POWER OUTPUT DURING THE 1ST AND 2ND PULL PHASES IN THE SNATCH BY WOMEN WEIGHTLIFTERS

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The purpose of this study was to compare the power outputs of the 1st, 2nd, and total pulls in the snatch lift for women competing in the 1999 United States national championships. The performance of ten lifters was recorded and analyzed using a Peak5 2D Motion Analysis system. The power output values for the 1st, 2nd, and total pulls ranged from 604.41 W to 2329.45 W, 756.45 W to 4532.75 W, and 702.39 W to 1909.67 W, respectively. These lifters demonstrated statistically significant differences ($p < 0.05$) during each phase of the snatch pull, and total power output values were comparable to values previously reported (Garhammer, 1991). Knowledge of the power output during each phase of the pull may help athletes to fully refine the training leading to competition.

KEY WORDS: weight lifting, power output, snatch, female weightlifters

INTRODUCTION: The popularity of women's weightlifting has grown in recent decades, and women competitors achieved Olympic status at the 2000 Games in Sydney. As with their male counterparts, weightlifting competition consists of the snatch and the clean and jerk, two of the most mechanically powerful of all athletic competitions. Stone (1998) described the importance of the 2nd pull to both the snatch and clean lifts as it is considered the highest power portion of both Olympic lifts. The 1st pull begins when the athlete lifts the loaded barbell from the floor until the bar has cleared knee height, and the 2nd pull starts when the bar clears the knee and the athlete extends the hips as she keeps the bar as close as possible to the body. The 2nd pull ends when the bar reaches its ultimate height, at the end of a typically short duration.
A number of variables are used to describe and analyze the biomechanical performance of Olympic lifters. One such performance gauge is the measure of power output. Numerous studies have investigated power output demonstrated by male lifters (Garhammer, 1979, Garhammer, 1980; Garhammer, 1985), but fewer reports exist on the power characteristics shown by their female counterparts (Garhammer, 1991).
It was the purpose of this study to calculate and compare the power outputs for the 1st and 2nd pulls in the snatch lift for women competing in the American national championships.

METHODS: The data for this study were collected at the 1999 USA Men's and Women's Weightlifting Championships held in St. Joseph, Missouri (USA). All female competitors at this national competition were filmed, but only the 69kg class (n = 10) was analyzed for this study. The 69kg class was considered to be one of the elite classes with the potential for setting the national record in this event. The camera was set to record at 60 fps, and it was placed perpendicular to the competitive platform and the lifter's sagittal plane. Data analysis was completed with the Peak5 software package and Microsoft Excel 2000; Statistical analysis was completed with SPSS (9.0), and power analysis was completed on each of the three lifts attempted by the 10 competitors in this weight class.
Power output for each athlete was calculated using the method described by Garhammer (1993). Power outputs for the 1st and 2nd pull were based on calculations of the total work done by the athlete divided by the respective time during the phase of interest. Total power output was based on the total work done divided by the total time. The total work done in lifting the barbell upward against the gravitational pull was determined from the relationship of $W=\Delta ME$, which is defined as the sum of the object's kinetic energy (KE) and potential energy (PE). This work output was added in turn to the work done in lifting the body's center of mass to calculate a total average output during the 1st and 2nd pull phases.

RESULTS AND DISCUSSION: The power outputs for the 1st pull, 2nd pull, and total in the snatch for the competitors in the 69 kg class are listed in Table 1, Table 2, and Table 3, respectively.

Table 1 Power Output Values for Female Weightlifters during 1st Pull

Lifter	Wt (Kg)	Vmax (m/s)	Time (s)	Ymax (m)	P_1 (W)	P_2 (W)	$Total_1$ (W)
A	98	1.05	0.56	0.267	567.67	507.15	1074.82
B	95	0.69	0.56	0.297	549.28	507.15	1056.43
C	92.5	0.21	0.24	0.186	870.29	1183.35	2053.64
D	92.5	0.62	0.32	0.208	716.12	887.52	1603.63
E	82.5	0.37	0.40	0.272	620.83	710.01	1330.83
F	75	0.91	0.48	0.358	659.75	591.68	1251.43
G	72.5	0.84	0.32	0.389	1121.31	887.52	2008.82
H	65	1.01	0.24	0.312	1013.47	1183.35	2196.82
I	65	1.04	0.40	0.363	704.63	710.01	1414.64
J	57.5	1.63	0.80	0.284	249.41	355.01	604.411

