CONTRIBUTION OF MAXIMAL STRENGTH TO PEAK POWER AND RATE OF POWER DEVELOPMENT IN BENCH PRESS MOVEMENT USING FREE WEIGHTS

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The purpose of the study was to demonstrate the relationships between peak power output, rate of power development (RPD) and maximal strength in the bench press movement with free weights. Eighteen healthy male subjects volunteered to participate in the study (mean age 21.1±1.4year, standing height 169.9±6.5cm, body mass (BM) 75.6±16.8kg). All subjects had moderate to extensive resistance training experience ranging from 1 to 5 years. The bench press movement was performed with a weight of 50% of one repetition maximum (1RM). Acceleration data were obtained with a uniaxial micromachined accelerometer attached to the centre of a barbell shaft. Based on the acceleration data, peak power output (W), time to peak power (TPP, s) and RPD (W/s) were computed. Significant correlations were found between peak power per body mass vs. 1RM/BM (r = 0.650, p < 0.01) and RPD/BM vs. 1RM/BM (r = 0.557, p < 0.01). However, RPD/BM and TPP were not significantly different between the high-strength group and the low-strength group. The current findings indicate that increasing maximal strength may play a great role in the peak power improvement, but not on the RPD using free weights. Authors recommend mixed training strategy using a heavy weight and a light to medium weight to effectively improve the bench press performance.

KEY WORDS: muscle power, accelerometer, resistance training

INTRODUCTION:

It has been demonstrated that peak muscle power in the upper body is a good predictor of athletic performance (Goronstiaga et al, 2005). In addition, since an athletic movement is usually completed in a short period of time, power development in the initial concentric phase may also be an important factor for great success in sports. Previous studies reported that significant contribution of maximal strength to peak muscle power, but not to the power production in the initial phase of concentric movement (Cronin et al, 2000). However, the previous study was conducted using a guided weight machine, which reduces the stabilizing requirement on the shoulder musculature during the movement (McCaw & Friday, 1994). On the other hand, a free weight exercise requires both stabilization and power production simultaneously. Therefore, the previous result may not be applicable when using free weight. The purpose of this study was to demonstrate the contribution of maximal strength to peak power output and power development in the concentric bench press movement using free weight.

METHOD:

Data Collection: Eighteen healthy male subjects volunteered to participate in the study. The mean (±SD) age, standing height and body mass (BM) of the subjects were 21.1±1.4years, 169.9±6.5cm and 75.6±16.8kg respectively. All subjects had moderate to intense resistance training experience ranging from1 to 5 years. After a warming-up session, one repetition maximum (1RM) was determined for all the subjects. Then, the subjects were instructed to attempt three sets of a single bench press with the weight of 50%1RM. We conducted the measurement according to the protocol used in the previous study (Koshida et al, in press). In the three attempts, the subjects were instructed to move the bar as fast as possible. A micromachined accelerometer (MYOTEST®, Myotest SA, Switzerland) attached to the centre of a barbell shaft was used to obtain the acceleration data (500Hz) in the bench press movement. The acceleration data were first stored into the data logger and then transferred to a personal computer for the calculation of peak power output, time to peak power (TPP)

and rate of power development (RPD). High intertrial reliability in these measurement variables was established in the pilot study (table1).

Table 1 Intraclass correlation coefficient in peak power, time to peak power (TPP), and rate of power development (RPD) in the pilot study (n=27)

Peak power	TPP	RPD
0.98	0.88	0.95

Data Analysis: Figure 1 illustrated a typical muscle power output-time curve. Peak power output was calculated with the software accompanying MYOTEST®. In addition, RPD was calculated by multiplying peak power by TPP. Pearson coefficient was obtained to demonstrate the correlation between peak power/BM, TPP, RPD/BM and 1RM/BM. In addition, to examine the role of maximal strength in peak power, TPP, and RPD, 6 subjects with the highest 1RM/BM (high strength group) and 6 subjects with the lowest 1RM/BM (low strength group) were compared. One-way ANOVA was used to compare the difference in 1RM/BM, peak power/BM, TPP and RPD/BM between the two groups. The alpha level was set at 0.05.

