The effects of variable resistance using chains on bench throw performance in trained rugby players.

ABSTRACT

This study sought to determine the effects of variable resistance using chain resistance on bench throw performance. Eight male rugby union players (19.4 ± 2.3 y, 88.8 ± 6.0 kg, 1RM 105.6 ± 17.0 kg) were recruited from a national league team. In a randomised cross-over design participant's performed three bench throws at 45% one repetition maximum (1RM) at a constant load (No Chains) or a variable load (30% 1RM constant load, 15% 1RM variable load; Chains) with seven days between conditions. For each repetition the peak and mean velocity, peak power, peak acceleration and time to peak velocity were recorded. Differences in peak and mean power were *very likely trivial* and *unclear* between the Chains and No Chains conditions, respectively. *Possibly* greater peak and likely greater mean bar velocity were accompanied by *likely* to *most likely* greater bar velocity between 50-400 ms from initiation of bench press in the Chains compared to the No Chains condition. Accordingly, bar acceleration was *very likely* greater in the Chains compared to the No Chains condition. In conclusion, these results show that the inclusion of chain resistance can acutely enhance several variables in the bench press throw and gives support to this type of training.

Key words: acceleration, power training, rate of force development

INTRODUCTION

Power output, the product of force and velocity, is a key element of sporting performance (2,3,11,21). For example, Baker (3) determined that power output during bench throws is a potent discriminator of rugby league playing standard, whilst Cronin and Hansen (11) found that squat jump power was greater in faster players. Consequently, strength and conditioning practitioners often employ various resistance training practices to enhance power output (25,30,35,39).

There is dispute as to whether athletes should train with heavy, light or a combination of loads to induce adaptations in neuromuscular power (15). Whilst some authors suggest the use of high loads (> 60% 1RM; 25,30,35,39) these loads are performed at low velocities. The use of lighter loads might resolve this issue (≤ 60% 1 RM; 19,23,27,37). However, during traditional resistance training exercises (e.g. squat, bench press), there are large periods of deceleration towards the end of the movement accounting for 23% and 52% of the total duration at 1 RM and 80% 1 RM, respectively (10). Practitioners can therefore use variable resistance to augment lifting performance during power training phases (4,20,22). Resistance exercises employing variable resistance attempt alter the load during certain phases of the range of motion by attaching chains to a barbell (34). During lifting (i.e. muscle shortening phase) the links are sequentially lifted from the floor providing a linear increase in resistance that reflects the ascending strength curve. Conversely, as the bar is lowered (i.e. muscle lengthening), the chain links are also lowered onto the floor decreasing the resistance (26). The mass of the chains added is typically substituted for a percentage of the total constant load lifted (5,7,32,34). Baker and Newton (4) proposed that the addition of chains alters the kinetic profile of the strength exercise by allowing an increased duration of acceleration throughout the range of motion and an ability to maintain higher forces towards the end of the movement. A recent meta-analysis by Soria-Gila et al. (31) reported greater strength gains in programmes using chains compared to conventional training, with significant increases observed in both trained and untrained populations where programmes lasted >7 weeks.

Despite the use of chains being purported as a popular resistance training method (14,33), few studies have examined their kinetic effect during dynamic resistance exercise. In studies examining the addition of 5% chain resistance to 75 and 80% 1RM during the clean and snatch , no difference in bar displacement, bar velocity, ground reaction forces and rate of force development were reported compared to a comparable constant load (7, 9). However, the relatively low contribution of the chains might have been insufficient to elicit changes in lifting performance throughout the movement range. Swinton et al. (34) observed equivocal results in that peak force and impulse were improved but velocity, power and rate of force development were impaired with chains amounting to 20 and 40% 1RM across three different loads. Conversely, during bench press exercise at 75% 1RM (15% chains and 60% constant load), peak and mean velocity were improved with the use of variable resistance (5). It would appear that the effect of chains is dependent on both the exercise and the contribution of the chains to the load lifted. Furthermore, to our knowledge no study has assessed the kinetic profile of ballistic type movements e.g. bench throws. A study that determines if bench throw performance is improved with the use of chains would help to clarify the aforementioned disparity. Accordingly, the aim of this study was to examine if the addition of chain resistance imroved of the bench press throw.

