

## PEAK POWER OUTPUT IN THE POWER CLEAN – THE INFLUENCE OF RELATIVE STRENGTH

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The aim of this study was to determine whether athletes of higher relative strength maximise their power output at higher percentages of their 1RM in the power clean. Twenty-nine male athletes (power clean 1 RM =  $99.2 \pm 18.9$  kg) performed two power cleans at 10% increments from 50% to 100% of 1 RM. Bar displacement was collected by a Ballistic Measurement System (BMS) and power output was calculated using system mass (SM) and bar mass (BM) methods. Optimal loads were 50% and 90% for the SM and BM methods respectively. However, a limitation of the study was that loads below 50% of 1RM were not examined. Relative strength was not related to percentage of 1 RM at which maximal power output was achieved.

**KEY WORDS:** power output, power clean, optimal load, strength

**INTRODUCTION:** Maximising power output in strength and conditioning exercises is important for athletic performance as many sports rely upon rapid movement of mass. Previous research has shown that power output is maximised between 30%-60% of the one repetition maximum (1 RM) (eg. Wilson et al., 1993) for a variety of movements and muscle groups. For example, the optimal load for maximising mechanical power output has been determined for jump squats and bench press throws (eg. Baker, 2001a, b; Wilson et al., 1999) as well as for single joint movements such as elbow flexion (Kaneko et al., 1983). Olympic weight lifting and associated lifts are utilised extensively for athlete training, in part because substantial power output is produced during such movements. The power clean is a variant of the clean and jerk that is commonly used to develop both strength and power in the athlete. The difference between the power clean and the traditional Olympic clean is that the power clean requires the athlete to catch the bar with the thighs above a parallel squat position. Garhammer (1993) hinted that the percentage of 1 RM that maximised power in the Olympic lifts may be higher than that of other more traditional exercises. Baker (1995) further versed the opinion that competence and training level of the athlete and nature of the exercise would determine the load that would maximise the mechanical power output. Furthermore, Garhammer (1993) reported that power output produced during the Olympic lifts in competition was highly dependent upon the strength level of the lifter, with higher power outputs being related to higher performance in elite weightlifters. No research has yet been conducted on the load that best maximises power output in the Olympic lifts and whether this load changes in accordance with relative strength levels. Therefore, the purpose of this study was to determine whether athletes of higher relative strength maximise their power output at higher percentages of their 1 RM in the power clean exercise.

**METHODS:** Twenty-nine male athletes from a variety of sports (Power Clean 1 RM =  $99.2 \pm 18.9$  kg) were invited to participate in this study. Informed consent, in accordance with the University Ethics guidelines was obtained from subjects prior to testing. Subjects 1 RM for the power clean had been derived in training or testing within the preceding month. Subjects performed two lifts at each of the 10% increments from 50% to 100% of 1 RM (total of 12 lifts). A complete warm up was given to the athletes and sufficient rest periods were enforced to ensure complete recovery between increments. While completing each power clean, bar displacement was measured by a Ballistic Measurement System (BMS) (Model 2003.1.4; Fitness Technology, Adelaide, Australia). Data from each lift was captured and saved to file for later analysis. Two methods to calculate the maximal power output were utilised in this study: 1) power output based on displacement of the bar and utilising the system (body and

bar) mass (SM); 2) power output based on bar mass only (BM). These power output calculations are outlined in Dugan et al. (2004) and have been used previously for the power clean by Burnett et al. (2004). Maximal power output during the second pull was calculated for each trial and an average over the two trials from each of the percentages of 1 RM was used to decrease within-subject variability. Subject's relative strength levels were determined using the method outlined by Kauhanen et al. (2002). This method was derived from a retrospective analysis of the performance of weightlifters from the 1973-1999 World Championships and Olympic Games. Descriptive statistics were used to summarize the average peak power outputs at each of the loads investigated in this study (50%, 60%, 70%, 80%, 90% and 100% of 1 RM). Also, a frequency analysis of what loads resulted in the maximal power output for each subject was performed. Furthermore, Pearson product moment correlations were used to determine whether levels of relative strength were related to the percentage of 1 RM of the power clean to maximise power output.

**RESULTS AND DISCUSSION:** The power clean is considered a special strength exercise that is used to develop quickness and jumping ability in athletes. To improve these capabilities an increase in exercise intensity needs to be evident. The load that maximised power output in this sample of athletes was 50% using the SM Method and 90% in the BM Method. A limitation of this study however was that loads below 50% were not examined indicating that loads for the SM method may have actually been maximised at loads lower than 50% of 1 RM. Loads below 50% of 1 RM were not examined in this study as a load of say 40% of 1 RM presents logistical problems. For example, if an athlete has a 1 RM of 80 kg a load of 32.5 kg would represent 40% but 5 kg standard diameter plates are rare in the training environment and so loads below 40 kg are difficult to set with Olympic barbells.

