EFFECT OF KINETICALLY ALTERING A REPETITION
VIA THE USE OF CHAIN RESISTANCE ON VELOCITY
DURING THE BENCH PRESS

DANIEL G. BAKER AND ROBERT U. NEWTON
School of Exercise, Biomedical and Health Sciences, Edith Cowan University, Joondalup, Western Australia

ABSTRACT


It is theorized that the force and velocity profile of a repetition performed during a standard barbell exercise may be altered by substituting suspended chains for some portion of the total resistance. The purpose of this study was to document the alterations in lifting velocity that occur when the bench press exercise is performed as standard (BP) or with the substitution of resistance via chains draped over the barbell (BP+CH). Thirteen professional rugby league players participated in this study as part of their usual training program. Each subject performed 2 sets of 3 repetitions under the following conditions: The BP+CH condition, where the barbell resistance of 60% 1RM (repetition maximum) was supplemented by 17.5-kg in chains draped over the barbell (total resistance was about 75% 1RM), and the BP condition, where the total resistance was the same but was constituted in the form of standard barbell weights. The BP+CH condition resulted in increases in mean and peak concentric lifting velocities of around 10% in both sets as compared to both BP sets. Eccentric peak velocities were more varied in response, but generally the addition of chain resistance could be said to allow for increased velocities. The result may be partially explained by the eccentric unloading that occurs as the chain links unfurl upon the floor in the latter stages of the eccentric range. This eccentric unloading precipitates a more rapid stretch–shorten cycle (SSC) transition and possibly a within-repetition postactivation potentiation (PAP) that allows the subject to utilize faster lifting velocities in the initial concentric portion, which flow through to the remainder of the concentric phase. Therefore the use of chains appears warranted when athletes need to lift heavy resistances explosively.

KEY WORDS variable resistance, power training, postactivation potentiation

INTRODUCTION

Power output appears to be a key descriptor of athletic success in some sports (2,3). The use of heavy resistances to develop power appears vital because strength strongly correlates to power output (2–5,22); however, the use of heavy resistances often entails slow lifting velocities (24,29,30,31). Because power is dependent on both strength and speed, it has been recommended that a multifaceted approach to power training be embraced (23). Consequently, exercises or sets that emphasize velocity also need to be utilized in training to enhance power output (10,23). However, when submaximal resistances, which allow for faster lifting velocities, are used in traditional strength training exercises such as squats and bench presses, large deceleration epochs occur in the latter stages of the concentric phase of the movement (29,30). Essentially in these situations the neuromuscular system is being trained to decelerate at the end range, not accelerate, as is required in many real-life sports tasks. This anomaly can be overcome by the use of exercises such as bench press throws (in a Smith machine) and jump squats (10,24,25,31) and the use of Olympic weightlifting derivatives (21), which allow full acceleration or high power outputs, or both, for the entire range of motion.

Recently other methods of modifying exercises to emphasize power and velocity have emerged. It has been recommended that athletes training to increase power use strategies that alter the force and velocity profile of a repetition by substituting some portion of the total resistance in the form of elastic bands or chains attached to the barbell (10,27). For example, if elastic bands or chains are attached to the barbell, increasing resistance is added to the barbell as the barbell proceeds further into the range of movement. In the case of the chains, as the chain links unfurl off the floor and start to act on the barbell, the total resistance is increased (10). Anecdotal evidence suggests that a major benefit of the use of the bands or chains is that it allows the lifter to explode more out of the bottom of the lift without being inhibited by having to slow the bar at the top of the lift because the increasing resistance coming from the elastic bands or
unfurling chain links necessitates having to maintain the pushing force (10,26,27).

To date, only a few studies have examined this phenomenon. Newton et al. (26) and Wallace et al. (28), using elastic bands and the squat exercise, demonstrated that the lifter was able to produce greater velocity and power during the lift. Wallace et al. also demonstrated improved rate of force development (28). Heinecke et al. (19) reported enhanced bench press strength as a result of using elastic bands in comparison to traditional bench press training. However, a number of other studies have not reported significant changes in variables as a result of combining barbell and elastic band resistance (13,15).

With regard to the use of chains, Coker et al. (11) reported that application of additional chain resistance during the snatch exercise did not result in a change in velocity or power output, although the exercise was perceived as being more difficult to perform under this condition (11). Ebben and Jensen did not report any differences in the investigated variables when comparing squats performed in the usual manner vs. under a chains or band condition (15). Clearly the effect of varying resistance within a repetition via the use of chains requires further study to determine what effect, if any, this strategy may have on lifting velocity and kinetic properties during the lift.

