THE EFFECT OF LOADING AND VELOCITY ON MUSCLE POWER OUTPUT

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Muscular power is considered one of the main determinants of dynamic athletic performance. Two major methods for power training programs were low-resistance with fast speed and high-resistance with low speed. The purpose of this research was to investigating the influence of different intensities and velocity on muscle power output. The subjects were 10 males who had trained at least 3 month using bench press machine. All lifts were performed on a traditional ballistic bench press machine with a mass of 9.08-36.32 kg (increase in 9.08 kg steps). High-velocity lifting program (HI): The subjects performed 3 trials in each level load, as fast as possible from an elbow angle 90 degrees to full extension. Lower-velocity lifting program (LO): The metronome was used to keep movement speed at 20 rpm. The mean power and peak power were significantly different between HI and LO for all the loads, HI were significantly greater than LO ($p < .01$). In addition, the mean power of 18.16 kg at high speed was significantly greater than mean power of 27.24 kg at low speed. Besides, the displacement decreased with the load increased in the different velocities. In conclusion, High velocity may be considered to be more important than heavy load to produce power output. The heavy resistance may reduce joint ROM in exercise.

KEYWORDS: muscle power, velocity, load.

INTRODUCTION:

Muscular power is considered one of the main determinants of dynamic athletic performance, especially in sporting events that require high force generation in a short amount of time (Newton and Kraemer 1994). So, it was important to increase the maximal power during training. Power was defined as the rate of doing work, and can be expressed as the product of force and velocity, which have an inverse relationship in concentric muscle actions. As the velocity of movement increased, the force that a muscle can produce decreased. And maximum force production occurred when the speed of movement is very low or zero such as performing a static or isometric exercise. The force was related to the mass of loads. So two major factors affect the power output are movement velocity and resistance loads.
Previous studies have suggested many power training programs, the major methods were low-resistance with fast speed (Jones, Bishop, Hunter and Fleisig 2001) and high-resistance (Østerås, Helgerud & Hoff 2002). Liow & Hopkins (2003) thought that weight training in different velocity could decrease different phases of time on kayak sprint performance. Fielding (2002) indicated that high-velocity resistance training was more effective than low-velocity resistance training for improving lower extremity peak power. Besides, using a heavy resistance training also increased power effectively (Mangine et al., 2008). Kawamori et al., (2005) suggested that power training should use the optimal loads to maximize power output during training. Therefore, it is important to identify how loads and velocity affect the power output. The purpose of this research was using the traditional ballistic bench press machine, investigating the influence of different intensities and velocity on power output.

METHOD:

The subjects were 10 males who had ever trained at least 3 month by bench press machine. Their mean age, height, and weight were 22.3±2.5 years, 161.7±4.7 cm, 61.8±5.1 kg, respectively. High-velocity lifting program (HI): All lifts were performed on a traditional ballistic bench press machine with a mass of 9.08-36.32 kg (increase in 9.08 kg steps). Each subject did a short warm-up in 10 minutes. The subjects performed 3 trials in each level load (9.08, 18.16, 27.24 and 36.32 kg), as fast as possible from an elbow angle 90 degrees to full extension. Each trial was followed by a rest period at least 3 min. The fast mean velocity was collected to analyze at each load level. Lower-velocity lifting program (LO): The

movement and loading were similar to high-velocity lifting program except the movement speed. The metronome was used to keep movement speed at 20 rpm.
A load cell (Tetea) was attached between cable and weight which accessed the strain from the cable to measure force (N). An ultrasonic system (KEYENCE UD-300) was fixed on the machine above the weight, recording the weight's instantaneous position. Displacement could be detected range from 20 mm to1300 mm. DASYLab software was used to calculate the instantaneous velocity from successive time-derivative of displacement. The displacement and force signals were sampled simultaneously (1000 Hz). Measuring maximum displacement, mean power, peak power and mean velocity. Power is equal to the force detected by load cell times weight velocity detected by ultrasonic system.
Mean ± *SD* was calculated using standard methods. The peak power and mean power values were compared using 2-way analysis of valiance (ANOVA).

RESULTS:
The mean values and *SD* for mean power (w), peak power (w), peak force (N), maximum displacement (m) and mean velocity (s/m) can be observed in Table1. The time curves for force, position, and velocity assessed by the load cell and the ultrasonic system are shown in figure1.

Table1. Mean power (W), peak power (W), peak force (N), maximum displacement (M) and mean velocity (M/S) during different loads and velocity (HI & LO).

