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Kinematics of the snatch in elite male weightlifters

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Abstract

The purpose of the study was to analyze the kinematical differences between the first and the second pull of the snatch technique in elite male weightlifters. The heaviest successful snatch lifts of seven male weightlifters who won gold medals at the 2010 Men's World Weightlifting Championship were analyzed. The snatch lifts were recorded using 2 S-VHS cameras (50 fields/s), and points on the body and the barbell were manually digitized using the Ariel Performance Analysis System. The results revealed that the maximum vertical velocity of the barbell was significantly greater in the second pull than that of the first pull ($p<0.05$). While the mechanical work produced in the first pull was significantly greater, the power output was significantly greater in the second pull ($p<0.05$). As a result, it was revealed that the second pull phase was faster and more powerful than the first pull, and that the kinematics of the barbell during the second pull had a decisive role for a successful lift.

Keywords: The first pull, the second pull, work, power output

INTRODUCTION

Weightlifting performance is strongly dependent on technique, explosive strength, and flexibility (Gourgoulis et al., 2002). The primary factors that affect the performance of weightlifters are the explosive power output required to lift a heavy weight and the skill required to lift the barbell efficiently (Ikeda et al., 2008). Thus, the snatch is one of the most technical competitions (Gourgoulis et al., 2009).

The snatch technique requires the barbell to be lifted from the floor to straight-arm overhead erect standing position in one continuous movement (Burdett, 1982). In the snatch, the total pull, which generates high power, refers to the initial portion of the lift in which the barbell is displaced from the floor to waist height (Enoka, 1979; Baumann et al., 1988). The total pull is done very rapidly in the snatch, with propulsion of the barbell against gravity occupying less than 1 s (Isaka et al., 1996). The total pull is divided into two parts as the first and second pull. The first pull of the total pull is slow and depends on strength, while the second pull is faster and depends on more power oriented (Garhammer, 1991). The average power output generated during a snatch lift ranges from 1300 to 4000 W in elite male weightlifters (Garhammer 1991; Gourgoulis et al., 2000). On the other hands, the linear kinematics of the barbell is important to reveal the intricacies of the snatch. The purpose of the study was to compare the kinematical differences of the barbell between the first and the second pull of the snatch technique in elite male weightlifters.

METHODS

Subjects

The data were obtained from the 2010 World Weightlifting Championship in Antalya, Turkey. Necessary permissions for visual recordings were obtained from the Turkish Weightlifting Federation and the World Weightlifting Federation. The snatch lifts of 7 men who won gold medals in their categories were analyzed. This study was conducted in accordance with the guidelines set forth by the Institutional Review Board of Selçuk University.

Procedures

Two digital cameras (Sony DCR-TRV18E, Tokyo, Japan) which captured images at 50 fields per second were positioned on the diagonal level of the platform at a distance of 9 m from the weightlifters, forming an approximate 45° angle with the sagittal plane of the weightlifters (Figure 1). The lift-off of the barbell was used to synchronize the 2 cameras. To determine the 3-dimensional kinematic data of the barbell and the angular kinematics of the hip, knee, and ankle joints during the snatch lifts, one point on the barbell and five points on the body were digitized using the Ariel Performance Analysis System (APAS, San Diego, CA, USA). The digitized points included the little toe, ankle, knee, hip, and shoulder on the right side of the body. In addition to these points, the digitized point on the barbell was located on the medial side of the right hand. A rectangular cube with a length of 250 cm, a depth of 100 cm, and a height of 180 cm was used to calibrate the movement space. The calibration cube was placed on the platform before the competition, recorded, and then removed. Three-dimensional spatial coordinates of the selected points were calculated using the direct linear transformation procedure with 12 control points. The raw position and time data were smoothed using a low-pass digital filter. Based on the residual analysis, a cut-off frequency of 4 Hz was selected (Gourgoulis et al., 2000; Gourgoulis et al., 2002). The mechanical work performed on the barbell

during the first and the second pulls was calculated from changes in the barbell's potential (PE=mgh) and kinetic energies (KE=½mv^2). These calculations included the vertical work done by lifting the barbell. The power output of the weightlifter was calculated by dividing the work done in each phase by the duration of the phase. The relative power and work values were calculated by dividing the absolute work and power values by the lifter's body mass. The calculated power outputs only included the vertical work done by lifting the barbell (Garhammer 1993).

