BIOMECHANICAL ANALYSIS FOR THE COACH OF OLYMPIC WEIGHT LIFING

Tony Bauer Cumberland College of Health Sciences
Sydney, Australia
Lakehead University, Thunder Bay, Canada

Leo Isaac Coach - N.SW. Sports Centre
Sydney, Australia

Sport biomechanics uses a variety of measurement methods to analyse and quantify human motion. The resulting data should be used to provide a better understanding of the movement or skill so that the motion efficiency might be changed through appropriate coaching techniques. This study utilizes biomechanical measurement techniques to provide quantitative data on olympic weight lifting. Qualitative and technical theories of lifting are then used in an attempt to understand and correct lifting faults.

PURPOSE

The purpose of the study was to analyze the lifting kinematics of the clean and jerk. The resulting data was used to provide a quantitative understanding of lifting techniques. The coach's technical expertise was then used to interpret and explain possible faults. An attempt was made to involve both the coach and the lifters in the collection and analysis of the data. Emphasis was placed on analyzing the clean phase particularly the pull.

SUBJECTS

The subjects included 4 competitive and one elite lifter all of which were in training for competition at the time of testing.

TABLE 1
SUBJECT DATA

Subject	Body Weight kg	Trial Load kg	Percent Maximum	Best Lift kg
D.T.-1	85.5	90	80	112.5
D.S.-2	76.6	90	80	112.5
L.I.-5	69.3	120	72	167.5
G.G.-3	76.0	100	73	137.5
R.L.-4	80.1	100	71	140.0

METHODS AND PROCEDURES

Subjects were filmed over three trials using a lo-cam high speed camera running at 50f/s. A lateral view was taken with appropriate joint centre markings indicated on each limb plus the end of the bar. Kinematic data was provided through the Waterloo Biomech program package and film data was analysed using a P.C.D. digitiser.

DATA ANALYSIS

Qualitative Analysis

Subjects were provided with visual feedback from 16 mm film and discussion was promoted through the technical guidance of the coach. Subjects were provided with tracings developed from film data. Critical events in the lifting process were indicated where it was felt that major errors might occur. The event markers and film tracings for the clean and jerk are indicated in figure 1 and include:

<u>CLEAN</u>
Start Pull
First Pull to Knees
Shift to Middle Pull to Waist
Top Pull
Catch
<u>JERK</u>
Dip
Catch

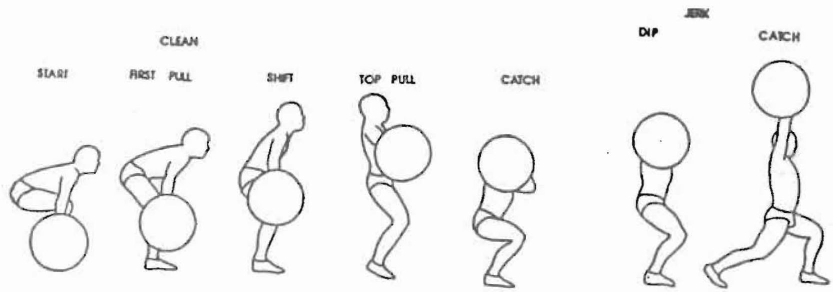

Figure 1. Critical event tracings - Clean and Jerk

Vertical Displacement

The maximum vertical displacement of the bar is a product of the lifters ability to move the load through a specific displacement. Maximum displacement is not necessarily a result of the lifters body height as each individual's ability to move under the bar with varying velocity will determine the height of the pull

Path of Bar

The path of the bar from the start of the pull phase to the catch is a product of both vertical and horizontal displacements.

Horizontal Displacement

The path of the bar is also a product of horizontal displacement. The horizontal motion of the bar is a result of the lifters ability to manipulate the bar along the body contours while maintaining maximum vertical acceleration. Angular displacement of the bar must be minimized by reducing the displacement of the bar from the vertical line through the base of support of the body. Bar motions toward and away from the vertical, trace a classic S shape curve which will vary for each lifter. Figure 3 illustrates bar tracing curves for each subject. At lift off two subjects 1 and 2 are moving the bar away from the body, a major technical fault. The mechanical force arm is increased considerably as the load moves away from the base of support. Subject 5 demonstrates motion toward the body while subject 6 tends to be more vertical. Bar motion should continue toward the centre of the base of support, a position of maximum stability for continuation of the pull. As the bar moves up the leg and over the knees motion should continue toward the body. Subjects 2 and 6 lack the curved path of the lower section of the 'S' curve and should demonstrate greater displacement toward the mid line of the body at the waist height level.