The purpose of this study was to document the alterations in lifting velocity that occur during a typical power training session when the bench press exercise is performed in the standard manner or with the addition of resistance gained from chains draped over the barbell.

**METHODS**

**Experimental Approach to the Problem**

A repeated measures procedure was utilized to determine the effects that within-repetition kinetic alteration has on lifting velocity during the free weight bench press exercise. Thirteen experienced athletes performed 2 sets of 3 repetitions for each condition: Bench press (BP) as the control condition and bench press with chain resistance (BP+CH) as the experimental condition during their normal power training session. The resistance was set at 60% 1RM (repetition maximum) plus 17.5 kg in chains for the BP+CH condition; the same total resistance was used for the BP conditions (which was about 75% 1RM for the subjects involved). An optical encoder that was attached to the barbell determined lifting velocity. This repeated measures approach provided data pertinent to whether the intervention strategy of kinetic alteration via the use of chain resistance during the bench press resulted in any change in peak or mean lifting velocity either averaged across each 3-repetition set or for the best repetition that may occur within any set.

**Subjects**

Thirteen professional rugby league players, who were moderately experienced in kinetic alteration training via the use of bands and chains (2 months to 2+ years), volunteered to participate in this study during their usual explosive power training session. The measurement conducted during this training was part of normal preparation as professional athletes. At a later time, all data were deidentified and then analyzed for the purposes of this study. All procedures were conducted according to the Declaration of Helsinki (1964) regarding human subjects. They are described as being 20.1 ± 2.3 years old, 91.5 ± 8.1 kg in weight, and 181.4 ± 8.4 cm tall and possessed a 1RM BP of 121.3 ± 10.1 kg.

**Procedures**

An optical encoder that was attached to the barbell determined lifting velocity (GymAware, ACT, Australia). The encoder samples data every 20 msec, and it has been previously validated for use with the free weight bench press (14). Velocities were assessed for peak and mean values for the concentric portion and as peak only for the eccentric portion and were recorded for the best effort in each set and as a set average.

Each subject performed 2 sets of 3 repetitions under the following conditions: BP, where the total resistance was equal to the BP+CH condition but was in the form of standard barbell resistance, and the kinetically modified BP+CH condition, where the total resistance was the same but was constituted as 60% 1RM in standard barbell resistance plus 17.5 kg in chain resistance (60% 1RM plus about an extra 12–16% 1RM, as recommended by Simmons [27]). For example, 2 subjects whose 1RM was 140 kg used 102.5 kg in the traditional BP condition and 102.5 kg constituted of 85 kg in barbell resistance plus 17.5 kg in chains draped over the barbell for the BP+CH condition. The chain resistance was set at 17.5 kg for all subjects and it represented 12–16% of the subjects’ 1RM, a figure that has been recommended when using chain resistance (10,27) and is essentially similar to the methodology used by Wallace et al (28).

The chains constituted a light chain that hung 80 cm (measured from the top of the barbell sleeve) and 2 heavier chains that were draped over the light chain. These heavier chains were doubled over and hung a further 25 cm from the light chain. In this situation when the athletes lowered the barbell to their chest, the heavy chains would furl on the floor and not add resistance to the barbell. As the barbell moved upward from this point an increasing portion of this 17.5 kg of chain resistance acted on the barbell until, after moving more than 25 cm, the total chain resistance acted on the barbell. The mean distance of each subject’s lift, calculated by the GymAware software, was 48 (±4) cm, meaning that the entire chain resistance acted on the barbell for about half of the range of motion. Consequently, although the mean total mass used was exactly the same for both conditions (91.3 ± 5.9 kg), the use of chains meant that the subjects typically lifted less than that resistance through half of the concentric portion in the BP+CH condition.
The subjects were assessed during their usual power training session when they were performing a power training “contrasting resistance complex” alternating heavier explosive bench press (circa 75% 1RM) sets with maximal power training (35–45% 1RM) bench throw sets (10). The order of lifting was BP+CH1, bench throws, BP+CH2, bench throws, BP1, bench throws, BP2, and then bench throws again. All sets were performed for 3 repetitions with a 2-minute rest between sets of each exercise. Power output for the bench throws was not recorded.