	9.08kg	18.16kg	27.24kg	36.32kg
mean power				
HI	25.62±3.78	45.04±4.3	55.51±7.47	65.01±10.46
LO	14.37±2.84	25.98±5.40	36.21±6.89	46.53±7.84
peak power				
HI	70.42±21.70	98.26±20.12	124.1±19.77	138.04±2513
LO	34.15±6.52	61.43±9.08	79.78±15.23	100.84±16.83
peak force				
HI	175.00±27.88	312.54±41.23	414.41±47.44	470.97±52.26
LO	125.26±11.22	227.81±15.37	328.49±19.81	426.14±25.57
displacement				
HI	0.28±0.04	0.27±0.02	0.24±0.02	0.22±0.03
LO	0.22±0.03	0.20±0.04	0.19±0.04	0.18±0.03
Mean velocity				
HI	0.34±0.03	0.27±0.03	0.21±0.02	0.19±0.03
LO	0.15±0.02	0.14±0.02	0.13±0.02	0.13±0.02

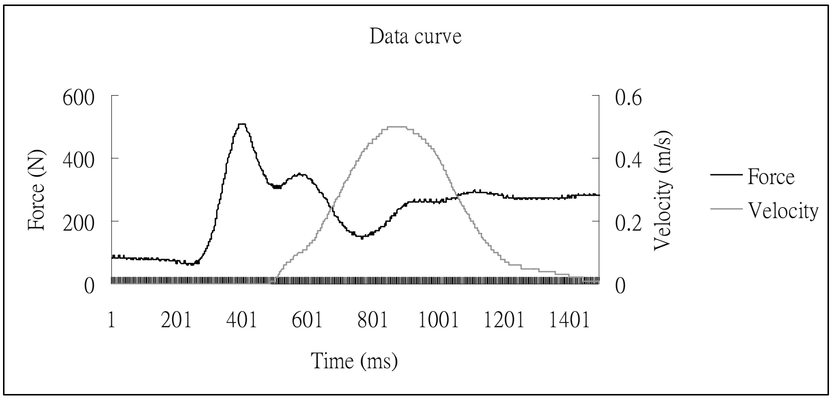

Figure 1: The force-time and velocity-time curves for a subject performance.

The mean power and peak power were significantly different between HI and LO for all the loads, HI were significantly greater than LO ($p < .05$). In addition, the mean power and peak power of 18.16 kg at high speed were significantly greater than 27.24 kg at low speed, and the mean power and peak power of 27.24 kg at high speed were significantly greater than 36.32 kg at low speed (shown in figure 2 and figure 3).

The displacement at HI was significantly greater than LO at each load ($p < .05$). Besides, the displacement decreased with the load increased in the different velocities (shown in figure 4).

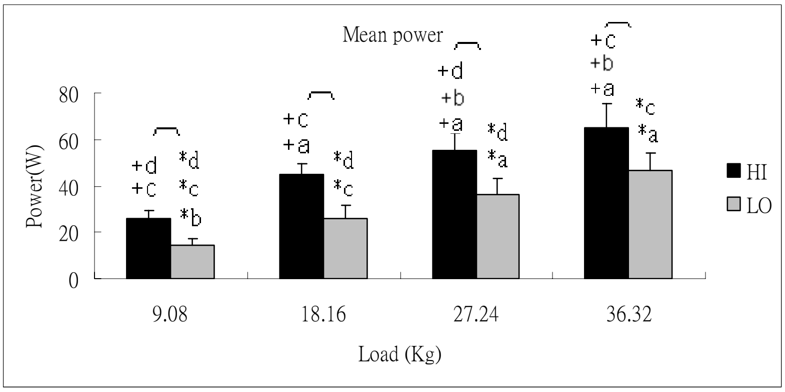

Figure 2: The mean power output detected in high-velocity (HI) and Low-velocity (LO).

The mean power was significantly between HI and LO at each load ($p < .05$).

