BIOMECHANICAL ANALYSIS OF THE SNATCH DURING WEIGHTLIFTING COMPETITION

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This study was performed on five elite Malaysian weightlifters during competition. Three digital video cameras were used to determine the motion in three dimensions of the CG of the weights and the CG of the lifter plus weights. For the pull phases, lifters showed consistent patterns of the greatest peak Weight acceleration in the First Pull and greatest system power in the Second Pull. Individual subject differences were greater than differences between successful and unsuccessful lifts. All the unsuccessful lifts were those that failed in the squat, the subject could not even begin to stand upright. System velocity may be a better indicator of why a lift is failing than are Pull Heights or Weight velocities.

KEY WORDS: weightlifting, snatch, kinematics, power.

INTRODUCTION: Biomechanical analysis of the weightlifters was conducted on the performance of the National Weightlifting Championship at Kuantan, Pahang. Weightlifters were Malaysian national team representatives who compete internationally. This project was conducted as part of the monitoring of athletes preparation for the South East Asia (SEA) Games Championship 2001. The snatch lift is usually described as having five phases. The lift begins from the Lift Off position, progresses through First Pull, Transition and Second Pull phases to the squat then the finish, or Hold position. The First Pull is from when athlete lifts the loaded barbell from the floor until the bar has cleared knee height. The Second Pull is from when the bar clears the knee and ends with the lower limbs in full extension. During the Second Pull the athlete extends the hips and keeps the bar as close as possible to the body. The Bar Clear is from when the lifter drops under the bar supporting it on extended arms in the full squat position to until the lifter stands. The lift finishes with the bar stable at the Hold position. Stone (1998) described the Second Pull as critical to both the Snatch and Clean lifts as it is considered the highest power phase of both lifts. Reiser *et al.*,(1996) interpreted bar kinematics as indicative of faults in lifting technique. Successful lifts were described by Isaka *et al.*, (1996) as those that maximised Pull Height after Second Pull and minimised the loss in height of the bar during the squat. The purpose of this study was to determine the bar plus weights and system (body plus bar plus weights) CG kinematics in the Snatch lift to determine the factors associated with successful and unsuccessful lifts for lifters during competition.

METHODS: The five subjects were video recorded during competition two months prior to the SEA Games. Three JVC9800 digital video cameras were set approximately 2 meters above, at the front, and rear of the lifting platform at 120 degrees to adjacent cameras and were used to record all attempts at 50 fields per second. A calibration frame (2.5m x 2.0m x 1.8m) was positioned on the platform and recorded prior to lifts for each weight category. Each of the lifting attempts was digitized using the APAS system. A 21 point body model including the bar and weights was used for determining the height of the weights and the System CG for analysis. Cameras were field synchronized using the frame in which the bar hit the floor after the lift as the synchronization frame. Digitized data were smoothed with a Butterworth digital filter at 3Hz and 3D data were constructed using the DLT method. Two lifts by each lifter were analysed with at least one of these lifts a clean lift. The CG of the weight lifted (Weight) and the CG location of the lifter plus weight (System) were determined by segmental analysis and described graphically. Weight height was expressed as a percentage of each lifters stature. CG velocities and accelerations were also calculated and presented as functions of time for between trial and between subject comparisons.

RESULTS AND DISCUSSION: The subjects were of mean (± standard deviation) age 23 ± 3.6 yr, weight 88 ± 19kg, and height 1.66 ± 0.10m. The Weight vertical displacement and the Weight and System CG vertical velocities for a lift for subject CA (lift 143kg), which was a record for this competition, are shown below. Stick figures A - G are also shown corresponding to the critical positions in the lift (see Figure 1). Stick figure A corresponds to the subject stooping to begin the first acceleration phase of the lift. Stick figure B corresponds to the acceleration peak of the First Pull. These acceleration peaks are important because they correspond to periods of peak force application. Stick figure C shows the end of the First Pull phase and beginning of the Second Pull. Stick figure D shows the acceleration peak during the Second Pull. Stick figure E shows the drop-under bar position. Stick figure F shows the acceleration peak during the Bar Clear. Stick figure G shows the end of the lift in the Hold.

