

VARIABILITY OF BARBELL TRAJECTORY DURING SNATCH FOR AN ELITE YOUNG FEMALE WEIGHTLIFTER

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The purpose of this study was to investigate the variability of the barbell trajectory for an elite young female weightlifter. One high speed camera (120Hz) was used to film the barbell trajectories of a female lifter during snatch. The subject was asked to lift different barbell mass from 65 to 80 kg (fourteen lifts in total), and thirteen successful lifts were analyzed. The barbell trajectories and movement pattern of different lifts were similar to the results of previous studies, and the barbell paths almost were overlapping for the heaviest four successful lifts. The coefficients of variation (CV) of four kinematic parameters of barbell trajectory were smaller than the results of previous studies. It can be concluded that this female weightlifter has a stable pattern of barbell trajectory under different barbell mass lifting.

KEY WORDS: snatch, barbell kinematics, variation, phase diagram.

INTRODUCTION:

The Olympic weightlifting includes snatch and clean and jerk. In the snatch lift, the lifter pulls the barbell off the platform and catches the barbell overhead with fully extended arms in a continuous movement, and then stands with the barbell in control. The general kinematic characteristics of barbell trajectories during the snatch for elite weightlifters have been investigated in previous studies (Isaka et al., 1996; Gourgoulis et al., 2000). During the snatch, the barbell moves towards the lifter after being lifted off the platform, and then it is pushed away the lifter's body due to the lifter extending his or her hip and knee joints. Finally, the lifter quickly squats down under the bar to be ready to catch the bar resulting in the barbell moving towards the body again. The results of Chiu et al. (2007) indicated that the displacement of the barbell in the media-lateral horizontal direction was small. This meant that the barbell movement is almost in the sagittal plane. Moreover, the vertical movement patterns of the barbell were found to be similar in the first 60% height between different lifters. Based on the results of Chiu et al. (2007), there was no standard pattern of barbell trajectory for each weightlifter because of the large differences in horizontal movement of the barbell. It has been unknown that if one lifter has his or her own stable barbell pathway under different barbell mass lifting. Therefore, the purpose of this study was to find out whether there is a stable pattern of barbell trajectory for a young female lifter.

METHOD:

Data Collection: One female subject (age:17, height:157cm, weight: 54kg) was asked to snatch different barbell mass from 65 to 80 kg (fourteen lifts in total), and thirteen successful lifts (the barbell mass were 65, 65, 68, 68, 70, 70, 72, 72, 75, 75, 77, 78, 79 kg, respectively) were analyzed. The order of the lifts was determined by the athlete's coach and this order is similar to that adopted in competitions. This female who can lift 82kg for her best record had a failed lift under the last 80kg lift. One high-speed camera (Mega Speed MS1000, sampling rate: 120 Hz) was set on the left side of the lifter to film the trajectory of the barbell in the sagittal plane. A calibration rectangular plane (47cm long, and 140cm high) with 30 control points was used in this study. The two dimensional spatial coordinates of the selected point was calculated using a direct linear transformation procedure by Kwon 3D motion analysis software. The raw data were smoothed using 4th-order butterworth low-pass filter at a cut frequency of 6Hz.

Data Analysis: The snatch is often divided into five phases: first pull, transition, second pull, turnover under the barbell, and catch phase. These phases are primarily determined by the change in the lifter's knee angle. However, since the athlete lifts the barbell as close to his

body as possible to decrease the resistant loading, five new events were chosen in this study. To easily describe the barbell trajectory, the five events are defined as: the barbell lifting off the floor (LO), the barbell clearing the knee of the lifter (CK), the lifter extending her hip joints to push the bar away from her body (PB), the barbell reaching its maximum vertical height (MH), and the lifter catching the bar overhead (CB). Four variables were used to present the characteristics of the barbell trajectory. These variables are maximum height of the barbell, vertical travel range (the vertical displacement from maximum height to catch position), horizontal travel range (the horizontal displacement from pushing away the body to the most forward position), and maximum vertical velocity. Compared between the lifts, the vertical displacement was normalized by the lowest position of the barbell during the catch phase. Coefficient of variation (CV) was used to present the variability of barbell kinematics.

RESULTS:

Figure 1a shows the barbell trajectories of the heaviest four lifts. The vertical reference line is through the center of the barbell just prior to lift-off. The subject stood to the right side of the vertical reference line. With the exception of the 77kg lift, the paths of the other three lifts are similar and stay in the right of the vertical reference line. The movement pattern of the barbell can be expressed with a phase diagram (showing the displacement-velocity relationship). Figure 1b and 1c show the barbell movement pattern in the horizontal and vertical directions for the heavies four lifts, respectively. Again, except for the horizontal movement of the 77kg lift, the other three lifts have the similar movement pattern in horizontal and vertical directions.

