BAR HEIGHTS NEEDED FOR SUCCESSFUL LIFTS IN MEN'S WEIGHTLIFTERS

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The purpose of this study was to analyze the techniques of 132 Chinese male weightlifters competing at the 2015 China Weightlifting Championships, and to examine the differences of maximum bar height (MbH) and relative MbH (MbH/body height) among the all 8 weight classes. All attempts were recorded with the Real-Time Feedback System during the competition, and 115 snatch and 132 clean & jerk successful attempts with heaviest loads were chosen to be studied. The statistical results show the relative MbHs for clean and jerk are 59.5% and 94.3% respectively, while in snatch the relative MbHs are 71.8%, 73.9%and 76.6% for 56 - 94, 105 and 105+ weight classes differently; the relative MbH (72.0%) of the elite group (n=48) was lower than that (73.2%) of the normal group (n=67) in snatch ($p<0.05$).

KEY WORDS: weightlifting, snatch, clean & jerk.

INTRODUCTION: The snatch and clean & jerk are two disciplines in Olympic weightlifting. The lifter has to raise the barbell from the floor to certain height, and to support it according to the regulations. At competitions, lifters should do their best to demonstrate their performance with maximum loads. So several researches have been done at the National level(Whitehead et al., 2013) and World level (Baumann et al., 1988, Szyszka et al., 2014) competitions to analyze the weightlifting technique and to identify the biomechanical indicators of performance. Two or three dimensional image analysis were used in these studies to track the bar path and examine joint characteristics. However, this method needs post - processing to obtain the kinematic data. It was hard work and took much time, which might be reason that only several attempts by lifters from one weight class were involved in previous researches.

In order to obtain the kinematic data of barbell at the competitions easily and quickly, a real-time feedback system (RTFS) was developed (Ai et al., 2014). This system uses a Kinect sensor to capture the depth data and RGB video. With the pattern recognition and algorithm, it can automatically track and calculate the barbell COM in three dimensions and provide bar heights at key moments, such as maximal vertical velocity, maximal force exerted on bar, maximal bar height and so on.

Reviewing previous literature, bar heights needed for successful lifts in snatch and clean & jerk were less discussed, so the purpose of this study was to examine bar heights lifted by China national level weightlifters of all weight class, and identify if there are differences of these parameters between weight classes.

METHODS: Subjects were 132 male weightlifters from the 56, 62 69, 77, 85, 94 105,and 105+kg weight classes competing at the 2015 China National Men's Weightlifting Championships. For each individual, only one successful lift with maximum barbell weight in Snatch and Clean and Jerk was chosen for analysis. Table 1 displays sample numbers for each weight class. The average heights and the average weights lifted in each weight class are listed in Table 2.

Table 1 Sample Numbers in Weight Classes *(N)*

Weight Class	56	62	69	77	85	94	105	105+	Total
Snatch	15	12	14	14	16	14	15	15	115
Clean & Jerk	11	14	24	18	21	15	13	16	132

Table 2 Average Body Heights and Weights Lifted of Each Weight Class *(Mean±SD)*

Weight Class	56	62	69	77	85	94	105	105+
Body Height (m)	1.57 ±0.03	1.61 ±0.03	1.65 ±0.03	1.69 ±0.03	1.72 ±0.03	1.72 ±0.04	1.78 ±0.04	1.83 ±0.03
Snatch Weight(kg)	130±8	139±4	150±7	159±8	158±6	161±8	166±7	171±13
C&J Weight(kg)	151±6	162±7	168±8	178±9	184±8	189±11	192±11	207±10

All lifts in snatch and clean & jerk during the competition were recorded with the Real-Time Feedback System (RTFS) at 30 frames per second. The Kinect sensor was set up on a tripod in the rear side of weightlifters, so that it did not block the camera views of TV station, and it had no negative influences on weightlifters as well. Once a lift was registered, the video and kinematic parameters, such as the heights and trajectory of the bar, were immediately shown on the screen of the system (Figure 1), then saved into database for later analysis.