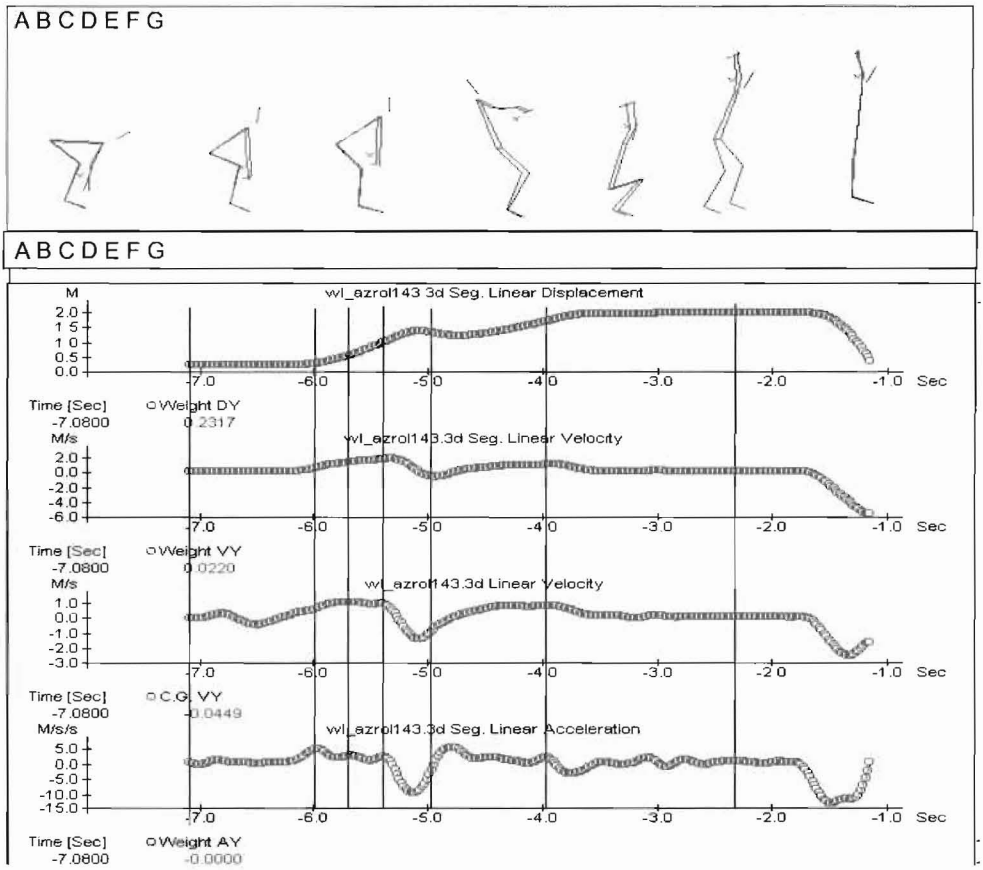

Figure 1. Stick figures and kinematic data of subject CA (lift 143 kg).

Some general observations can be made for this subject: The end of First Pull corresponds to a peak Weight acceleration; the end of Second Pull is at the peak Weight velocity; squat is when the system CG velocity is least. The Weight velocity increases uniformly to a single peak velocity at the end of Second Pull. Weight vertical displacements and vertical displacement as a percent of stature for individual lifts at peak Weight accelerations for first and Second Pull, and at maximum Pull Height, Squat and at Hold are shown in Table 1 together with means and standard deviations for "Clear" and "No lift" (failed) lifts.

Table 1. Displacement data

Lifter	Load (kg)	Clear Lift Displ(m) First Pull	%	2nd Pull	%	Pull Ht	%	Squat	%	Hold	%	No Lift Displ(m) First Pull	%	2nd Pull	%	Pull Ht.	%	Squat	%
CA	143 -R	0.27	15	0.97	54	1.33	74	1.18	66	1.93	107								
	150											0.26	14	0.96	53	1.31	73	1.18	66
JN	125											0.37	22	0.89	54	1.27	77	1.17	71
	125 -R	0.27	16	0.86	52	1.28	78	1.19	72	1.80	109								
RM	120	0.38	24	0.76	48	1.20	76	1.11	71	1.70	108								
	125	0.26	17	0.79	50	1.20	76	1.10	70	1.69	108								
HY	117.5	0.29	18	0.71	45	1.21	77	1.11	71	1.79	114								
	122.5											0.29	18	0.64	41	1.20	76	1.08	69
AF	125											0.28	16	0.97	56	1.33	77	1.12	65
	125	0.27	16	0.89	51	1.32	76	1.1	64	1.84	106								
	Mean	0.29	18	0.83	50	1.26	76	1.13	69	1.79	109	0.30	18	0.87	51	1.28	76	1.14	67
	SD	0.05	3.4	0.09	3.1	0.06	1.3	0.04	3.4	0.09	2.7	0.05	3.4	0.15	6.9	0.06	2.0	0.05	2.9

Weight pull heights are similar values to those reported by Isaka *et al.* (1996). Lift heights during First and Second Pull expressed as percentages of stature were more different between subjects than between successful and unsuccessful lifts. Pull heights for unsuccessful lifts were the same as for successful lifts and were only marginally less than for successful lifts at Squat height. Weights vertical velocities at the end of First Pull, Second Pull and at Max Pull Height for individual lifts are shown in Table 2 together with means and standard deviations for "Clear" and "No lift" (failed) lifts.

