SHORT COMMUNICATION

Comparison of lift velocity and power output between barbell and dumbbell bench presses

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Objectives: The purpose of this study was to assess differences in bench press velocity and power production with barbell and dumbbells.

Design: Randomized cross-over design.

Methods: College men (n = 20, age = 18-24 yrs) were measured for average and peak velocities and power during maximal effort single repetitions using barbell and bilateral dumbbells at loads equivalent to 30%, 50%, and 70% of body mass. Three repetitions were performed at each load with one-minute recovery between each repetition and 10 minutes between loads. During each repetition for each mode, average and peak velocity and power were monitored using a linear accelerometer.

Results: Interclass correlation coefficients across the 3 trials for peak and average velocities were high for both barbell (ICC = 0.957 and 0.821, respectively) and dumbbells (ICC = 0.947 and 0.855, respectively). Peak power output was significantly higher ($p < 0.009$) for barbell than dumbbells at 50% and 70% loads. Average power output was significantly different ($p < 0.001$) across the 3 loads but not significantly different between barbell and dumbbells ($p = 0.35$). Although velocity decreased as load increased, higher power outputs were produced across increases in loads. Peak power output was reached at 70% of body mass with barbell and 50% with dumbbells.

Conclusion: Either barbell or bilateral dumbbell bench press exercises can be used to evaluate upper-body power with similar effectiveness.

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Key words: force-velocity profiling ■ muscular strength ■ resistance training ■ exercise mode

INTRODUCTION

The barbell bench press (BBP) is one of the most popular and widely used resistance training (RT) exercises designed to strengthen the anterior chest and shoulder muscles.[1,2] It is typically performed in a supine position with moderate to heavily loaded barbells. In addition, dumbbells are often used as a supplemental exercise to achieve similar training benefits.[3] A previous investigation found peak electromyographic amplitude (EMGa) was not significantly different between the pectoralis major and anterior deltoids during performance of a 6 repetition maximum (6RM) in BBP and dumbbell bench press (DBP).[3] Saeterbakken, van den Tillaar, and Fimland[4] concluded there was similar peak EMG activity between the two lifts in the pectoralis major and anterior deltoid despite 1 repetition maximum (1RM) BBP being 17% greater than 1RM DBP. They also indicated that biceps brachii total EMG activity was significantly higher during DBP. In a follow-up study, van den Tillaar and Saeterbakken[5] again determined that 1RM BBP was significantly greater than DBP by approximately 19% and biceps total EMG activity was higher during DBP while triceps activity was less compared to BBP. Recently, Farias et al.[6] noted greater peak EMG activity in the triceps in BBP than DBP but greater activity in the biceps during DBP than during BBP. To date, no studies have determined the degree of EMG activity in the aforementioned muscles during an acute session comparing the BBP and DBP using the same loads. Similar EMG activity could suggest that BBP and DBP may produce similar movement velocities throughout their range of motion.

In recent years, lifting velocity has become an important metric for evaluating the effects of resistance training on muscle strength and speed of contraction.[7] Technology that allows measurement of lifting velocity has added another dimension to the analysis of performance through measurement of bar velocity and power output during a lift.[8] Thus, inclusion of lifting velocity during resistance training is widely supported in order to insure consistency in exercise intensity, with numerous studies noting a strong relationship between bar velocity and %1RM in BBP.[9,10] A summary of training studies suggest that training with fast movement velocities may produce greater gains in strength and power than methods using a slower velocity.[11]

Despite the widespread use of dumbbells for training the upper body, little research has compared the power output when performing BBP and DBP exercises with similar loads. Since individuals tend to use comparable loads in DBP to

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those they are accustomed to using in BBP, it would beneficial to determine if comparable loads with BBP and DBP would produce similar effects in velocity and power output. Therefore, the purpose of this study was to compare lifting velocity and power output during BBP and DBP with comparable loads. We hypothesize that lifting velocity for DBP will be slower than for BBP at each load, resulting in lower power output across the load spectrum.

METHODS

Participants

A priori analysis for repeated-measures ANOVA indicated 19 participants would be required for a power of 0.90, a theoretical effect size = 0.70, and an alpha = 0.05.[12] Twenty college men (age = 20.7 ± 1.5 yrs, height = 180.9 ± 8.5 cm, and weight = 84.5 ± 10.9 kg) with substantial resistance training background (minimum of 3 days/week for > 1 yr using multiple upper-body exercises) volunteered to participate. All participants had some experience with power-based RT. After the study protocol was fully explained, volunteers signed an informed consent document. Study methodology was approved by the university Institutional Review Board (form number: TSU.IRB #2.8.18). All procedures were conducted in accordance with the ethical standards of the Helsinki Declaration.