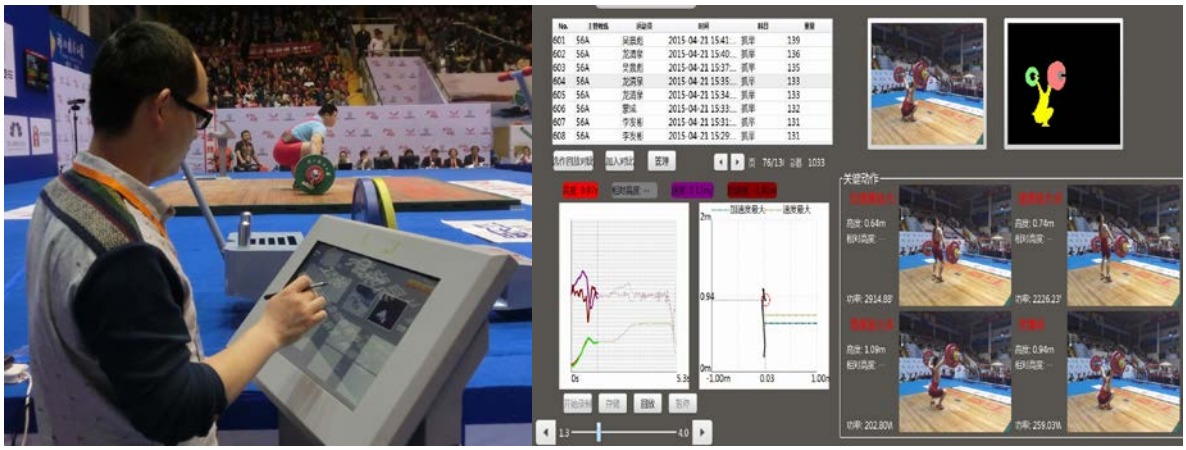

Figure1: System Setup and Results Shown on Screen

SPSS software was used to calculate the average, standard deviation, correlation, regression, also calculating relative bar height, which is defined as follows: relative bar height = bar height / body height. Bonferroni's post hoc was used to examine significant differences between groups.

RESULTS: The maximum bar heights and its relative heights of successful lifts in snatch, clean and jerk are shown in Table 3, 4 and 5 respectively. No significant group differences were noted for relative maximum bar heights in clean and jerk, while significant group differences were found in snatch: 105+ class has significant group differences with other 7 classes ($p<0.05$), 105 class also has significant group differences with 69, 85 and 105+ classes ($p<0.05$), and no significant group differences were observed between the 56, 62, 69, 77, 85 and 94 weight class.

Table 3 Maximum Bar Heights and Its Relative Heights in Snatch *(Mean±SD)*

Weight Class	56	62	69	77	85	94	105	105+
Bar Height (m)	1.12±0.04	1.15±0.04	1.17±0.04	1.23±0.03	1.24±0.02	1.26±0.04	1.32±0.05	1.39±0.06
Re.Bar Height (%)	72.6±2.6	71.4±2.3	70.6±2.3	72.2±1.8	71.4±1.4	73.3±1.2	73.9±2.2	76.6±2.5

Table 4 Maximum Bar Heights and Its Relative Heights in Clean *(Mean±SD)*

Weight Class	56	62	69	77	85	94	105	105+
Bar Height (m)	0.93±0.03	0.96±0.04	0.98±0.06	1.00±0.05	1.01±0.04	1.03±0.05	1.07±0.05	1.12±0.06
Re.Bar Height (%)	59.2±2.3	59.0±1.9	59.3±2.8	58.9±2.6	59.0±1.8	59.5±1.9	61.2±4.3	61.1±2.3

Table 5 Maximum Bar Heights and Its Relative Heights in Jerk *(Mean±SD)*

Weight Class	56	62	69	77	85	94	105	105+
Bar Height(m)	1.48±0.03	1.51±0.03	1.56±0.04	1.58±0.04	1.62±0.03	1.64±0.05	1.69±0.04	1.74±0.04
Re.Bar Height(%)	94.6±1.6	93.4±1.6	94.2±1.5	93.3±1.9	93.9±1.2	95.1±1.2	94.9±1.0	95.5±1.7

Table 6 shows where 115 lifters in snatch were categorized into an elite group, which was comprised of top-six lifters of each weight class. A normal group came from other lifters. A significant difference of relative maximum bar heights was observed between the elite and normal groups ($p<0.05$).

Table 6 Descriptive Statistics for Elite and Normal Group in Snatch

Group	N	Mean	SD	t	df	sig.
Elite	48	0.720	0.022	-2.587	112.703	.011
Normal	67	0.732	0.029			

DISCUSSION: Maximum bar height lifted by a weightlifter is a most important biomechanical indicator for a successful attempt at competition, and is strongly influenced by the strength abilities of the weightlifter (Stone et al., 2001). Two phenomena are easily observed at training and competition of weightlifting: (a) the maximum bar height (MbH) decreases when the load increases, (b) the MbH needed for successful lift increases along with body height increase (Table 2 - 5). In this study, a scaled value, relative MbH was introduced to examine differences of this value among the weight classes in snatch and clean & jerk.

