BIOMECHANICAL CHARACTERISTICS OF SQUATTING WEIGHT LIFT: A CASE STUDY

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The purpose of this study was to provide biomechanical data analysis of the squatting lift skill of an elite weight lifter. The performance of the athlete (X. Z.) was studied by means of 3-D fixed video testing and data analysis. Some key parameters of the body and barbell in every important phase were provided in this article. The objective was to profile a sample of biomechanics pattern of this technique with these parameters. The results of the study showed that the subject (X. Z.) performed the squatting and propping skill too long to complete catching barbell movement after the barbell reached the maximum speed. However the attempt was surprisingly successful. This proved that the strength of the lower limbs was sufficiently strong enough to complete the move.

KEYWORDS: squatting lift, barbell, beforehand squat, braking, breaking lift

INTRODUCTION: The squatting lift is a relatively new technique that was developed in China in the 1980's. This move has drawn considerable attention from weight lifters. With this technique, Chinese weight-lifter (X. Z.) won the gold medal and broke the world record in the 1996 Atlanta Olympic Games. Moreover, at the Asian Weight Lifting Championship held in China in September 1999, the same athlete won the championship with the result of 206kg breaking the world record, thus further proving that this technique was scientific and applicable. Meanwhile, increasingly more world class lifters in Russia, Bulgaria and other countries have adopted this technique, bringing new recognition to this technique in international weight lifting. However, very little research has been done on this technique, and it is very rare that even references are available. The purpose of this study was to profile the biomechanical pattern of the squatting lift technique. It is hoped that this study would provide the necessary scientific bases for the promotion and training of this technique.

RESEARCH SUBJECT AND METHODS: Subject. The subject of this study was (X. Z.) a Chinese male, world record holder in weight lifting, aged 25 years of age, with a body weight of 78 kg and body height 1.68m. This athlete had 14 years of training experience.

Data collection and data processing. The 3-D fixed photographing technique was employed to collect data during the National Games held in Shanghai, October 1997. Two video cameras were placed so that the lens axis of one camera was perpendicular to the frontal plane of the athlete and the other, perpendicular to the saggittal plane. The distance of each camera to the athlete was approximately 20m. Videotapes were then digitized on the motion analysis system using 3-D model (Bewegungs Analysis System Germany). The figure wave filtering method was used for data smoothing, with cut-off frequency of 3.

RESULT AND DISCUSSION:

The phase of bringing the barbell to the chest is the first action of the whole clean and jerk technique. The successful execution of this movement can provide bases for further movements. The analysis showed that the subject's movement in this phase was not different from the others in terms of speed and trajectory of the barbell, joint angles, and timing.

The action of jerk was divided into five phases, which are as follows: preparatory posture, before hand squat, breaking lift, squatting and propping, and finally, standing up. The curve of the speed of the center of barbell and the curve of knee joint in the vertical direction in jerk phase are demonstrated in Figure 1 and 2 respectively.

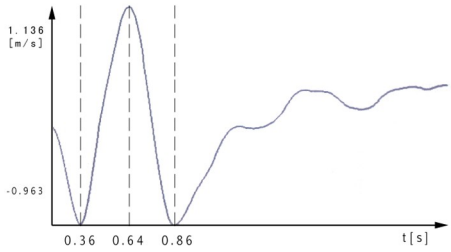

Figure 1 - The velocity curve of the center of barbell in the vertical direction.

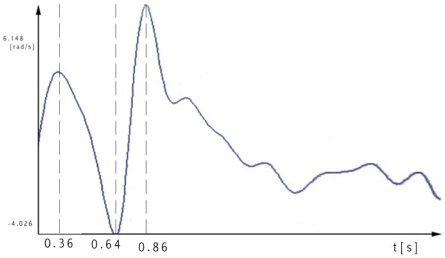

Figure 2 - The velocity curve of the knee joint in the vertical direction.

The preparatory posture. Analysis shows that barbell's center of gravity vertical line and human body's center of gravity connect in the ankle joint in the subject's preparatory posture. Thus the moment of gravity was not formed, namely, the moment of gravity is zero. Thus, balanced condition was provided for stability and strength saving and the before hand squat was well prepared.

