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The Acute Effects of Prior Dynamic Resistance Exercise Using Different Loads on Subsequent Upper-Body Explosive Performance in Resistance-Trained Men

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Abstract. Brandenburg, J.P. The acute effects of prior dynamic resistance exercise using different loads on subsequent upper-body explosive performance in resistance-trained men. *J. Strength Cond. Res. 19(2):427–432. 2005.*—The purpose of this study was to determine if explosive upper-body performance could be improved when it was preceded by conditioning contraction protocols that incorporate resistance exercise. Providing that performance was enhanced, it was also the intention to determine the optimal conditioning contraction load for enhancing performance. Eight recreationally trained men completed 4 experimental sessions. Each session consisted of a warm-up, 3 bench press throws (pre), a conditioning protocol, and 3 bench press throws (post). The different conditioning protocols consisted of 5 bench press repetitions using 100, 75, or 50% of 5 repetition maximum (5RM) strength. The fourth protocol, in which no repetitions were completed, acted as a control. Participants performed each conditioning protocol on a different day, and the order in which the protocols were performed was randomized. Average power, assessed during the bench press throws, was determined for the starting segment and the end segment (point of bar release) for each throw. Comparisons in average power, for each segment of the bench press 1RM, were made between the pre- and postconditioning protocol bench press throws. None of the conditioning protocols had an effect on bench press throw performance in either of the 2 segments of the movement. The results suggest there is no performance advantage when explosive upper-body movement is preceded by resistance exercise of varying loads. Alternatively, the performance of a set of resistance exercise did not compromise explosive upper-body performance. Considering this, training methods that combine both resistance exercise and plyometric-like exercise may offer a practical and time-efficient training system.

Key Words. bench press throw, complex training, power, potentiation

Introduction

In explosive movements, such as jumping, throwing, and kicking, performance appears more closely related to achieving high rates of force development than to achieving high levels of force production (4, 16, 21). Thus, training methods used to enhance the rate of force development should positively influence performance in explosive movements (21). Training strategies designed to bring about postactivation potentiation (PAP) may be such methods.

PAP is observed as a temporary improvement in skeletal muscle performance following conditioning contractile activity (9, 19). Conditioning contractions are synonymous with aspects of the sports-specific phase of a warm-up, and examples of conditioning contractions used in research include short-duration isometric actions (8) and a brief series of dynamic contractions (22). PAP appears to result from multiple physiological mechanisms. The primary mechanism responsible for PAP appears to be a more effective interaction between the actin and myosin filaments as a result of myosin light-chain phosphorylation (9, 19). An additional mechanism thought to contribute to enhanced performance following a conditioning contraction is an elevation in neural excitability (11).

Typically, PAP manifests itself as an increase in evoked or electrically stimulated muscle twitch force following a conditioning contraction in comparison to twitch force produced prior to a conditioning contraction (9, 12, 19). However, during voluntary contractions in which the central nervous system is required to maximally activate the necessary motor units, Sale (19) suggests that the influence of PAP on maximal isometric force–producing ability as well as maximum shortening velocity under unloaded circumstances will be negligible. Although PAP may not enhance muscle performance in these 2 extreme situations, it is speculated that PAP can increase the rate of force development during maximal explosive efforts. In explosive efforts performed against a resistance provided by the mass of a body (i.e., jumping) or a piece of equipment, an increase in the rate of force development should enhance maximum acceleration and maximum velocity (19). As these attributes are important to successful performance in explosive activities such as jumping and throwing, it would seem that PAP could improve performance in these activities. Alternatively, complex/contrast training is a method of training that alternates between heavy resistance exercise and explosive plyometric exercise (6, 7, 22). The intent behind this configuration is that the functioning of the neuromuscular system during the plyometric exercise will be enhanced due to PAP elicited from the preceding set of heavy resistance training, ultimately leading to a more effective development of power (6, 7, 22).

Findings from investigations examining the acute influence of dynamic resistance exercise conditioning contractions on PAP during subsequent maximal effort power performance are equivocal (8, 10, 13, 14, 18, 22). Although a considerable amount of research has been performed to examine the prevalence of PAP following conditioning contractions that incorporate resistance exercise, a paucity of research has attempted to systematically determine the most effective methods to elicit PAP.