For snatch, the results (Table 2) show that the relative MbHs of 105 (73.9%) and 105+ (76.6%) weight classes are obviously higher than that other weight classes, and only 105+ has significant group differences with other 7 classes ($p<0.05$), while105 class has significant group differences with three other classes (69, 85 and 105+) ($p<0.05$). The explanation of this evidence might be that the snatch is highly technical movement, and the large lifters may have poor technique and coordinate abilities relative to lighter body weight lifters. Because of no significant group differences among the 56, 62, 69,77, 85 and 94 weight class, relative MbHs can be obtained with 71.8% (n=85), 73.9% (n=15) and 76.6% (n=15) respectively for 56 - 94 classes, 105 and 105+ class. There is no significant group difference of relative MbHs in clean and jerk, the relative MbHs for clean and jerk are 59.5% and 94.3%.

It should be emphasized here that these relative MbHs were acquired for the successful attempts with heaviest load, that means the bar height at least reaching at relative MbHs during lifting is necessary condition for successful, or in other words, if the bar height do not reach at relative MbHs, the attempt by a lifter must be unsuccessful. Therefore relative MbH is an essential and useful index to evaluate the strength abilities and technique levels. Figure 2 shows the relationship between body height and maximum bar height in snatch, as expressed by a linear regression equation: $y=0.940x – 0.362$ ($r=0.896$, $n=115$). By knowing the body height of a lifter, the maximum bar height needed for successful attempt can be estimated using this equation. Similarly, the equations for clean and jerk are obtained as follows: $y=0.735x – 0.239$ ($r=0.858$, $n=132$) and $y=1.015x – 0.121$ ($r=0.930$, $n=132$).

Szyszka (2014) studied the snatch technique of 16 female weightlifters competing at the World Championship in 2013, and compared the maximum bar heights between the first place and last place weightlifters of 48, 63 and 75+kg weight classes. One result of Szyszka's research was that the relative MbH of first place lifter was smaller than that of last place lifter. But it was case study, and didn't have statistical meanings.

In this study, 115 lifters in snatch were divided into elite and normal groups according their performance results. The mean values of relative MbHs were statistical analyzed, the relative MbHs of elite group (72.0±2.2%, n=48) is smaller than that of normal group (73.2±2.9%, n=67), and there is a significant difference between these two groups ($p<0.05$). It could be concluded that the lower the bar height lift, the more economical the movement is, and a great bar height suggests a lower technical performance level of lifter.

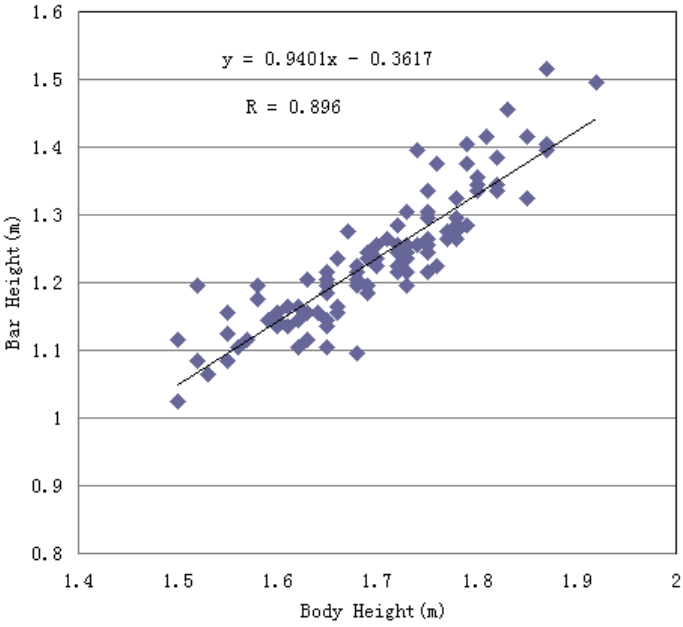

Figure 2: Relationship between Body and Bar Height

It should be mentioned here that some weightlifting pulling derivatives, such as clean pull, snatch pull, hang high pull that are carried out with barbell, are essential exercises to develop lower body power (Suchomel et al., 2015). The Real-Time Feedback System used in this study can also be applied to analyse these movements and to examine the effect of various loads on kinetic and kinematic characteristics of weightlifting pulling derivatives systematically.

CONCLUSION: This study examined the relative maximum bar heights needed for successful attempts with heaviest loads, and established relationships between maximum bar heights and body heights in snatch and clean & jerk movements. The results can be used to evaluate the weightlifter's strength abilities and their performance levels, and the method used in this study can also be applied to other studies on the training exercises with barbell. Future research should consider examining the relative maximum bar heights of female weightlifter and identifying the differences of the relative maximum bar heights between men and women weightlifters.

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