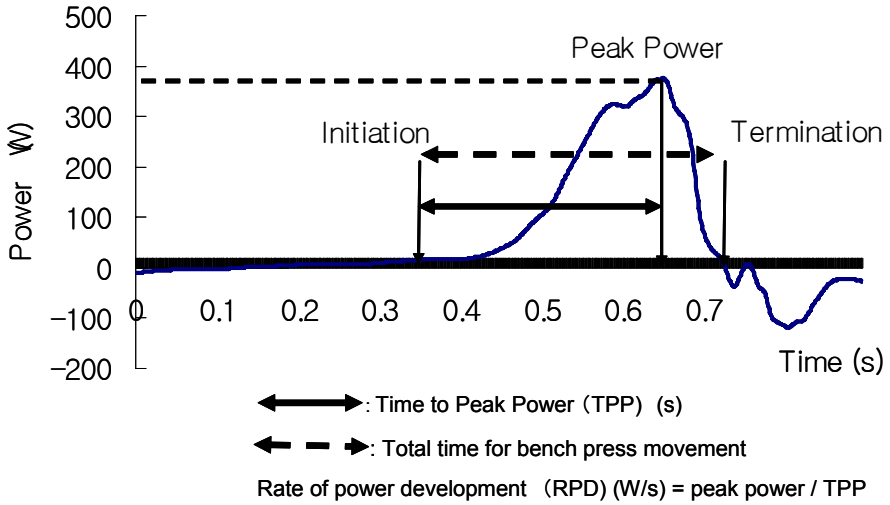

Figure 1: A typical presentation of power-time curve in bench press movement

RESULTS:
Mean (±SD) of 1RM/BM was 1.12±0.24 kg/BM (1RM=83.2±19.1kg). Mean values (±SD) of peak power/BM, TPP and RPD/BM were 6.86±2.34W/BM (peak power=498.2±143.8W), 0.32±0.03s and 21.6±7.3W/s/BM (RPD=1601.9±490.4 W/s) respectively. Significant correlations were found between 1RM/BM and peak power output/BM ($r=0.650$, $p<0.01$)(Fig.2A), 1RM/BM and RPD/BM ($r=0.557$, $p<0.01$)(Fig.2C), but not between 1RM/BM and TPP (Fig.2B). Mean (±SD) of 1RM/BM, peak power output/BM, TPP and RPD/BM in the high strength and the low strength group were shown in table 2. Peak power output/BM appeared to be greater in the high strength group ($F= 4.955$, $p=0.05$), whereas there were no significant differences in TPP and RPD between the two groups.

DISCUSSION:
Our result demonstrated that the peak power was significantly correlated with the maximal strength in the bench press movement with a free weight of 50%1RM. In addition, peak power output in the high strength group appeared to be greater than that in the low strength group. On the other hand, TPP was not significantly correlated with the maximal strength. Moreover, there were no significant differences in the TPP and the RPD between the high

strength and the low strength groups. The results indicate that, whether using a free weight or a bench press machine, maximal strength may be a good predictor of peak power output, but that the contributions of maximal strength to TPP and RPD are questionable.