Table 2 Power Output Values for Female Weightlifters during 2nd Pull

Lifter	Wt (Kg)	Vmax (m/s)	Time (s)	Ymax (m)	P_1 (W)	P_2 (W)	$Total_2$ (W)
A	98	1.17	0.40	0.59	1419.34	710.01	2129.35
B	95	0.80	0.40	0.65	1515.81	710.01	2225.81
C	92.5	0.71	0.40	0.65	1484.12	710.01	2129.35
D	92.5	0.16	0.32	0.55	1770.11	887.51	2225.82
E	82.5	0.44	0.24	0.33	1435.04	1183.35	2194.13
F	75	0.52	0.16	0.34	2373.48	1775.03	2657.62
G	72.5	0.31	0.16	0.37	2174.65	1775.03	2618.39
H	65	1.41	0.40	0.47	757.758	710.01	4148.50
I	65	1.59	0.32	0.47	934.24	887.51	3949.67
J	57.5	1.06	0.40	0.70	993.88	710.01	1467.77

Table 3 Power Output Values for Female Weightlifters during Total Pull

Lifter	Wt (Kg)	Vmax (m/s)	Time (s)	Ymax (m)	P_1 (W)	P_2 (W)	$Total_3$ (W)
A	98	0.02	1.04	0.99	917.13	273.08	1190.21
B	95	0.17	1.04	1.04	938.39	273.08	1211.48
C	92.5	0.29	0.72	0.93	1183.33	394.45	1577.78
D	92.5	0.88	0.72	0.88	1202.19	394.45	1596.64
E	82.5	0.89	0.72	0.68	867.99	394.45	1262.45
F	75	1.56	0.72	0.85	1045.00	394.45	1439.45
G	72.55	0.84	0.56	0.94	1339.44	507.15	1846.59
H	65	0.57	0.72	0.88	784.59	394.45	1179.05
I	65	0.29	0.80	0.96	764.65	355.01	1119.66
J	57.5	0.71	1.28	1.09	480.52	221.88	702.39

Note: Wt Lifted (kg) is best attempt; Vmax is maximum vertical velocity (m/s) of barbell during the pull phase; Time is time from bar lift-off until Vmax is reached; Ymax is maximum bar height (m); P_1 is the power (W) output in lifting the barbell; P_2 is the power (W) achieved in lifting the body's center of mass; Total $output_1$ is the total average power output (W) while lifting the barbell from floor to knees: Total $output_2$ is the total average power output (W) while lifting the

barbell from knees to peak height; and Total output$_3$ is the total average power output (W) while lifting the barbell from the floor to peak height, respectively.

The lifters in the 69 kg class each attempted 3 lifts as is the custom of international weightlifting rules, and they successfully completed 53.3% of the total 30 lifts. Analysis of variance (ANOVA) revealed statistically significant differences in the power outputs for the 1st pull, 2nd pull, and total ($p >. 05$). Post-hoc analysis using Bonferroni's method showed that the power output for the 2nd pull differed significantly from that of the 1st pull and total pull, but the 1st pull and the total pull did not differ significantly. The power output demonstrated during the 1st pull correlated significantly ($r=.616$; $p > 0.01$) with that demonstrated during the total pull, and the power output demonstrated during the 2nd pull also correlated significantly ($r = .783$; $p > 0.01$) with that demonstrated during the second pull. A multiple regression analysis was conducted to evaluate how well the following variables – resistance, success of lift, 1st pull, and 2nd pull – predicted total power output. The linear combination of these predictor measures was significantly related to the total power output, $F (4, 25) = 110.548$, $p > 0.001$. The sample multiple correlation coefficient was .973, indicating that approximately 95% of the variance of the total power output in the sample can be accounted for by the linear combination of measures noted above.
At the time of this competition, the 98 kg lift represented the U.S. national record for the snatch. The lifter later reset the national record at 100 kg and again at 100.5 kg. The 100 kg mark represents the current U. S. national record for the snatch in the 69 kg weight class for women lifters. The current world record in the 69 kg class is 111.5 kg.
The total power output values calculated in this study generally agree the values for the complete snatch pull reported by Garhammer (1991), and the values found for the 2nd pull support previous work describing this particular phase as the most powerful segment of the Olympic snatch lift (Stone, 1998). Additional points of interest include the lack of a general relationship between a lifter's placing in the class standings and her power output for a given phase of the pull. While the capacity to generate power is of obvious importance in weightlifting, this finding perhaps underscores the many factors playing an important role in performing well in this activity.

CONCLUSIONS: A fuller understanding of the power production demonstrated during the two phases of the pull during the snatch has a number of potential benefits. Examining the power production during these phases contributes to the description of the biomechanical factors contributing to success in this sporting activity. As many lifters break down aspects of the Olympic lifts during the training process, this knowledge may help athletes and coaches refine this aspect of training more precisely. Finally, information on power production may help athletes improve the application of force so critical to successful technique in Olympic weightlifting.

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