft (28 mm). The proper catch position, which determines the success or failure of the snatch lift is very sensitive to the barbell's horizontal position. Among elite male weightlifters, the proper range of backward displacement of the barbell is around 10 to 15 cm.

**Stone, M. H., O'Bryant, H. S., Williams, F. E., Johnson, R. L., & Pierce, K. C. (1998). Analysis of bar paths during the snatch in elite male weightlifters. Strength & Conditioning Journal, 20, 30–38.