METHODS

Experimental Approach to the Problem

The study incorporated a randomised cross-over design, with participants visiting the laboratory on three occasions over a 15 day period. The first visit consisted of a familiarisation to the testing procedures and one repetition maximum (1RM) assessment on bench press. During the familiarisation trials participants undertook several un-weighted bench throws to check technique. Participants were then randomly assigned to either the variable resistance (with chains) or control condition (without chains). Participants returned to the laboratory a minimum of seven says later for trial 1 with or without chains and a further seven days for trial 2 (opposing condition). Participants were asked to record a food diary for the 48 h before the testing sessions and asked to repeat this for the second testing session. In addition, the participants were asked not to engage in any activity that was considered unduly fatiguing with regard to upper body impulsive-type movements in the 48 h period before each testing session.

Subjects

After institutional ethics approval, eight well-trained males (19.4 ± 2.3 y, 88.75 ± 5.98 kg) from a national league rugby union club provided written informed consent to take part in the study. All participants had a minimum of two years' experience resistance training, a bench press greater than their body mass and were asymptomatic of illness or injury.

Procedures

Before testing trials, participants completed a standardised warm up comprising five minutes light cardiovascular activity, dynamic flexibility exercises of the chest and triceps and submaximal bench press throws up to 30% 1RM. For the testing trials, participants performed three maximal bench press throws with either 45% 1RM (No Chains [control]) or 30% 1RM plus 15% 1RM chains (Chains condition) with 5 minutes between each repetition (28). Participants were instructed to lower the bar under control to the chest, then push maximally and release the bar at full elbow extension. During each repetition the participant's head, shoulders, gluteals and feet remained in contact with the bench and floor. A spotter was used to catch the bar and replace onto the Smith machine. Commercially available chains (Reliant Marine, Hoylake, UK) were 12 mm and 6 mm diameter steel linked chain in 1 m lengths, with each metre of chain weighing 2.7 kg and 1 kg, respectively. Additional mass was supplied by D-rings if needed and attached to the bar using 6 mm steel snap hooks (Reliant Marine, Hoylake, UK). At the lowest phase of the lift, when the bar touched the chest, all the chain rested on the floor. The chains were doubled looped so that all of the chain would leave the floor in the concentric phase at full elbow extension. The mean ± SD loads lifted are shown in Table 1.

****** Insert Table 1 about here ******

Measurements of peak and mean power, peak and mean velocity and acceleration were assessed using a FitroDyne rotary encoder (Fitronic, Bratislava, Slovakia) during the concentric phase of the lift. Instantaneous velocity was also measured at 50 ms intervals during the concentric phase of the lift (50-400 ms). The FitroDyne measures the vertical velocity of a Kevlar cable. Briefly, this apparatus comprises an optical sensor and a light source. The velocity of the movement is determined by the displacement time data with sampling frequency determined by the rotational velocity of the sensor (Garnacho-Castaňo, 2015). The FitroDyne was attached directly under a Smith machine bar via the Kevlar cable (< 2 N resistance). The data collection system of the FitroDyne was connected to the computer via USB allowing for capture and saving of each performance measurement. Fernandes et al. (12) has shown this apparatus to produce reliable measures of muscle power and barbell velocity for bench press exercise (coefficient of variation of 3.1 and 4.7% for 30 and 40% 1RM).