Protocol

Body weight was determined using an electronic digital scale (Tanita, model BWB-800). Prior to testing each participant performed a warm-up of their choosing. Each test lift was performed in a supine position on a standard lifting bench. BBP grip width and DBP initial position were self-selected by participants and tended to be slightly wider than shoulder width. Test assistants handed each weight to the lifter. BBP was controlled by one assistant who positioned the bar at arms' length from behind the participant. Separate assistants controlled each dumbbell and simultaneously handed them to the participant at arms' length. Participants were instructed to lower the BBP until the bar touched the sternum and the DBP until the bar of the dumbbell was in line with the sternum. The load for each mode was then lowered slowly (~2 sec), followed by a 3-second paused to eliminate the stretch-shortening cycle before initiating the lift with maximal effort. During the DBP, participants were instructed to maintain the dumbbells in a horizontal position with the thumbs pointing to the centerline of the body throughout the lift. Participants were instructed to perform each lift as fast as possible.

A linear accelerometer (Tendo Power Analyzer Unit, Ver 4.1.0, Tendo Sport Machines, Trecin, Slovakia) was used to record average and peak velocities during maximal effort single repetitions. Each load was input into the device to calculate average and peak power for each repetition. The accelerometer tether was placed on the right side of the barbell and right dumbbell. Equivalent loads for BBP and DBP were set at 30%, 50%, and 70% of body mass (%BM). Three single repetitions were performed at each load with one-minute recovery between each repetition; barbell and dumbbells where taken from the particiant after each repetition. Lift methods were randomized, and loads were performed in succession. A 10-minute rest was given between loads and modes to insure adequate recovery and avoid any residual fatigue.

Statistical Analysis

Interclass correlation coefficients (ICC) were used to assess relative reliability across the 3 trials for average and peak velocity and power at each load for each mode of lifting. The Wilks-Shapiro test indicate normal distributions for both peak ($p = 0.57$) and average powers ($p = 0.33$). A mode by load by trial ($2 \times 2 \times 3$) ANOVA with repeated measures over the third factor was performed to assess differences between modes and loads and among trials. If F-ratios were significant, Bonferroni *post hoc* analysis was performed. Relative technical error of measurement (%TEM) was used to determine the percent variation among repeated measurements of power. Coefficient of variation (%CV) was used to evaluate relative distribution of data around each mean within each mode. Pearson correlation coefficients were used to determine the relationship between performance variables for each mode. SPSS Version 25 (IBM, Chicago, IL, USA) was used to assess all statistical comparisons.

RESULTS

Interclass correlation coefficients across the 3 trials for peak and average velocities were high for both BBP and DBP for each load condition (Table 1). Since the 3 trials were not significantly different at each loads, the three values were averaged to represent each mode. A mode by load two-way ANOVA on peak velocities indicated a significant difference across all 3 loads ($p < 0.001$) with BBP velocities significantly greater than DBP ($p = 0.001$) (Figure 1a). The load × mode interaction was not significant ($p = 0.16$). A mode by load two-way ANOVA on average velocities found no significant difference between modes ($p = 0.24$) but significant differences across all 3 loads ($p < 0.001$) (Figure 1b). Again, the interaction was not significant ($p = 0.88$).

Interclass correlation coefficients across the 3 trials for peak and average power were high for both BBP and DBP for each load condition (Table 2). Since the 3 trials were not significantly different at each load, the three values were averaged to represent each mode. A two-way ANOVA on peak power revealed a significantly greater power output for BBP mode than for DBP mode ($p = 0.009$). The 50% and 70% relative loads produced significantly higher values than the 30% load ($p = 0.001$), but there was no significant difference between the 50% and 70% relative loads (Figure 2a). The mode × load interaction was not significant ($p > 0.47$). Across the 3 loads, the relative difference in peak power between BBP and DBP at 30% load was 5.9% which increased at 50% load to 12.6% and increased again at 70% load to 19.6%. The highest peak power tended to occur at 70% load for BBP and at 50% load for DBP.

A two-way ANOVA on average power revealed a signifi-

Table 1 Barbell and dumbbell peak and average velocity performances at different percent of body mass (n = 20).