Table 2. Velocity data for weights.

Lifter	Category	Load (kg)	Clear Lift Vel (m/s) 1st Pull	2nd Pull	Max Pull Ht	No Lift Vel (m/s) 1st Pull	2nd Pull	Max Pull Ht
CA	>105	143 (R)	1.26	1.69	-0.09			
		150				1.2	1.66	0.03
JN	95 – 105	125				1.3	1.73	0.04
		125 (R)	1.24	1.84	0.07			
RM	62 – 69	120	1.11	1.75	0			
		125	1.01	1.67	0.05			
HY	62 – 69	117.5	1.1	1.87	0.01			
		122.5				1.05	1.66	0.04
AF	69 – 77	125				1.04	1.8	-0.11
		125	1.14	1.74	0.08			
		Mean	1.14	1.76	0.02	1.15	1.71	0.00
		SD	0.09	0.08	0.06	0.13	0.07	0.07

Weight velocities are similar to those reported by Isaka *et al.*(1996), Stone and Pierce (1998) and Reiser et (1996), with a weight velocity at end of Second Pull of approximately 1.8m/s corresponding to that of an elite lifter. There was an apparent difference in the vertical velocity at the end of the Second Pull with unsuccessful lifts having a lesser velocity than successful lifts (1.71 vs. 1.76 m/s). This is consistent with the lower squat height and lesser pull heights for unsuccessful lifts (three of the four lifts), compared to successful lifts. This is also a result of less momentum being imparted to the weights in pull phases of the lifts. System vertical velocity at end of First Pull, Second Pull and at max Pull Height for individual lifts are shown in Table 3 together with means and standard deviations for "Clear" and "No lift" (failed) lifts. System velocities were lesser in First Pull for all of the four unsuccessful lifts and markedly lesser in second pull in two of the unsuccessful lifts compared to the successful lifts. The system velocity is also more negative at maximum Pull Height indicating that the body is moving rapidly downwards as the weight is stationary at max Pull Height.

Table 3. Velocity data for the system.

Lifter	Load (kg)	System Mass (kg)	Clear Lift Vel (m/s) 1st Pull	2nd Pull	Max Pull	No Lift Vel (m/s) 1st Pull	2nd Pull	Max Pull
CA	143 (R)	258.3	0.99	0.55	-1.46			
	150	265.3				0.93	0.56	-1.52
JN	125	225.4				0.98	0.39	-1.37
	125 (R)	225.4	1.01	0.66	-1.28			
RM	120	192.45	0.81	0.66	-1.17			
	125	197.45	0.79	0.59	-1.17			
HY	117.5	190.5	0.84	1.02	-1.48			
	122.5	195.5				0.68	0.78	-1.4
AF	125.5	202.9				0.8	0.89	-1.25
	125.5 (R)	202.9	0.83	0.79	-1.3			
Mean			0.88	0.71	-1.31	0.85	0.66	-1.39
SD			0.10	0.17	0.14	0.13	0.22	0.11

CONCLUSION: In unsuccessful lifts there appeared to be less system momentum at Second Pull and lower squat heights. All the unsuccessful lifts were lifts that failed in the squat, the subject could not even begin to stand upright. The largest differences between unsuccessful and successful lifts were observed for the system velocities and squat height. Our interpretation is that the system velocity may be a better indicator of why a lift is failing than are pull heights or weight velocities. The subject may have over-extended in the pull phases and begins to lower the body before the end of the pull phase. Further work in analysing the subject kinematics to describe the drop under the bar is warranted.

REFERENCES:

Isaka, T., Okada, J., & K. Funato. (1996). Kinematic Analysis of the Barbell During the Snatch Movement of Elite Asian Weightlifters. *Journal of Applied Biomechanics* **12,** 508-516.
Reiser,R. F., Smith, S. L., & R. Rattan. (1996). Science and Technology to Enhance Weightlifting Performance: The Olympic Program. *Strength and Conditioning.* **18,** 43-51.
Stone, M. H., & Pierce, K. C. (1998). Analysis of bar paths during the snatch in elite male weightlifters. *Strength and Conditioning*, **20**, 56-64.

Acknowledgement: The assistance of Siti Nazariah Abdul Razak and Dzuribastian Azmi during data collection and the Weightlifting Association of Malaysia is gratefully acknowledged.