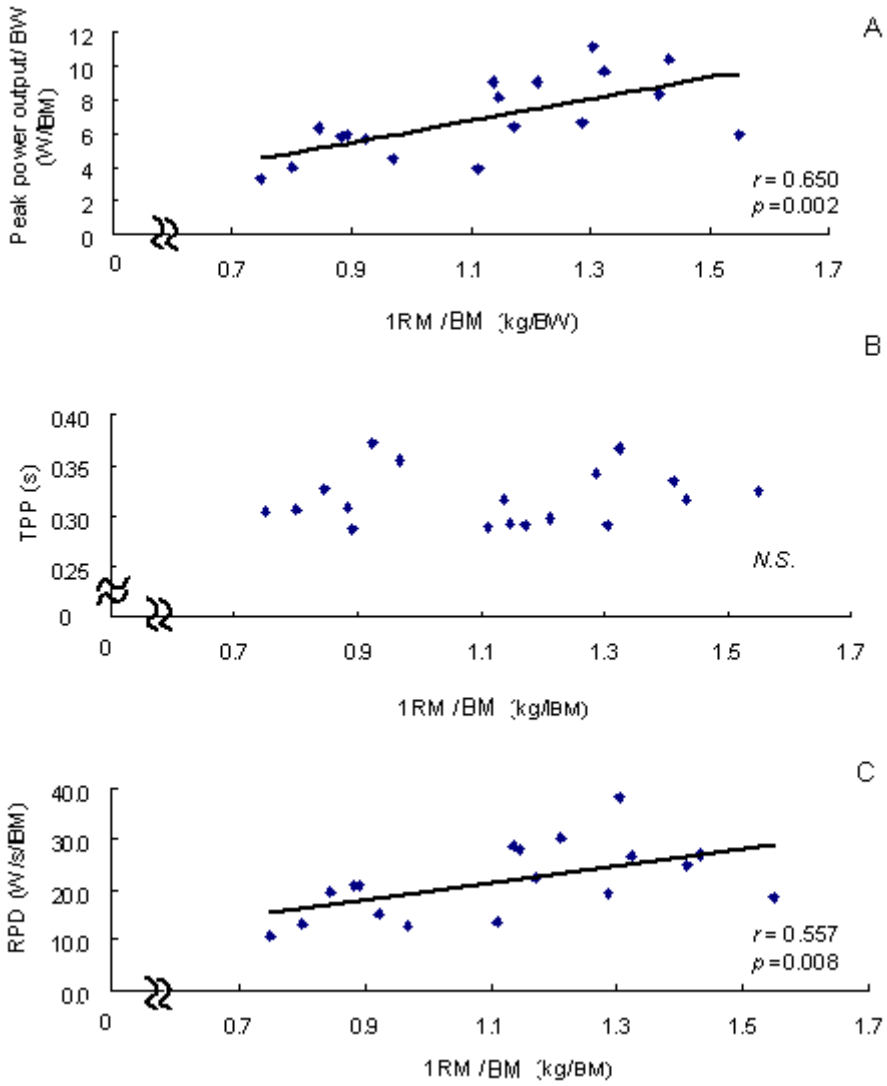

Figure 2: Linear correlations between one repetition maximum (1RM) per body mass (BM) and peak power/BM(A), 1RM/BM and time to peak power (TPP) (B), and 1RM /BM and rate of power development (RPD)/BM (C)(n=18) *N.S.*: Not significant

Table 2 Comparison of body mass, one repetition maximum (1RM), peak power, time to peak power (TPP), and rate of power development (RPD) between the high strength and the low strength groups

	High Strength (n=6)		Low Strength (n=6)		
	Mean	SD	Mean	SD	
Body Mass (kg)	72.0	6.7	65.8	4.2	
1RM (kg/ BM)	1.37	0.12	0.94	0.10	**
Peak Power (W/BM)	8.30	1.77	6.17	1.53	
TPP (s)	0.33	0.02	0.33	0.03	
RPD (W/s/BM)	24.38	4.64	19.50	5.54	

* p <0.05
* * p <0.01

The study of McCaw et al. (1994) demonstrated that deltoid muscle activity was significantly greater in a free weight bench press than in a machine bench press due to the difference in stabilizing requirement during the movement. The current result suggests that the difference in the muscular activity may have little effect on the relationships between maximal strength, peak power, TPP and RPD.
Cronin et al. (2000) stated that neuromuscular function may play a greater role in power production in the initial concentric phase of a machine bench press. Based on the previous and the current findings, whether using a bench press machine or a free weight, the mixed training strategy combining slow lift with a heavy weight and fast lift with a light to medium weight may be effective at improving both peak power and RPD.
In the future study, the bench press test using different load needs to be carried out to demonstrate the influence of the load on the relationships between maximal strength, peak power, TPP, and RPD.

CONCLUSION:
We concluded that maximal strength is a good predictor of peak power when using free weights. However, the influence of maximal strength on TPP and RPD may not be as significant.

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Acknowledgement
The authors would like to thank the staff members of the Sport Rehabilitation Laboratory in Hiroshima University for their support.