Conditioning contraction variables that may influence the incidence as well as the extent of PAP include loading intensity, conditioning contraction duration, and speed of contraction, as well as the elapsed time between the conditioning contraction and subsequent power performance (14, 19). Of these variables, high-intensity loads during conditioning contractions are thought to be necessary in order to prepare the neuromuscular system and elicit an acute performance-enhancing effect on subsequent explosive efforts (11, 18, 22). Contrary to these beliefs, conditioning contractions that incorporated a submaximal warm-up, in which participants performed multiple sets of half-squats with progressively increasing submaximal loads, yielded a 2.4% improvement in countermovement vertical jump height (10). Thus, if the performance of voluntary explosive movements can be acutely enhanced with the execution of a prior conditioning contraction, the optimal conditioning contraction load remains uncertain. Therefore, the primary purpose of this study was to determine if the performance of explosive upper-body movement was enhanced when it was preceded by conditioning contractions that incorporated upper-body dynamic resistance training, and, if so, the secondary purpose was to determine if there was an optimal load for eliciting a performance-enhancing effect.

Methods

Experimental Approach to the Problem

Each participant of this research project was required to visit the laboratory on 6 separate occasions. The objectives of the first session were to assess bench press 1 repetition maximum (1RM) and 5 repetition maximum (5RM) strength. Assessments of both bench press 1RM and 5RM were necessary to establish the relative loads for the concentric-only bench press throws and the 3 conditioning protocols to be used in the following sessions. The second session provided an opportunity for participants to become familiar with the execution of the bench press throw movement. During this familiarization session, participants performed maximal effort bench press throws until no further increase in performance was observed (16). Following the initial testing and familiarization sessions, each participant performed a total of 4 different experimental sessions in order to examine the acute effect of a single set of resistance training protocols on subsequent bench press throw performance.

During each experimental session, participants performed a warm-up, followed by a series of 3 bench press throws (preconditioning), a conditioning contraction or control protocol, and then a second series of 3 bench press throws (postconditioning). The only difference between the conditioning contraction protocols was the magnitude of the load. The first conditioning protocol involved subjects performing 1 set of 5 repetitions of bench press while using 100% (ONE) of the previously determined 5RM load. Conditioning protocol 2 consisted of subjects performing 1 set of 5 repetitions of bench press at 75% (SVF) of 5RM. During the third conditioning protocol, each participant completed 1 set of 5 repetitions of bench press using 50% (FIF) of the 5RM load. Functioning as the control (CTL) treatment was protocol 4 in which no actual conditioning exercise was performed by the subjects. Bench press throw performance was assessed 2 minutes before the start, and 4 minutes after the completion, of each of the 4 protocols. The order in which each participant performed the conditioning and control protocols was randomized. A minimum of 48 hours separated each session, and each session was performed at approximately the same time of day. Although subjects were permitted to perform their normal activities during the course of this study, they were asked to refrain from any activities involving the chest and triceps musculature 48 hours prior to each laboratory visit.

Subjects

Subjects included 9 men, all of whom were either undergraduate or graduate students in Kinesiology and Physical Education (mean $\pm$ *SD,* age = 25.4 $\pm$ 4.0 years, weight = 87.7 $\pm$ 14.6 kg, height = 178.4 $\pm$ 10.4 cm). At the onset of the study, all participants had been involved in a regular recreational weight-training program (minimum of 3 times per week) for a minimum of 1 year, and each participant was required to demonstrate a 1RM bench press equal to or in excess of his body mass (mean $\pm$ *SD* bench press per body weight = 1.46 $\pm$ 0.34 $kg \cdot kg^{-1}$ body weight). A limited number of the participants had prior experience with training methods used to improve power, and none of the participants had previous experience with the performance of explosive bench press throws. Prior to participating in the study, each subject provided written consent after being informed of the specific experimental protocols to be used in the investigation. All experimental protocols used were approved by the Northern Illinois University Institutional Review Board. One subject withdrew from this investigation because of causes unrelated to the study, leaving 8 subjects who fulfilled the requirements for this study.

Strength Testing Procedures

To determine bench press strength, subjects underwent 1RM as well as 5RM testing. Bench press 1RM strength was measured as the maximum amount of weight that could be concentrically raised one time throughout the full range of motion, whereas bench press 5RM equaled the maximum amount of weight that could be raised and lowered throughout the entire range of motion for 5 successive repetitions. Both bench press 1RM and 5RM were determined on a Smith press machine (Samson Equipment, Inc., Las Cruces, NM), which restricted the path of the bar exclusively to the vertical plane.