The movement of the bar away from the body during the pull finish is initiated through a forward drive of the hips as the body extends. The average motion of the bar is approximately 5 cm. In the final stages of the pull to support, lifters often jump forward or backward to receive the bar. Ideally this forward and backward motion should not be necessary but is acceptable providing the lift is consistent with the motion and correct pull technique. Three subjects jump back to receive the bar and two subjects jump forward. Providing the displacement is small and consistent (less 8 cm) the jump movements are not considered a major technique fault (ISAAC.86). Horizontal displacement variations were also observed during the descent or squat in the clean. This data is not illustrated, however, through qualitative observations it was noted that the less experienced subjects indicated a tendency to rotate forwards and backwards indicating a lack of trunk stability possibly caused through squat technique and weaknesses in supporting trunk musculature.

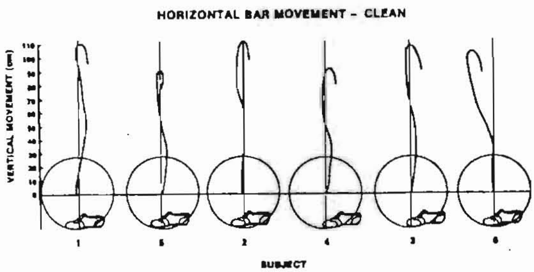

Figure 3. Path of Bar

TABLE 2

VERTICAL DISPLACEMENT OF BAR AND BODY HEIGHT

Subject	Max Vertical Displacement (Metres)	Rank Order Body Height (Metre)
DT-1	1.19	1
DS-2	1.12	4
L1-5	.93	5
GG-3	.91	2
RL-4	.85	3

The variation in vertical displacement over time (velocity) and the changes in velocity (acceleration) are indications of the lifters ability to apply a vertical force on the bar. Table 3. The force velocity relationship or power is a product of a number of physiological and hereditary factors which will not be discussed here. Of importance to the coach however is the ability to develop power through training and coaching methods. Special importance has been given to the acceleration of the bar from lift off and how initial velocities vary at different stages of the pull. The lifters ability to effectively accelerate the bar during the total pull stage will determine the consistency and efficiency of maximum force application and will effect the total time to complete the lift. There are numerous variables which may effect the lifters performance, in particular the weight of the bar, training prior to performance, possible injury or muscle soreness and the complications of psychological motivation. (ONO. 1969)

The kinematics of bar motion provides an effective tool for gauging the lifters performance and helps to provide the coach with a measuring tool to categorize the strengths and weakness of his lifters. Lifters are often categorized according to their differences in ability to accelerate the bar at different stages of the pull. For example a lifter may be very effective off the floor and another effective in the final stages of the pull. The question remains whether it is better to maintain a constant acceleration, concentrate on developing weaknesses or rely on areas of strength. Figure 2 indicates the variations in vertical displacement of the bar for each of the 5 subjects.

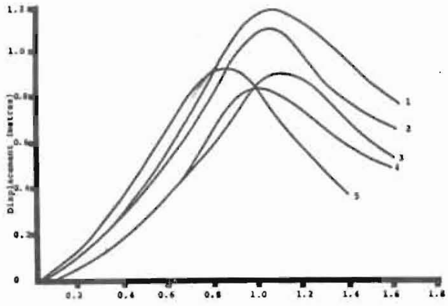

Figure 2. Vertical Displacement of Bar

Vertical Velocity and Acceleration of Bar

Figure 3 illustrates the vertical velocities of the bar and provides a measure of lifting consistency and force application. The information taken from this data might prove to be more effective if shorter time intervals were used and more instantaneous readings taken at each stage of the pull. Subject 5 demonstrates a strong first pull however little acceleration during the .5 to .6 period from mid thigh shift to waist position. This could be considered a fault due to lack of continuous force application and failure to maintain maximum acceleration on the bar. Subject 2 indicates a major decrease in velocity during the end of the first pull and the shift to waist level. Obvious deficiencies in the positioning of the upper body over the bar plus rotation of the body segments around the bar resulted in failure to apply force and velocity changes. These faults were reinforced through film tracings and film data observations.