Statistical analyses

All data were log transformed to reduce bias due to non-uniformity of error and analysed using the ES statistic with 90% confidence intervals (CI) and % change to determine the magnitude of effects. Magnitude-based inferential statistics were employed to provide information on the size of the differences allowing a more practical and meaningful explanation of the data (6). Thresholds for the magnitude of the observed change for each variable was determined as the within-participant standard deviation (SD) in that variable x 0.2, 0.6 and 1.2 for a small, moderate and large effect, respectively (8,18). Threshold probabilities for a meaningful effect based on the 90% confidence limits (CL) were: <0.5% most unlikely, 0.5–5% very unlikely, 5–25% unlikely, 25–75% possibly, 75–

95% likely, 95–99.5% very likely, >99.5% most likely. Effects with confidence limits across a likely small positive or negative change were classified as unclear (19). All calculations were completed using predesigned spreadsheets (16,17). The reliability for each measure was tested using ICC and SEM (38), with variability between repetitions reported using the coefficient of variation (%CV).

RESULTS

Reliability for each outcome measure were favorable and are reported in Table 2.

*******Insert Table 2 here*******

There was a *very likely trivial* difference in in peak power between the Chains and No Chains condition (0%, ES 0 ± 0.1) whilst the difference in mean power was *unclear* (1.4%, ES 0.07 ± 0.28). Peak (2.8%, 0.22 ± 0.23) and mean bar velocity (4.7%, 0.38 ± 0.23) were *possibly* and *likely* greater in the Chains compared to No Chains condition. There were *very likely* greater bar acceleration (25.2%, ES 0.96 ± 0.74) in the Chains compared to the No Chains condition.

*******Insert Table 3 here*******

When the initial phase of the bench press was analysed separately, bar velocity was *likely* to *most likely* greater at 50 ms (10.9%, ES 0.39 ± 0.51), 100 ms (14.6%, ES 0.50 ± 0.39), 150 ms (15.8%, ES 0.55 ± 0.33), 200 ms (16.2%, ES 0.64 ± 0.29), 250 ms (15.9%, ES 0.70 ± 0.23), 300 ms (15.6%, ES 0.73 ± 0.17), 350 ms (13.8%, ES 0.66 ± 0.19) and 400 ms (9.4%, ES 0.51 ± 0.28) in the Chains compared to No Chains condition (Figure 1).

*******Insert Figure 1 here*******

DISCUSSION

This study has demonstrated that certain kinematic variables can be augmented with the use of chains during bench throw exercise in well-trained male rugby union players. In particular, peak and mean bar velocity, and bar acceleration are improved with the addition of variable resistance. Our findings support the use of variable resistance for enhancing dynamic muscle function of collision sport athletes.

This study reported small increases in peak (2.8%) and mean (4.7%) bar velocity during the bench press throw which were greater than the measurement error. These findings are consistent with those of Baker and Newton (5), albeit the relative improvements in performance with the addition chains are smaller than the 10% reported previously. This is similar to the findings of Berning et al. (7) and Coker et al. (9) and is in contrast to Stevenson et al. (32) who noted impaired peak and mean squat velocities with elastic bands. Improvements in mean velocity, peak acceleration and time to peak velocity may be explained by the reduction in mass at the start of the lift. This supports McCurdy et al. (24) who suggested that a greater acceleration of a bar would occur at the start of the lift due to the lighter total mass. The momentum generated by the participants at the start of the lift may have been greater than the standard weight plate group due to the mass being approximately one third lighter (30% versus 45% 1 RM). It is well documented that muscles can contract at higher velocities with less force, as illustrated by the inverse nature of the force-velocity relationship (10,). Therefore, the momentum during the initial phase of the lift may have been greater for the chains condition. Additionally, Baker and Newton (5) suggest that in the chains condition there is an increase in preparatory muscle stiffness. When the bar is un-racked neural receptors sense the load and recruit the appropriate number of motor units and rate of firing (5). However during the concentric phase the load is lighter due to the chains being furled, as such the disparity between this and the load at the bottom of the lift may result in improved bench throw performance (5). A further explanation proposed by Baker and Newton (5) is an enhanced stretch shortening cycle (SSC). The SSC of exercise incorporates a passive pre-stretch (eccentric phase) which serves to enhance performance on subsequent active shortening (concentric phase; 29). During the pre-stretch the muscle and series elastic components store energy, the amount of which is relative to the force acting on the muscle (1,36). Theoretically, for both conditions, the elastic energy storage during the eccentric would be similar as the load is the same. At the bottom range of the lift, the SSC is more compliant during the chains condition compared to the control as the load is lighter (5).