	Barbell				Dumbbell			
Load[§]	Mean ± SD	TEM%[¶]	CV%[#]	ICC	Mean ± SD	TEM%[¶]	CV%[#]	ICC
Peak Velocity (m/s)								
30%	1.96 ± 0.27*	11.2	13.7	0.957	1.84 ± 0.26*	12.8	14.2	0.947
50%	1.46 ± 0.22	3.0	15.1	0.982	1.29 ± 0.24	7.2	18.7	0.964
70%	1.06 ± 0.21	2.2	19.6	0.984	0.88 ± 0.24	3.4	27.4	0.982
Average Velocity (m/s)								
30%	1.27 ± 0.17*	17.7	13.4	0.821	1.24 ± 0.16*	13.4	12.9	0.855
50%	0.97 ± 0.13	7.3	13.9	0.886	0.94 ± 0.18	5.4	18.9	0.951
70%	0.73 ± 0.14	1.3	19.8	0.982	0.67 ± 0.18	3.7	26.3	0.962

[*] Significantly different from 50% and 70% loads ($p < 0.01$)
[§] Percent of body mass.
[¶] Relative technical error of measurement.
[#] Relative Coefficient of Variation

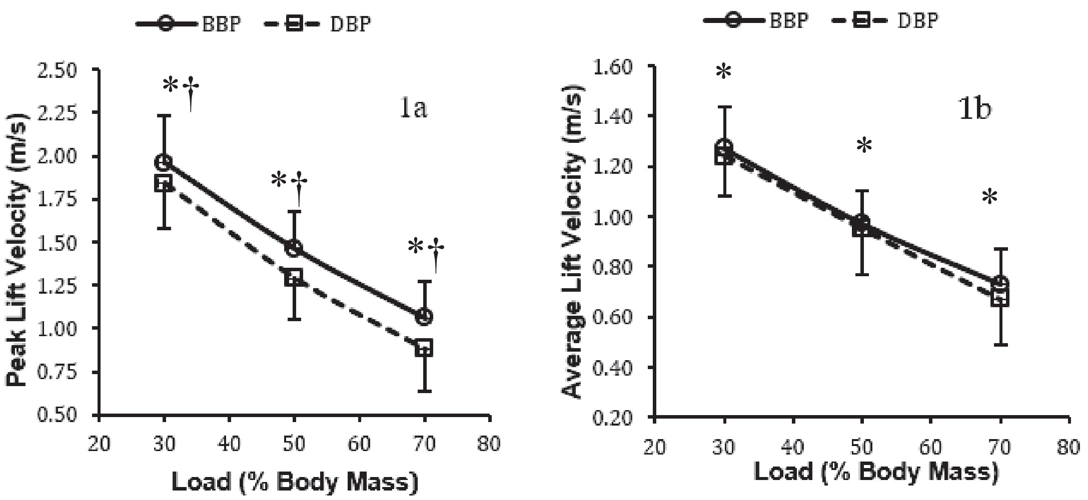

Figure 1 Comparison of patterns for peak velocity (1a) and average velocity (1b) across loads. (* indicates significant difference among loads; † indicates significant difference between modes.)

Table 2 Barbell and dumbbell peak and average power performances at different percent of body mass (n = 20).

	Barbell				Dumbbell			
Load[§]	Mean ± SD	TEM%[¶]	CV%[#]	ICC	Mean ± SD	TEM%[¶]	CV%[#]	ICC
Peak Power (W)								
30%	487.1 ± 99.8*	5.2	20.2	0.980	459.8 ± 101.1*	22.0	22.0	0.976
50%	608.2 ± 129.2	3.8	21.2	0.991	539.7 ± 132.9	24.6	24.6	0.980
70%	616.0 ± 153.8	5.2	24.2	0.991	515.0 ± 174.7	33.9	33.9	0.986
Average Power (W)								
30%	315.9 ± 62.0*	13.2	19.2	0.928	309.5 ± 61.2*	19.8	19.8	0.938
50%	403.2 ± 80.9	11.1	20.1	0.952	394.5 ± 95.2	24.1	24.1	0.970
70%	423.3 ± 101.3	4.6	23.9	0.988	391.7 ± 125.0	31.9	31.9	0.975

[*] Significantly different from 50% and 70% loads ($p < 0.01$)
[§] Percent of body mass.
[¶] Relative technical error of measurement.
[#] Relative Coefficient of Variation.