**Statistical Analyses**

A repeated measures analysis of variance (ANOVA) was performed to determine if the intervention strategy of substituting chain resistance instead of standard weight plate resistance during the BP resulted in changes in peak or mean lifting velocities, either for the best repetition performed within each set or as expressed as a set average. In the event of a significant f-ratio, Fisher PLSD was used for post hoc comparisons to see where the differences occurred. Significance was accepted at an alpha level of \( p < 0.05 \).

**RESULTS**

The results for mean and peak concentric lifting velocities are displayed in Tables 1 and 2, respectively. Peak eccentric lifting velocities are displayed in Table 3. The intervention strategy of substituting chain resistance for a portion of the standard

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**Table 1.** Mean concentric velocities (m/s) that occurred within each set of bench press without (BP) and with kinetic modification via the addition of chain resistance (BP+CH). Mean (standard deviation).

<table>
<thead>
<tr>
<th></th>
<th>Set 1 BP+CH 1</th>
<th>Set 2 BP+CH 2</th>
<th>Set 1 BP 1</th>
<th>Set 2 BP 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best repetition</td>
<td>0.63 (0.06)*</td>
<td>0.62 (0.09)*</td>
<td>0.57 (0.07)</td>
<td>0.56 (0.08)</td>
</tr>
<tr>
<td>Set average</td>
<td>0.59 (0.06)*</td>
<td>0.59 (0.09)*</td>
<td>0.53 (0.07)</td>
<td>0.51 (0.1)</td>
</tr>
</tbody>
</table>

*Both BP+CH sets different to both BP sets but not to each other.

**Table 2.** Peak concentric velocities (m/s) that occurred within each set of bench press without (BP) and with kinetic modification via the addition of chain resistance (BP+CH). Mean (standard deviation).

<table>
<thead>
<tr>
<th></th>
<th>Set 1 BP+CH 1</th>
<th>Set 2 BP+CH 2</th>
<th>Set 1 BP 1</th>
<th>Set 2 BP 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best repetition</td>
<td>0.78 (0.09)*</td>
<td>0.80 (0.13)*</td>
<td>0.74 (0.11)</td>
<td>0.7 (0.10)</td>
</tr>
<tr>
<td>Set average</td>
<td>0.75 (0.08)‡</td>
<td>0.76 (0.11)†</td>
<td>0.70 (0.11)</td>
<td>0.67 (0.11)</td>
</tr>
</tbody>
</table>

*Both BP+CH sets different to both BP sets but not to each other.  
†Different to both BP sets but not to BP+CH1.  
‡BP+CH 1 different to BP2 but not different to BP1.

**Table 3.** Peak eccentric velocities (m/s) that occurred within each set of bench press without (BP) and with kinetic modification via the addition of chain resistance (BP+CH). Mean (standard deviation).

<table>
<thead>
<tr>
<th></th>
<th>Set 1 BP+CH 1</th>
<th>Set 2 BP+CH 2</th>
<th>Set 1 BP 1</th>
<th>Set 2 BP 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best repetition</td>
<td>1.35 (0.27)*</td>
<td>1.44 (0.27)†</td>
<td>1.3 (0.26)</td>
<td>1.22 (0.25)</td>
</tr>
<tr>
<td>Set average</td>
<td>1.15 (0.20)§</td>
<td>1.25 (0.22)‡</td>
<td>1.18 (0.22)</td>
<td>1.07 (0.19)†</td>
</tr>
</tbody>
</table>

*Different to BP2.  
†Different to both BP sets.  
‡Different to BP+CH2.  
§Different to BP2.
Alterations in Lifting Velocity During Bench Press

Barbell resistance resulted in predominantly significant increases of around 10% in both peak and mean concentric lifting velocity for both BP+CH sets compared to both BP sets, irrespective of whether velocity was expressed as either for the best effort within a set or as the set average. Peak eccentric movement velocity was also enhanced in the BP+CH condition but only for the second set.

**Discussion**

Variable resistance or within-repetition kinetic alteration training appears to be becoming more popular, with anecdotal evidence suggesting enhanced lifting velocities, among other outcomes, since first advocated by Simmons (27). Very little work has been performed concerning the effects of substituting some standard barbell resistance for chain resistance on lifting velocity. Cofer et al. (11) compared snatches with only 5% resistance substituted via chains and found no significant differences in velocity or power; however, they stated that all subjects reported that they felt they had to work harder under the conditions. The reason why they may have reported no difference in lifting velocity or power may be because of 2 reasons. First, 5% resistance may not be enough to induce large or significant changes in lifting parameters, which will be discussed in more detail later. Second, Olympic weightlifting exercises such as squats and power cleans are full acceleration exercises where lifting velocity is always high and no long deceleration epoch occurs (18,21), as compared to submaximal bench pressing and squatting (29,30). Accordingly, there may be little benefit in using chain resistance with Olympic weightlifting exercises if the goal is simply to enhance lifting velocity.