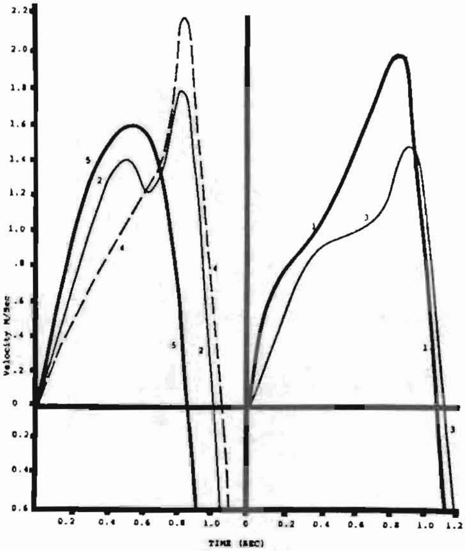

Figure 4. Vertical Velocity of Bar

TABLE 3

VERTICAL ACCELERATION OF BAR

SUBJECT	3	4	1	2	5
Time (sec)	Vertical Acceleration (m/sec^2)				
0.0	0.0	0.0	0.0	0.0	0.0
0.1	2.56	2.56	3.06	3.35	5.13
0.2	2.81	2.05	1.50	3.35	4.33
0.3	1.93	2.00	0.98	3.35	2.41
0.4	0.82	2.07	1.84	1.82	1.20
0.5	0.38	1.53	2.21	0.00	0.64
0.6	0.37	1.47	2.56	(0.60)	(1.28)
0.7	1.30	3.28	2.73	3.32	(4.94)
0.8	4.55	0.00	0.00	0.00	(9.81)
0.9	0.00	(9.81)	(9.81)	(9.81)	(9.81)
1.0	(9.81)	(9.81)	(9.81)	(9.81)	(9.81)

CONCLUSION

The data and discussion presented are illustrations of how relatively simple kinematic data collection techniques taken from either cinematography or video can be used as an effective coaching aid. Film tracings combined with horizontal and vertical displacements of the bar and velocities and accelerations of the bar can be presented in graphical and raw data form. The coaches technical expertise can then be utilized to combine qualitative interpretation with quantitative biomechanical measures of the kinematics of bar motion. The emphasis in this study was to include the coach and subjects in the collection and analysis of data. The intention is that the coach develop and apply biomechanical techniques to practical coaching applications.

REFERENCES

ENOKA, R. 1979. The Pull in Olympic Weightlifting Med and Science in Sport. Vol. 11, No. 2, p. 131.

GOTSHALK, L. 1985. Analysis of the deadlift. N.S.C.A. Journal, Jan.

GRABE, S. A. 1985. Kinematics of the Jerk from the Chest: Cluster Analysis of Olympic Style Lifters. Proceedings of ISBS. 1985. Biomechanics in Sports II. Terands, J. J. N. Barnam

HAMILL, B.P. 1985 Teaching the Power Clean and Power Snatch. N.S.C.A. Journal. Vol. 7. No. 4

ISAAC, Leo. 1986 N.SW. Sports Centre. Olympic Weight Lifting Coach Personal communications.

JOHNSON, B. 1983. The Power Snatch, How to use it and why. N.S.C.A. Journal. Feb/March.

ONO, M., M. Kubota and K. Kato. (1969). The analysis of Weight lifting movement at three kinds of events for weight lifting participants at the Tokyo Olympic Games. Journal of Sports Medicine and Physical Fitness. 9:263-281.

ROMAN, R.A. and M.S. Shakirzyanov. (1978). The snatch, the clean and jerk. Fizkulturi i Sport. Publ., Moscow Transl. A. Charniga.