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The influence of isometric preload on power expressed during bench press in strength-trained men

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Abstract
The purpose of this study was to compare the power expressed during the bench press exercise in resistance-trained men following different pre-activation conditions. Twenty-two trained men (age 24.1 ± 1.7 years, height 178.6 ± 6.1 cm, body mass 81.1 ± 10.6 kg) completed a maximal effort bench press (1-RM) test (100.0 kg ± 8.1 kg). In a subsequent assessment, each participant performed concentric bench press movements with loads of 20%, 30%, 40% and 50% of their 1-RM preceded by either a concentric contraction (CC), a low isometric preload (LIP; 70% 1-RM) or a high isometric preload (HIP; 100% 1-RM) conditions. All movements were performed in a Smith machine with a settable quick-release device. Participants performed all three conditions in randomized fashion. Results indicated that power outputs during the bench press exercise following HIP were significantly (*p* < 0.05) greater than CC at 20% 1-RM (+9%), 30% 1-RM (+16%) and 40% 1-RM (+14%), and LIP at 20% 1-RM (+4%), 30% 1-RM (+20%) and 40% 1-RM (+15%). No differences were found between conditions at 50% 1-RM. Area under the force–power curve with HIP was greater (*p* < 0.05) than with CC and LIP. In conclusion, results of this study indicate that the use of a HIP (100% 1-RM) in trained participants results in significantly greater power output during the concentric phase of a multi-joint exercise when compared to standard concentric movement.

Keywords: Exercise, strength, performance

Introduction
Several studies have reported an enhancement of muscle contractile function associated with movements utilizing the stretch-shortening cycle (McBride, McCaulley, & Cormie, 2008) and isometric preload (Abbott & Aubert, 1952; Meijer, Grootenboer, Koopman, Vander Linden, & Huijing, 1988). Walshe, Wilson, and Ettema (1988) described an increase in the power expressed during dynamic muscle actions with high transitional forces during the first 300 ms of concentric movement, but found no differences in work output following isometric preload and ballistic pre-stretch conditions. However, others have shown that concentric movements immediately preceded by either isometric or eccentric contractions result in higher strength production compared to purely concentric actions (Jensen, Warren, Laursen, & Morrissey, 1991; Komi, 2003), and that maximal eccentric force may be increased by isometric pre-activation (Linnamo, Moritani, Nicol, & Komi, 2003; Linnamo, Strojnik, & Komi, 2006).

On the basis of the aforementioned investigations, both isometric pre-activation and the stretch-shortening cycle appear to benefit from the development of tension in contractile and elastic elements of the musculotendinous unit prior to concentric contraction (CC) (Walshe et al., 1988). Additionally, electromyography studies examining drop jumps have detected muscle pre-activation during the eccentric phase (McBride et al., 2008). However, the examination of isometric pre-activation has been limited to isokinetic movements due to its ease of use and the availability of
isokinetic dynamometers in laboratory settings (Jensen et al., 1991). Thus, this preloading strategy has yet to be examined with dynamic multi-joint concentric muscle actions. Interestingly, Zatsiorsky and Kraemer (2006) and Cometti (2002) mentioned this type of stimulus, and Soviet trainers may have used a similar device for strength training of throwers and jumpers in the 1980s (Cometti, 2002). Therefore, the purpose of this study was to examine the power expressed during the bench press in resistance-trained subjects following varying levels of isometric pre-activation. It was hypothesized that different preloads would result in graduated effects on power production during explosive CCs.

Methods

Participants

Thirty-two men who were participating in a strength training programme for at least two times a week for more than two years agreed to participate in the study and were tested for maximal bench press (1-RM) strength. The combined weight of the barbell and isometric pre-activation testing device was 18 kg. As such, inclusion criteria for study enrolment required participants to have a 1-RM bench press of 90 kg or better (equating to a 20% 1-RM greater than 18 kg). Thus, data from 22 men (age 24.1 ± 1.7 years, height 178.6 ± 6.1 cm, body mass 81.1 ± 10.6 kg) meeting this criterion were utilized. The study protocol was approved by the University of Bologna bioethics committee and all participants were required to sign an informed consent form.

Experimental design

Participants completed two testing sessions separated by a minimum of 24 hours. The first session consisted of 1-RM testing of the barbell bench press exercise for each participant. The second session consisted of mean power assessment during 12-bench press repetitions of varying loads (20–50% 1-RM) following low isometric preload (LIP), high isometric preload (HIP) and pure CC conditions. During the LIP and HIP conditions, participants were required to produce isometric force (inclusive of the loaded barbell) corresponding to approximately 70% and 100% 1RM, respectively. A 3-min recovery time between each attempt was used. During the CC condition, participants were only required to produce enough force to overcome the loaded barbell.