Ebben and Jensen compared traditional squats to squats with 10% of the resistance supplied by either chains or elastic bands (15). They reported no differences in electrical muscle activity or ground reaction force between conditions and therefore questioned the use of kinetic alteration strategies such as bands and chains. However, lifting velocities or power output were not reported. It would also be expected that the ground reaction forces would be similar if the total resistance is the same in each condition. As a result of the paucity of data concerning how the use of chains may alter lifting velocities during bench press or squatting exercises, much of the rationale for their possible augmentation benefits must be gleaned from studies utilizing the conceptually similar elastic bands strategy.

Some discrepancies occur in the literature concerning what effect, if any, elastic band resistance may have when combined with barbell training. Newton et al. (26) reported that when bands are utilized to provide equivalent resistance in the top portion of a 6RM squat lift, then power output and lifting velocity are increased, especially in the lower portion of the range of movement. Wallace et al. (28) reported that the use of bands that provide 20% of the 85% 1RM (i.e., the bands provide 20% × 85% = about 16% 1RM, similar to this study) results in large increases in force and power over a squat with 85% 1RM and no bands. Other studies have reported no significant changes in the variables measured (12,14). Wallace et al. explained that this is most likely a result of the magnitude of resistance that the bands provide. Studies where the bands or chains provide only 10% or less resistance do not appear to report significant alterations in lift kinetics or velocities. However, the typical training recommendations for bands and chains to provide 10 to 20% 1RM (or more for experienced lifters) (10,27,28). Studies in which the resistance was of the magnitude of >10% 1RM, such as those reported earlier (1,19,26,28) and this study, have found significant changes in power, force, or velocity.

Although the magnitude of the variable resistance may explain why conflicting results have appeared in the literature, it does not explain the neuromuscular mechanisms of how chains or bands may work. This study did not provide a vehicle of neuromuscular mechanistic explanation as to the reasons for the increased velocity, so the following explanations are based on other existing neuromuscular research and need to be substantiated in this context. By advancing possible explanations it is hoped that future research may determine the extent or validity of these possible theories in explaining the augmentation effects of within-repetition kinetic variation training such as afforded by chains and bands.

We posit that there are at least 3 possible explanations as to why the same total mass, constituted as chains mass plus barbell mass, can be lifted with greater velocity as compared to the standard barbell mass. These explanations are not by any means exclusive of each other, and most likely it is the interaction or combinations of these mechanisms that gives rise to greater lifting velocity in the BP+CH condition.

First, although the BP+CH total mass is the same as the standard barbell mass, it must be stated that this total mass only comes into play in the top portion of the bench press. When the chain links are furled on the floor as the barbell is in the lower positions of the range of movement (e.g., barbell on the chest), they do not act on the barbell and the actual resistance being lifted at this point is equal to total mass minus 17.5 kg. In this study the barbell had to move at least 25 cm before all the chain mass acted on the barbell. The average lift range of motion was 48 cm. Accordingly, the subjects are actually required to lift 60% 1RM from the chest, with the resistance increasing steadily for 25 cm, whereafter the resistance is equal to the total mass (60% 1RM + 17.5 kg, about 75% 1RM for the subjects in this study) for the remaining 23 or so centimeters. Therefore, a lighter resistance is being lifted off the chest and for around half of the range of movement, and lighter resistances allow for greater lifting velocities to be generated in the bench press exercise (24). Typically submaximal resistances lifted explosively in the bench press are associated with a large deceleration phase (29); however, it appears that the use of bands and chains either negates or reduces that phenomenon so that velocity can remain high.
A second reason why greater lifting velocities can be achieved may be a result of initial preparatory muscle stiffness and a resultant postactivation potentiation (PAP) effect occurring within the repetition. As the athlete lifts the barbell from the bench press racks, the resistance is heavy enough to require a large degree of preparatory muscle stiffness induced through the various neural receptors that sense the existing force levels and activate the appropriate number of motor units and rate of firing to deal with the “sensed” force levels. If there is enough disparity between the sensed force levels at the top portion of the lift compared to what is required to lift the 60% resistance at the bottom portion of the lift, the resultant surplus of neural activation results in a within-repetition PAP situation with augmented lifting performance. This within-repetition PAP mechanism may explain why some studies with band resistance using >10% 1RM disparity between total resistance and barbell resistance have obtained significant results, whereas using <10% have not. It may be that >10% 1RM and preferably 15 to 25% 1RM may be needed to create an effective within-repetition contrast-loading PAP effect. Despite some theories that PAP requires full activation of motor units brought about by maximally heavy resistance to induce a ensuing augmentation (13,16,17, 20,31), some results show this level of maximal resistance is not always necessary and the resistances merely need to be in enough contrast to each other to induce some augmentation (2,6,9). During contrasting resistance complexes, it has been shown that sets of submaximal resistances ranging in disparity from 20 to 50 kg have been shown to induce ensuing PAP effects (2,6,9). If maximal resistances are not necessary to induce PAP, then it is definitely plausible that a within-repetition PAP effect could occur when resistances vary by around 15% or more within a repetition.