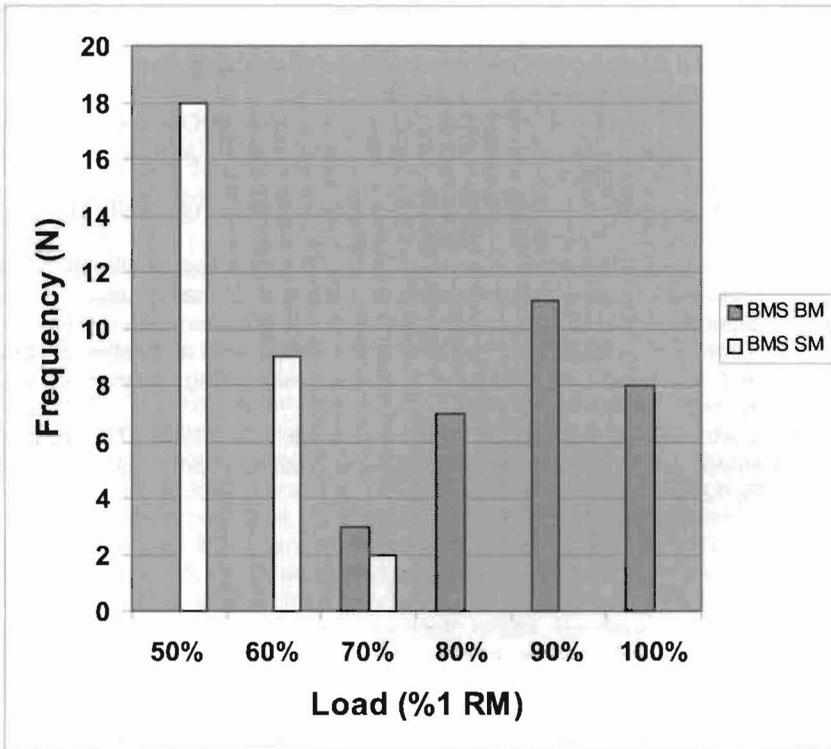
**Table 1 Absolute and Relative Power Output for System Mass (SM) and Bar Mass (BM) Calculation Methods for Percentages of One Repetition Maximum (1 RM).**

	50%	60%	70%	80%	90%	100%
SM Peak Power (W)	4221.4 (596.3)	4152.7 (508.0)	3999.6 (548.2)	3819.4 (498.6)	3618.3 (467.4)	3486.3 (503.7)
SM Peak Power (W/kg)	48.1 (5.6)	47.3 (4.1)	45.5 (4.4)	43.6 (3.6)	41.3 (3.3)	39.6 (3.8)
BM Peak Power (W)	1550.2 (223.8)	1665.0 (251.7)	1779.8 (266.3)	1802.4 (266.6)	1835.9 (234.2)	1813.8 (235.9)
BM Peak Power (W/kg)	17.7 (2.7)	19.1 (3.2)	20.3 (3.0)	20.6 (2.8)	21.1 (2.7)	20.7 (2.4)

When calculating the power output the BM method relies upon calculating the power output generated from the bar only whilst the SM method involves calculating the power output resulting from moving the bar as well as the centre of mass (CM) of the athlete. Both Garhammer (1993) and Johnson and Bahamonde (1996) revealed that the power output generated as a result of moving the CM was not trivial. The appropriate calculation to choose will depend upon why the athlete is doing the exercise. Strength training specialists who are coaching athletes who wish to use the power clean to increase general explosiveness (eg. jumping ability in most sports) should use the SM Method (Burnett et al., 2004). However, weightlifters who are concerned with moving the bar only (as opposed to the bar and the body's centre of mass) should use the BM method. Figure 1 shows the frequency at which power output was maximised for each load examined in this study. This clearly outlines that whilst average statistics are useful to provide training guidelines athletes do have individual needs therefore testing with individual recommendations is important.

Also worth considering is that there were 18 out of 29 instances in the BM method where the load that maximised power output and the next highest load were within the relative Standard Error of Measurement (%SEM) (Burnett et al., 2004). For example, if the power output was maximised at 90% of 1 RM and the next highest load was 80% of 1 RM the raw power output values were within the %SEM value. Furthermore, this was the case in 8 instances for the

SM Method). This means that in a majority of cases the load that maximises power output may be a range (ie. 80%-90% of 1 RM) rather than a discrete Figure (ie. 90% of 1 RM).



**Figure 1 Frequency of Peak Power Output (PPO) Using the System Mass (SM) and Bar Mass (BM) Calculation Methods.**

The hypothesis of this study was that stronger athletes maximise power output at higher percentages of 1 RM. In this study there was no correlation between the load that maximised power output (%1 RM) and relative strength as determined by Kauhanen and associates' index ( $r^2 = 0.13$ ).

**CONCLUSIONS:** The loads that maximised power output were 50% and 90% for the SM and BM methods respectively. However, a limitation of the study was that loads below 50% of 1 RM were not examined for logistical reasons. Further, relative strength was not related to the percentage of 1 RM that maximal power output was achieved at which meant the hypothesis of the study was rejected. Strength and conditioning specialists should individualise training programs and the %SEM should be considered when prescribing training intensity.

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