Assessment protocols

Before each testing session, a standardized warm-up, consisting of 5 min of treadmill running at 5 km h⁻¹, was employed. In addition, a warm-up set of 10 repetitions of the bench press exercise using 50% of the perceived (prior to 1-RM testing) or actual 1-RM (prior to power testing) was performed.

1-RM bench press testing was performed in the standard supine position using the Smith machine as outlined by Lawton, Cronin, Drinkwater, Lindsell, and Pyne (2004). To standardize bench press techniques, grip width was measured and subjects were required to use the same hand placement for each trial of both 1-RM and power test. The participants pressed the bar from mid chest until the arms were fully extended. Each test began with an initial load of 80 kg which was increased in 5 kg increments with participants completing attempts at 3-min intervals until failure.

During the bench press power test, loads corresponding to 20%, 30%, 40% and 50% of the previously determined 1-RM were performed using maximal effort following the LIP, HIP and CC conditions. While the loading sequence was standardized (from lowest to highest), the order of the conditions were randomized and a recovery time of 2 min was provided between each lift. An optical encoder (Globus Real Power; Globus Inc., 500 Hz) was used to assess mean power for each attempt. A force–power curve was constructed for each condition (Bartolomei, Hoffman, Merni, & Stout, 2014; Cormie, McBride, & McCaulley, 2008) and the area under the force–power curve (AUC) was calculated. Intraclass coefficients using the CC condition in 32 men in the same laboratory were 0.89 (SEM: 382.7 au) for the AUC; 0.64 (SEM: 18.83 N) for power at 20% of 1-RM power; 0.82 (SEM: 18.65 N) for power at 30% of 1-RM; 0.69 (SEM: 24.61 N) for power at 40% of 1-RM and 0.82 (SEM: 26.91 N) for power at 50% of 1-RM.

Isometric preload device

The isometric preload was achieved by an electronic settable quick-release device applied to the Smith machine (VISB prototype, patented by the University of Bologna: RM2013A000688/A63B, Rome, 13 December 2013). The device consisted of an electromagnetic brake controlled by an electronic unit. A strength gauge applied to the barbell measured the force produced by the subject (Nuova Allemano SRL, mod. C10, Collegno, Italy), and the brake was instantly removed when the subject overcame a pre-imposed force threshold (Figure 1). The release threshold could be set using the personal computer.
connected with the quick-release controller. After the participant surpassed the threshold, the barbell was released and accelerated vertically resulting in an explosive movement. Before each test, the quick-release device was calibrated using an isometric dynamometer (Globus Iso Control; Globus Inc., Treviso, Italy).

Statistical analysis

Normal distribution of the data was tested using a Kolmogorov–Smirnow test. Data were analysed using a two-way [condition (LIP, HIP, CC) × load (20%, 30%, 40%, 50% of 1-RM)] repeated measures analysis of variance (ANOVA) to evaluate mean power and a one-way repeated measures ANOVA were used for follow-up comparisons and to evaluate AUC. The Bonferroni post hoc test was used to determine pairwise differences. A significance level of $p \leq 0.05$ was used. All data are reported as mean ± SD. Per cent change in power expressed in different conditions was calculated as follows: (condition 1 – condition 2)/(condition 1) × 100.

Results

The average 1-RM strength expressed by the participants was 100.0 kg ± 8.1 kg. Table I reports all 1-RM and power values. A significant condition × load interaction was found for mean power ($F_{2,65} = 6.917; p = 0.002$). Significant differences between the CC, LIP and HIP conditions were detected for power expressed at 20%, 30% and 40% of 1-RM ($F_{2,65} = 8.545, p = 0.001; F_{2,65} = 6.225, p = 0.005$ and $F_{2,65} = 6.662, p = 0.002$, respectively). No significant differences were detected between CC, HIP and LIP conditions for the power expressed at 50% of 1RM ($F_{2,65} = 2.202, p = 0.119$). Significant differences were also found between CC, LIP and HIP conditions for AUC ($F_{2,65} = 11.992, p < 0.001$).