Aligned with both of these mechanisms is the fact that a more rapid stretch–shorten cycle (SSC) is possible with the reduced resistance occurring in the bottom range. The eccentric unloading occurring in the lower portion of the range appears to be the key behind the rapid SSC transition because the series elastic component (SEC) would become more temporarily compliant, a factor associated with more explosive bench press performance in the bottom range (30). It was visually observed that the most experienced lifters appear to increase the eccentric velocity of the lift in the lower range. This then allows for a more effective SSC transition to occur and with it comes the performance benefit seen with enhanced SSC use (30).

It could be argued that the protocol used in this study was fatiguing or that there were some intervening factors such as an order effect or the interspersing of the bench throw sets. We chose to look at how the BP+CH method would manifest itself during actual training of high-level athletes, rather than in an isolated situation. A finding concerning the performance of 1 set of BP+CH in a strictly controlled laboratory setting has less implication for altering the training program of high-level athletes than does a protocol of monitoring of the normal training session with multiple sets performed in the usual manner and context. The subjects involved in this study were accustomed to this type of power training, such as performing a set of explosive bench presses (60–75% 1RM), rest 1.5 to 2 minutes and then perform a set of bench throws (35–45% 1RM), rest 1.5 to 2 minutes and repeat for 3 to 4 sets. Although athletes unaccustomed to this type of training may find this protocol fatiguing, the professional athletes involved in this study did not display signs of fatigue, such as marked changes in velocity between the 2 sets in each condition, which may compromise the validity of the findings. In fact the results were reasonably stable as evidenced by the resultant means and standard deviations for concentric velocities. Based on the stability of the results from set to set in both conditions and the fact that these professional athletes regularly perform this protocol as only 1 part of a larger workout, it is believed that the results are a true reflection of the effect that substituting a portion of barbell mass with chains mass has on lifting velocity during explosive bench pressing.

### Practical Applications

The use of chains weighing the equivalent of about 15% 1RM attached to a barbell weighing 60% 1RM allows athletes to generate about 10% greater velocity as compared to a standard barbell resistance of 75% 1RM when performing explosive bench press training. A similar result has been found using a conceptually similar elastic band resistance attached to the barbell during squat training. It would appear the possible reasons for these findings—a reduced resistance for half of the range of the lift, a within-repetition PAP effect, and an augmentation through enhanced SSC mechanisms—all may contribute to the overall findings. Based on this and other results and taking into account the need for greater disparity for the within-repetition resistance(s), it is recommended that when using chains (and bands) the resistances delivered by these means should be 15 to 25%+ 1RM. The barbell resistance may vary, but a resistance of 60% 1RM was recommended by Simmons (27) and has been used in this bench press study and another squat study (28), with significant results achieved. With a barbell resistance of 60% 1RM plus chains or band resistance of 15 to 25% 1RM, a situation arises where the athlete can explode rapidly out of the bottom of the lift with 60% 1RM and continue to attempt to accelerate for the full range of motion as the total resistance increases to 75 to 85% 1RM in the top portion of the range. Therefore, the athlete can lift explosively and heavy within the same repetition. Accordingly, this method of within-repetition kinetic variation may be of benefit to collision-sport athletes, where high velocities and high forces are desired in overcoming an opponent. Further, in sports requiring fending off or punching an opponent such as football or boxing, a resistance profile that allows rapid initial acceleration followed by suddenly increased resistance may provide uniquely specific training loads.
REFERENCES