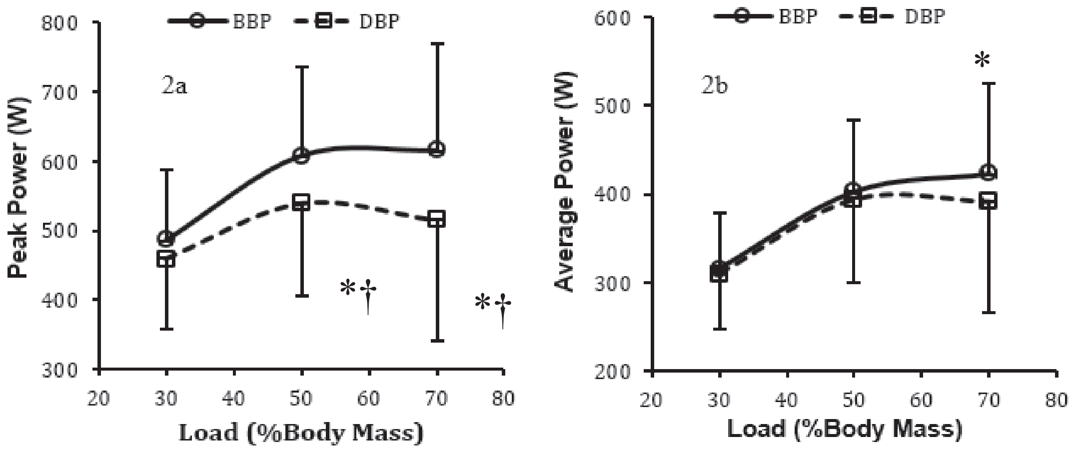

Figure 2 Comparison of percent body mass lifted to peak power output (2a) and average power out (2b). (* indicates significant difference among loads; † indicates significant difference between modes.)

cantly greater power output for BBP mode than for DBP mode ($p = 0.001$). The 50% and 70% relative loads produced significantly higher values than the 30% load ($p = 0.001$), but there was no significant difference between the 50% and 70% relative loads (Figure 2a). The mode × load interaction was not significant ($p = 0.79$). Across the 3 loads, the relative difference in peak power between BBP and DBP at 30% load was 1.9% which was similar to the 50% load (2.0%) but increased to 7.9% at the 70% load. The highest output for average power tended to occur at the 70% relative load in BBP and at the 50% relative load in DBP.

DISCUSSION

The current study is the first to compare velocity and power production between BBP and DBP across a range of identical loads to evaluate what might occur during a typical training session. Given that most individuals do not typically perform a 1RM DBP but instead use the same load as their established 1RM BBP, these findings provide valuable information concerning the similarities and differences between lifting velocities and power outputs. Since velocity-based training has been shown to be superior to traditional low-velocity training for strength increase,[13] these results provide support for the use of either BBP or DBP for velocity-based training. Behm and Sale[13] suggest that individuals can improve their high-velocity strength by training with heavy loads while attempting to work at a high velocity. Yet to be determined is the effect of consistent DBP velocity-based training on improvements in peak and average power production. Such information might have substantial impact on participants in unilateral sports such as tennis, baseball, shot putting, javelin throwing, and others.

In the current group of resistance trained men, difference in peak power between BBP and DBP tended to increase from lighter to heavier loads (Figure 2a). To the contrary, DBP average power was only slightly less than that of BBP across all loads (Figure 2b). This might suggest that as the load increases with DBP, lifters may have difficulty achieving comparable peak velocities to BBP but may be able to achieve comparable average velocity across the range of motion. Part of this difference might lie in the neural activation between dominant and nondominant sides of the body during the movement. Krzysztofik et al.[14] noted consistently higher EMG amplitudes in the dominant triceps and anterior deltoid during BBP at 50% and 90% of 1RM. Golas et al.[15] found a similar response in a world-class powerlifter. Lawrence et al.[16] found increased total EMG activity in unstable BBP loads compared to stable BBP, suggesting that stabilizer muscles may be a limiting factor in controlling the load being lifted. Coordination of bilateral movement velocities might be more imperative during DBP lifting in order to maintain stability on the bench. If use of DBP could be considered an unstable situation, it may be that the nondominant arm has to match the dominant arm in velocity in order to maintain stability on the bench.

Several studies have determined that BBP 1RM is typically 16-17% greater than for DBP 1RM.[4,5] While peak power production in BBP has been reported to occur between 30% and 70% of 1RM[16], this information appears to be lacking for DBP. Using equated loads for the BPP and DBP in the current study makes it difficult to draw compare with other studies using %1RM methodologies. It would be interesting for subsequent studies to compare BBP and DBP velocity-load profiles when measuring at comparable %1RM values to determine if the patterns for velocity and power would be similar to those noted in this study. Furthermore, although each dumbbell in the current study appeared to move upward at the same velocity, confirmation of this would require an accelerometer on each dumbbell or the use of high-speed video tracking.[17] Simultaneous video analysis and EMG of unilateral and bilateral dumbbell pressing could provide information on the degree of agreement between velocities and muscle activation patterns throughout their range of motion.

CONCLUSIONS

The outcome of the current study partially supports our hypothesis that peak lifting velocities for DBP are slower than for BBP, resulting in lower peak power output across the load spectrum. Thus, for the development of peak power during a supine pressing motion, BBP appears superior to DBP. However, similarity of the patterns for average power production across the different velocities for the two modes might indicate that both BBP and DBP can be used to enhance average pressing power.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest relevant to the content of this manuscript.

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