The before hand squat. The analysis shows that the time for the subject's before hand squat was 0.36s. Critical parameters that reflect the kinematics characteristics of this movement were presented in Table 1. At the beginning of before hand squat, the velocity and acceleration were zero. With the commencement of before hand squat, the acceleration was positive and the velocity increased. Then, the acceleration turned from zero to negative and the velocity gradually decreased to zero, at which point the before hand squat ended. The athlete body's capacity of bearing the barbell reached the maximum. The before hand squat facilitates the quick braking and powerful stretch of the legs. If the before hand squat was too deep, the moment arm of the resistance would be too large, and the quick braking and the stretch of legs would be influenced, which would in turn increase forward leaning of the upper body. The minimum knee angle in the subject's beforehand squat was 0.3546r and the depth of squat was 0.15m. The effects of breaking lift depended directly on the performance of braking. Less time in the barbell braking resulted in greater braking acceleration, which was more helpful in accomplishing the jerk. The subject's braking time was 0.16s and the maximum acceleration period was about 7.50m/s^2.

Table 1 Kinematics of Barbell Center and Athlete Body Center of Gravity

Barbell			Athlete's Body				
Descend. Range (m)	Max. velocity (m/s)	Max. accel. (m/s^2)	Descend. Range (m)	Max. velocity (m/s)	Max. accel. (m/s^2)	Min. knee angle, (radian)	Min. hip angle (radian)
0.37	0.96	6.77	0.15	0.55	2.78	0.35	0.15

The breaking lift. Breaking lift was performed after the completion of braking and before hand squatting through extending the knee and hip, flexing the ankle and extending the arms rapidly to exert maximum strength on to the barbell. The aim is to provide the barbell with greatest ascending velocity to the necessary height, which would create the optimum condition for squatting and propping. The data showed the time for this movement was 0.28s. As shown in table 2, the velocity of the center of gravity of barbell quickly increased from zero to 1.32m/s, during which time the center of gravity of the barbell ascended to 0.23m. The maximum angular velocity of the knee was 4.15r/s, which was lower than the value of 4.5r/s showed by another competitor (J. M.) at this movement. This indicated that the athlete (X.Z.) extended his knees relatively slowly and thus failed to perform the breaking lift fully. This analysis also showed that the maximum angular velocity of the hip appeared later than that of the knee, indicating that the knee extension was performed before the hip extension. Movement of breaking lift was completed when the barbell reached the maximum velocity. Then the barbell begins the vertical projectile movement.

Table 2 Key Parameters of Center of Gravity of Barbell and Body in Breaking Lift

Barbell			Athlete's Body				
Max. velocity (m/s)	Max. accel. (m/s^2)	Ascend. range (m)	Descend. range (m)	Max. velocity (m/s)	Max. accel. (m/s^2)	Max. knee angular velocity (r/s)	Max. hip angular velocity (r/s)
1.32	7.55	0.39	0.14	0.78	5.83	-4.16	3.66

The squatting and propping. The main difference between squatting lift and common lift lies in the squatting and propping technique. For better understanding of this technique, the technique was divided in to three sub-phases: ascending, zero and descending.

The barbell ascending. After the barbell reaches the maximum velocity, it can be brought into the projectile movement in the vertical direction and then the barbell ascends. This sub-phase takes 0.22s. At the same time, the athlete is required to move downwards rapidly. Less time taken to do this results in greater squatting and propping velocity of the body, which was more favorable to propping up the barbell and offering better conditions for standing up. In this phase, the subject (X.Z.) descended slowly which influenced the subsequent barbell catching movement. See Table 3.