Table I. Power expressed during bench press during the pure CC, LIP, and HIP conditions (Mean ± SD)

<table>
<thead>
<tr>
<th></th>
<th>Power at 20% of 1-RM (w)</th>
<th>Power at 30% of 1-RM (w)</th>
<th>Power at 40% of 1-RM (w)</th>
<th>Power at 50% of 1-RM (w)</th>
<th>AUC (au)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC</td>
<td>240 ± 32$^*$</td>
<td>304 ± 40$^*$</td>
<td>365 ± 52$^*$</td>
<td>366 ± 63</td>
<td>12487 ± 1136$^*$</td>
</tr>
<tr>
<td>LIP</td>
<td>242 ± 29$^*$</td>
<td>290 ± 47$^*$</td>
<td>371 ± 67$^*$</td>
<td>366 ± 73</td>
<td>12544 ± 1145$^*$</td>
</tr>
<tr>
<td>HIP</td>
<td>272 ± 25</td>
<td>337 ± 42</td>
<td>402 ± 68</td>
<td>393 ± 74</td>
<td>13863 ± 1112</td>
</tr>
</tbody>
</table>

Note: AUC, area under the curve.

$^*$ Significant difference ($p \leq 0.05$) compared to the HIP condition.
HIP showed significantly higher AUC compared to CC (+11.02%, \(p < 0.001\)) and LIP (+12.21%, \(p < 0.001\)). No significant differences (\(p = 1.000\)) were detected between CC and LIP.

Post hoc pairwise comparison indicated that the mean score for the HIP condition was significantly different from the CC (\(p < 0.001\)) and LIP (\(p < 0.001\)) conditions for AUC and power expressed with loads ranging from 20% to 40% of 1-RM (\(p < 0.05\)). There were no significant differences between the CC and LIP conditions in the power expressed with any loads from 20% to 50% of 1-RM and in the AUC. Figure 2 shows the percentage changes from the CC condition using HIP and LIP.

Discussion

The results of this investigation indicated that an isometric preload equivalent to a person’s 1-RM (HIP) will significantly improve bench press power when compared to a standard lifting condition (CC) and an isometric preload of 70% 1-RM (LIP) at 20%, 30% and 40% 1-RM, but not at 50% 1-RM. While multiple studies have indicated that muscle potentiation from a pre-exercise isometric muscle contraction can improve power performance during subsequent isokinetic contractions (Fenn, Brody, & Petrilli, 1931; Helgeson & Gajdosik, 1993; Jensen et al., 1991; Svantesson, Thomee, & Thomee, 1994; Viitasalo, 1982), studies analysing the influence of different isometric preload conditions on the power produced during dynamic resistance exercise are to the best of our knowledge very limited. The findings of the current investigation confirm that isometric preload can also increase muscular power in multi-joint concentric exercises.

According to Wakayama, Nagano, Hay, and Fukashiro (2005), increased power expression due to pretension could be related to both enhanced myoelectric contribution and the use of elastic energy. Furthermore, a longer period of time to activate additional motor units before the concentric phase could be responsible for the increased power output (Jensen et al., 1991). The current study provides insight regarding the isometric pre-activation threshold required to increase performance in explosive CCs. Levels of isometric pre-activation correspondent to 70% of 1-RM do not appear to be enough to improve muscular power during dynamic muscle actions and may lead to a reduction in performance. This is consistent with Jensen et al. (1991) who reported increased isokinetic torques using HIPs (75% of maximum), but no differences with lower levels of isometric pre-activation. Therefore, low intensity isometric preloads may not be sufficient to activate the neurological and mechanical mechanisms that contribute to concentric work output (Linnamo et al., 2006).

The lack of differences between conditions in mean power using a workload of 50% 1-RM may indicate a reduced effect from the isometric pre-activation with higher loads. While the use of the stretch-shortening cycle (Mrdakovic, Ilic, Jankovic, Rajkovic, & Sefanovic, 2008) and isometric pre-activation (Linnamo et al., 2006) may enhance power output by extending the duration of contraction, this may be not useful with workloads in excess of 50% 1-RM due to a decrease in barbell velocity. Increases in bench press power using lighter weight coupled with an upward shift of the force–power curve does demonstrate the beneficial effects of isometric pre-activation. As suggested by Cometti (2002), the rapid shift from isometric contraction to explosive concentric movements may represent an effective training approach for improving strength and power.

Conclusion

Results of the present study indicate that the use of HIP in trained participants results in significantly greater power output during the concentric phase of a multi-joint exercise on the Smith machine when compared to standard concentric movement. However, isometric preload of 70% 1-RM does not appear to confer the same benefit and a threshold potentially exists between 70% and 100% 1-RM. This investigation also demonstrates the potential training utility of an adjustable quick-release device.
that allows for a rapid switch from isometric to CC during dynamic movements.

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Disclosure statement

No potential conflict of interest was reported by the authors.

References