***a Significantly different from HI at 9.08 ($p < .05$). +a Significantly different from LO at 9.08 ($p < .05$).**
***b Significantly different from HI at 18.16 ($p < .05$). +b Significantly different from LO at 18.16 ($p < .05$).**
***c Significantly different from HI at 27.24 ($p < .05$). +c Significantly different from LO at 27.24 ($p < .05$).**
***d Significantly different from HI at 36.32 ($p < .05$). +d Significantly different from LO at 36.32 ($p < .05$).**

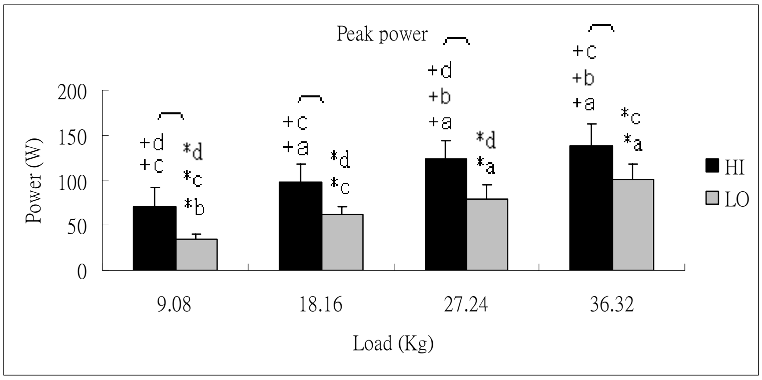

Figure 3: The peak power output detected in high-velocity (HI) and Low-velocity (LO).

The peak power was significantly between HI and LO at each load ($p < .05$).

***a Significantly different from HI at 9.08 ($p < .05$). +a Significantly different from LO at 9.08 ($p < .05$).**
***b Significantly different from HI at 18.16 ($p < .05$). +b Significantly different from LO at 18.16 ($p < .05$).**
***c Significantly different from HI at 27.24 ($p < .05$). +c Significantly different from LO at 27.24 ($p < .05$).**
***d Significantly different from HI at 36.32 ($p < .05$). +d Significantly different from LO at 36.32 ($p < .05$).**

DISCUSSION:

The force-time and velocity-time curves did not coincide at beginning (shown in figure 1). The difference was due to the load cell attached between the cable and weight, and the cable had across 13 plastic pulleys. The force detected by load cell was delayed because the cable tension need to deform the pulleys before create load cell deformation. The load cell exhibited lower output values than actual force. Furthermore the displacement data was not obtained from handle movement but from the load weight displacement. Even though the displacement was not the actual hand movement, but this displacement of load may reflect the performance from the participants (Hori et al., 2007).

Currently, people always practice in strength training by machine, whereas velocity and power are usually neglected. Power is a reliable estimate of muscle performance for athletes and general publics (Fielding et al., 2002), The results of this study showed that peak and mean power of lighter load (27.24 kg) at high velocity were greater than those of heavy load (36.32 kg) at low velocity. This finding indicated that increasing velocity may be more important to produce power than increasing load.

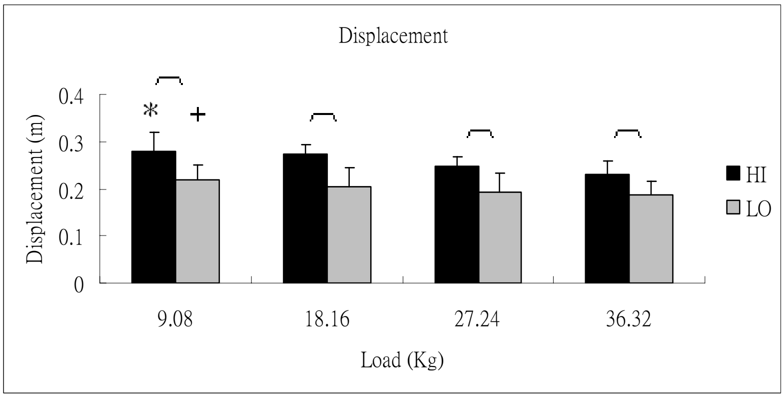

Figure 4: The maximum displacement detected at high-velocity (HI) and Low-velocity (LO).
The displacement was significantly between HI and LO at each load (p＜.05).
＊Significantly different from HI at 36.32 (p＜.05).
+ Significantly different from LO at 36.32 (p＜.05).

The displacement was significantly different among different velocities as well as among different loads (9.08~36.32). This may be attributed to the inertia of loads, according to Newton's second law, a force on an object is equal to the mass of the object multiplied by the acceleration of the object. So the mass of the loads and acceleration of loads had an effect on the displacement. The displacement decreased with the load increased in different velocities (shown in figure 4). The reason was that the subjects might not be able to perform full extension which could be observed by the decreased displacement of loads.

CONCLUSION:

Velocity and resistance weight could determine peak power and mean power, different velocity and loads have significant effect on the power output. High velocity may be considered to be more important than heavy load to produce power output. Furthermore, the heavy resistance may reduce joint ROM in exercise which require more thorough study in the future.

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