Table 3 Key Parameters of Center of Gravity of Barbell and Body in Barbell Ascending

Barbell	Athlete's Body				
Ascend. Height (m)	Max. velocity (m/s)	Max. accel. (m/s^2)	Descend. Height (m)	Max, knee angular velocity (r/s)	Max. hip angular velocity (r/s)
0.19	-1.22	-10.97	0.10	6.15	-6.7

The barbell zero velocity. The barbell reached the highest point when the barbell speed reached zero. In order to prevent barbell from falling freely, it is necessary to catch the barbell in the way of tracing, i.e. after the quick squatting is performed, a positive stretch of legs should be performed. This kind of tracing movement, compared with only waiting for the barbell weight to come down, gains time and releases the pressing force for the standing up movement. This technique is more important to those who have comparatively weaker strength in their legs. The analysis showed that the ideal movement is demonstrated when the athlete positively reaches up to catch the barbell and continues to descend when the barbell reaches its highest position. On the other hand, if the athlete intended to catch the barbell, once the barbell started to descend, it would be quite difficult to stand up or may even result in failure. The center of gravity of subject (X.Z) was still descending at the speed of 1.2169m/s, with the knee and hip angle of 4.20 and 2.41 radius respectively, which were not the ideal values. However the athlete succeeded in standing up, demonstrating that his legs were very powerful.

Table 4 Key Parameters of the Center of Gravity of His Body from Barbell Ascending to Zero Velocity

Velocity of CG (m/s)	Accel. Of CG (m/s^2)	Angular velocity of knee (r/s)	Angular velocity Of hip (r/s)	Knee angle (radius)	Hip angle (radius)
-1.22	1.71	6.09	-6.72	4.20	2.41

From barbell descending to zero velocity. As shown in Table 5, time spent in this movement was 0.8s, with the maximum barbell velocity being 0.96m/s. The knee and hip angles were 5.65 and 0.85r, and the barbell descending range was 0.34m. These parameters reflect the difficulty in standing up, which would be improved in the future, with

training.

Table 5 Kinematics of Gravity Center of Barbell and His Body from Barbell Descending to Zero Velocity

Barbell		Athlete's Body				
Descend. height (m)	Max. velocity (m/s)	Descend. Range (m)	Max. velocity (m/s)	Knee angle (rad)	Hip angle (rad)	Ankle angle (rad)
0.34	0.96	0.33	1.22	5.65	0.85	1.45

The standing up phase. After propping up the barbell, athlete is required to achieve a standing up position without a pause. In this movement, the data showed that the knee angle was small and the angle of standing up was not very wide. But the lifter should not pause to think of standing up after the stable posture. Otherwise, there exists little possibility of being able to stand up when the human body is pressed to full squatting. As the table 6 shows, the subject (X.Z.) took a longer time of 1.76s to reach complete standing up position, because the barbell descended 0.34m from the highest position. Without his powerful legs, the athlete would not have been able to complete this movement successfully.

Table 6 Barbell and the Human Body Gravity Centers' Important Indexes in the Stage of Standing Up

Barbell		Athlete's Body			
Ascend. Height (m)	Max. velocity (m/s)	Ascend. Height (m)	Max.ascend Velocity (m/s)	Max, knee angular velocity (r/s)	Max. hip angular velocity (r/s)
0.62	0.54	0.47	0.41	-1.94	1.12

CONCLUSION AND SUGGESTIONS: The maximum barbell ascending velocity during the breaking lift was relatively low. After breaking lift, the squatting and propping movements were slow, which caused the subject to fail in applying the tracing technique to catching the barbell. After catching the barbell, the barbell and human body descended for 0.34m. This indicated that the lower limbs were more powerful that the upper limbs. The improvement in these techniques would undoubtedly make the subject (X.Z.) more successful.

Therefore, based on the results of this study, it is recommended that the training of upper limbs and breaking lift techniques should be stressed. A rapid squatting and propping after breaking lift with a view to gaining time to catching the barbell and releasing the load in standing up would be another important aspect to be considered for successful completion of the squatting lift.

REFERENCES:

Wang, Y.D. at al. (1986). The compare of succeed or aborted and the study on influence in squatting lift Jiguang Miao's. *Sports Science*, **6**, 64~68.

Ai, K.W. et al. (1992). The biomechanics analysis on factors in clean and jerk. *Sports Science*, **12**, 74~76.