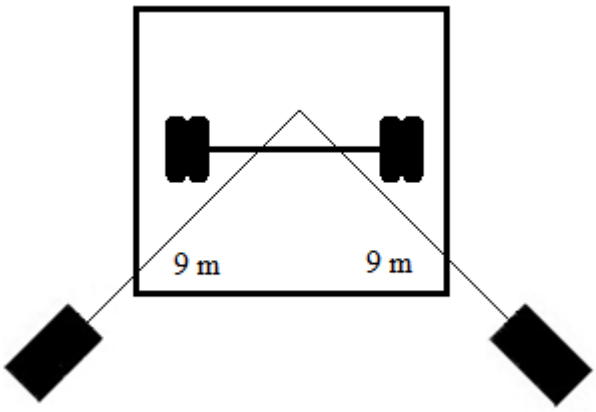

Figure 1. The view from the top of the camera set-up and the platform.

Statistical analysis

Data were presented as mean and standard deviation (Mean ± SD). The hypotheses of normality and homogeneity of the variance were analyzed via Kolmogorov-Smirnov and Levene tests, respectively. The kinematical differences between the first and the second pull were compared using the paired t-test (SPSS 15.0, Chicago, IL, USA). The level of significance was set at α=0.05.

RESULTS

The physical and performance characteristics of weightlifters were presented in Table 1. The heaviest snatch lifts of the elite weightlifters were analyzed in 7 different weight categories at the World Weightlifting Championship. The heaviest snatch lift was performed by the weightlifter in 62-kg category.

Table 1. Physical characteristics of the weightlifters.

Subject	Category (kg)	Age (y)	Barbell mass (kg)	Body mass (kg)	Relative barbell mass (kg/kg)
1	56	22	132	55.61	2.37
2	62	23	147	61.51	2.39
3	69	25	160	68.75	2.33
4	77	23	173	76.72	2.25
5	85	29	175	83.05	2.11
6	94	22	185	91.92	2.01
7	105	28	192	104.43	1.84

The linear kinematics of the barbell related to the snatch performance of the elite weightlifters was presented in Table 2. During the second pull, the vertical velocity of the barbell was significantly greater than that of the first pull (t_6=4.85, p<0.05).

Table 2. Linear kinematics of the barbell.

	Mean±SD
Barbell height at the end of the first pull (cm)	55.0±8.7
Barbell height at the end of the second pull (cm)	97.1±8.1
Maximum barbell height (m)	1.20±0.07
Drop displacement (cm)	16.4±2.55
Maximum vertical velocity of the barbell in the first pull (m/s)	1.16±0.25
Maximum vertical velocity of the barbell in the second pull (m/s)	1.67±0.07*

*p<0.05

The power output and mechanical work values done on the barbell during the first and the second pull were presented in Table 3. The absolute and relative mechanical work and power output values were significantly greater in the first pull than that of the second pull (p<0.05).

Table 3. Mechanical work and power output in the first and the second pull

	First pull	Second pull	t-value
Absolute work (J)	681±240	402±103	2.63*
Relative work (J/kg)	8.6±1.9	5.4±1.6	2.58*
Absolute power (W)	1020±306	2645±456	9.47*
Relative power (W/kg)	13.1±2.4	34.9±6.6	7.40*

*p<0.05

DISCUSSION

The kinematical analysis of the barbell in the present study revealed the evident mechanical differences between the first and the second pull. In literature, the barbell displacement, barbell velocity, barbell acceleration, and angle of the resultant acceleration of the barbell are parameters used for technical evaluation with regard to the barbell kinematics (Ikeda et al., 2012). Elite women weightlifters who won gold medals at the same world championship lifted less height than men the barbell, and the barbell velocity was lower during the first pull, and produced less power output in the second pull (Akkuş, 2012). Although it was observed that the height of the barbell was similar to those reported in the literature, it was remembered that the vertical linear kinematics of the barbell is related to the height of the weightlifter and his/her technique (Baumann et al., 1988). Both the height of the barbell and loss of barbell's height until the catch phase were consistent with those reported by the previous studies (Gourgoulis et al., 2000; Gourgoulis et al., 2004; Harbili 2012). A greater mechanical work during the first pull and a greater power output in the second pull were crucial for a successful lift in the snatch technique (Korkmaz and Harbili, 2016). In the literature, it was reported that the first phase is relatively slow and can be considered strength oriented, while the second pull is faster and can be considered more power oriented (Garhammer, 1991). It was observed in the present study that the first pull produced more mechanical work, whereas the second pull produced higher power output.

CONCLUSION

In the present study, the vertical velocity of the barbell was higher up to by 30% in the second pull with respect to the first pull. In the second pull, greater power and velocity is required to pull the barbell high enough to squat beneath as the barbell weight is held overhead. As a result, it was revealed that the second pull phase was faster and more powerful than the first pull, and that the kinematics of the barbell in the second pull had a decisive role for a successful snatch lift.

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