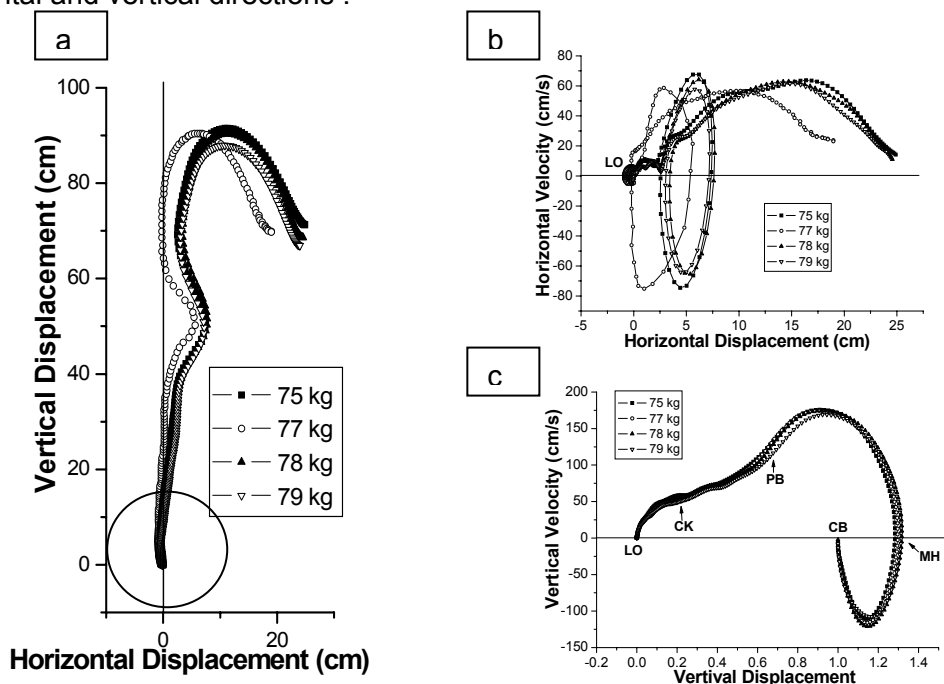


Figure 1: (a) The barbell trajectories, (b) horizontal movement patterns and (c) vertical movement patterns for the heaviest four lifts.

The mean horizontal travel range, maximum height, vertical travel range, and maximum vertical velocity of the barbell for the thirteen successful lifts were 5.5 ± 0.8 cm, 93.7 ± 3.9 cm, 17.6 ± 3.4 cm and 182.2 ± 9.2 cm/s, respectively. The CV of the four variables were 15%, 4%, 20% and 5%, respectively.

DISCUSSION:

The purpose of this study was to find out whether there is a stable pattern of barbell trajectory for the female lifter. The subject in this study participated in 2008 National Young

Weightlifting Championship and broke the national record of snatch. Her achievement was 83kg and 100kg for snatch and clear and jerk, respectively. It shows that this female lifter is an elite young weightlifter in Taiwan.

The barbell trajectories and movement patterns showed in figure1 were similar with the previous study (Chiu et al., 2007). It could be found that the trajectories and movement patterns almost are overlapping during the snatch, except for the 77 kg lift. The barbell trajectories of all lifts were categorised to Type-B which was defined that the trajectory does not cross the vertical reference line (Schilling et al., 2002). This technique was observed in most world class weightlifters, especially in elite Asian lifters (Gourgoulis et al., 2000).

Table 1 shows that the kinematic variables in this study and previous studies. The subjects were males in the study of Gourgoulis et al. (2000), and were females in the study of Hoover et al. (2006). It can be found that the vertical travel range for female lifters was larger than male lifters. The female lifters seem to enlarge the vertical drop displacement of the barbell to catch the barbell because of their weaker strength. Moreover, larger vertical travel range can let the lifter has enough time to squat and turnover under the barbell to catch it.

Table 1: Comparisons of the barbell kinematics between previous studies and present study.

Investigators	Lifter	Horizontal Travel Range (cm)	Maximum height (cm)	Vertical travel range (cm)	Maximum Vertical Velocity (cm/s)
Gourgoulis <i>et al.</i> (2000)	Male	3.17±4.18	121±8	13.5±2.8	167±10
Hoover <i>et al.</i> (2006).	Female	N/A	101.5±7.4	20.7±5.92	164.8±19.1
Present Study	Female	5.5±0.8	93.7±3.9	17.6±3.4	182.2±9.2

Table 2 shows the comparisons of the CV of the barbell kinematics between this study and previous studies. The horizontal variables of the barbell had been shown to have greater variations between the lifters than the vertical variables (Gourgoulis et al., 2000). The CV of the horizontal travel range in this study was notably smaller than previous studies. In previous studies, the data were observed from different lifters, however, this study focused on the same one lifter. This indicates that this female lifter has a stable barbell pathway under different barbell mass lifting. Each lifter has different body condition and his or her own movement habit. This probably results in different barbell trajectories and movement patterns.

Table 2: Coefficient of variation of the barbell kinematics between previous studies and present study

	Maximum height	Vertical travel range	Horizontal travel range	Maximum vertical velocity
Present study	4%	20%	15%	5%
Chiu et al. (2007)	4%	12%	44%	7%
Hoover et al. (2006)	7%	29%	N/A	7%
Gourgoulis et al. (2000)	6%	21%	132%	12%

CONCLUSION:

It can be concluded that this female lifter has a stable barbell pathway under different barbell mass lifting. However, it has been unclear that if there is an optimum trajectory for all lifters. The characteristic of the snatch movement, that the lifter pull the barbell towards her body from the time the barbell lifted off the platform until it is pushed away from the lifters with the whole extension of the hip and knee joints and a jump backwards to catch the barbell with a more vertical drop displacement, are observed in this female lifter. In the future, a monitoring system for the trajectory of the barbell could be developed to give real time feedback and instruct the lifter using a more correct and successful barbell trajectory.

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Acknowledgement

Funding for this project was provided by the National Science Council in Taiwan (NSC-95-2413-H-006-014-).