It is unsurprising that peak velocity was not different between conditions given that peak velocity for bench throw exercise occurs near the release point (28). That is, at this point in the movement the total load would be similar between conditions because the chains would be completely unfurled. This study observed no significant differences in peak and mean power, which is supported by previous findings (32,34). Swinton et al. (34) noted a loss of peak and mean power, despite increased force, during deadlift exercise with chains, which was explained by a loss of velocity during the exercise. Interestingly, we noted higher mean velocity with chains but no changes in power. As power is a product of force and velocity, it is plausible the lower force negated the higher velocity, especially given that the relative loadings through the movements are lower with chains. Moreover, it is suggested that untrained participants may show greater improvements with the use of variable resistance training (7). That we found no improvement in peak and mean power may be due to the trained status of our participants. That is, they were already highly impulsive athletes due to the nature of the training with which the engage themselves in physically preparing for their sport.

A limitation of the present study is the small sample size. However, presenting the magnitude and precision of the data using effect sizes with 90% confident intervals and magnitude-based inferences addresses any such concerns by indicating the likelihood that the effect is meaningful compared to between individual variations. These statistics are not susceptible to bias from small sample sizes and should be used to interpret these data.

PRACTICAL APPLICATIONS

The results in this study suggest that the use of variable resistance equivalent to 45% 1RM (30% free weights and 15% chains), can be used as a method to increase certain performance characteristics of the bench press throw. The use of a 15% variable resistance enabled athletes to accelerate and produce a higher mean and peak velocity during upper body exercise, which has been shown to be a key element in sporting performance. As such, athletes who require the ability to develop impulse, such as rugby players, may benefit from the inclusion of this training method. Although the current study only demonstrated the acute effects of variable resistance on the bench press throw, it is recommended that athletes who are speed-strength dominated include the use of chains as a method to enhance acceleration and velocity in upper body movements.

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Figure Legend

Figure 1. Mean bar velocity from initiation of the bench press exercise at 50 to 400 ms for Chains and No Chains conditions. Values are means ± SD. * denotes small change; † denotes moderate change

Table 1. Mean ± SD for 1 RM, constant load (45% 1RM) and variable load (30% 1RM constant load + 15% 1RM chain load).

	Constant load	Variable load	
1 RM (kg)	45% 1 RM (kg)	30% 1RM (kg)	15% 1RM chains (kg)
105.6 ± 17.0	46.3 ± 6.9	30.8 ± 4.6	15.7 ± 2.3

Table 2. Reliability of measures for the study

	Chains			No Chains			
	ICC	SEM	CV%	ICC	SEM	CV%	Power
Peak power output (W)	1.0	26.1	1.2	0.99	25.6	1.6	0.05
Mean power output (W)	1.0	11.8	1.1	0.99	11.2	1.3	0.06
Peak bar velocity (m/s)	0.99	2.8	0.8	0.99	3.0	1.0	0.18
Mean bar velocity (m/s)	0.99	1.9	1.1	0.99	1.7	1.3	0.43
Bar acceleration (m/s/s)	0.75	0.5	16.3	0.86	0.3	9.0	0.99

Table 3. Bench throw performance with and without chains. Values are mean ± SD

	No chains	**Chains**
Peak power output (W)	732.7 ± 132.9	732.7 ± 134.9
Mean power output (W)	397.9 ± 62.2	403.4 ± 64.4
Peak bar velocity (m/s)	13.5 ± 16.0	13.9 ± 14.5*
Mean bar velocity (m/s)	8.4 ± 9.2	8.7 ± 9.5*
Bar acceleration (m/s/s)	7.0 ± 1.5	8.9 ± 3.1†

* denotes small change; † denotes moderate change