Participants were positioned supine on a bench with their head, shoulder blades, and buttocks in contact with the bench at all times. Additionally, their knees were bent to approximately 90°, and both feet were placed flat on the floor. When each subject was in the supine position, the height of the bar was adjusted so that the starting position of the bar was approximately 5 cm superior to the sternum and parallel to the nipple line (5). Mechanical restraints allowed the bar to rest in the starting position. With the bar at the appropriate height, subjects were asked to grasp the bar with a comfortable yet wider than shoulder-width grip. The bar height as well as the placement of the hands on the Olympic bar were recorded to ensure consistency between all sessions.

From the starting position, each subject was instructed to push the bar upward until full arm extension was achieved (16). If the participant was successful, the weight on the bar was increased, and another attempt was made. Following the determination of the bench press 1RM, the bench press 5RM was assessed in order to prescribe the load to be used during each of the conditioning contraction protocols. The 5RM test was initiated from the same starting position as the 1RM test. However, on the lowering phase of each repetition, subjects were instructed to lower the bar to the starting position and then repeat the movement with no pause in between repetitions. If more than 5 repetitions were performed, the weight on the bar was increased, and another attempt was made. Four minutes of rest separated all 1RM and 5RM attempts. Prior to the bench press strength tests, subjects performed a specific warm-up consisting of 1 set of 10 repetitions at 50% of the estimated 1RM and 1 set of 4 repetitions at 80% of the estimated 1RM (3). The warm-up sets were separated by 2–3 minutes of rest.

Concentric-Only Bench Press Throws

Upper-body power performance was assessed during a series of 3 maximal effort concentric-only bench press throws performed 2 minutes before (preconditioning) and 4 minutes after (postconditioning) each of the conditioning and control protocols. During each concentric-only bench press throw, each subject was instructed and encouraged to lift the bar from the starting position as explosively and forcefully as possible and throw it as high as possible (5, 16). To avoid deceleration and achieve maximal bar velocity, the bar was released at the top of the range of motion (16). The starting position for the concentric-only bench press throw was identical to that previously described for the 1RM and 5RM strength tests (5). In each of the experimental sessions, all bench press throws were performed with a load of approximately 45% of 1RM (range = 44–46% of 1RM) (2, 16). Among the subjects, there was a slight difference in the load used during the throws, because the smallest increment in resistance was 1.14 kg. Bench press throws were performed against a load of approximately 45% of 1RM, as it has been demonstrated that the highest mean power during a concentric-only bench press throw is achieved with this load (17). Although a braking system was unavailable, mechanical restraints and spotters were in position to stop the bar so that each subject did not need to catch and decelerate the bar following the throw. Three throws were performed in each series with 30 seconds of rest between each throw. During each throw, subjects were required to keep their heads, shoulders, and trunks in contact with the bench as well as their feet in contact with the floor. Prior to the performance of the preconditioning series of bench press throws, subjects completed a warm-up that consisted of 5 minutes of light pedaling on a Monarch Cycle Ergometer and 2 sets of bench press throws using a load of approximately 40–50% of 1RM for 10 repetitions. As performance in explosive movements has been observed to be compromised following stretching, stretching exercises were not included in the warm-up procedures (15).

Measurement of Average Power

Average power during each bench press throw was determined using a chronoscopic timing system (Powertool, Patent 6 672 157 B2) similar to that used by Siegel et al. (20). Two pairs of timing lights were positioned within the bench press throw range of motion, with 1 pair measuring the starting segment and 1 pair measuring the end segment of each bench press throw. Each pair of timing lights included a "start" and "stop" beam. The start and stop beams, within each pair of timing lights, were separated by 10 cm (20). To measure power during the starting or initial segment of the bench press throw, the first pair of lights was positioned immediately superior to the bar when resting in the starting position. The initial segment of the bench press throw range of motion was selected for measurement, as it has been previously demonstrated that it is during this segment that the highest force and highest acceleration are achieved (16). The second pair of lights was positioned so that the height of the "stop" beam was level with the height of the release point of the bar during the bench press throw. This position was selected because Newton et al. (16) established that maximum velocity during a bench press throw is achieved at the point of release. Average bar velocity during each of the 2 segments was determined from the elapsed time between the start and stop beams (10 cm). From this, average power was calculated as the product of average bar velocity and bar mass. The height of each set of lights was recorded and kept constant for each participant during all of the conditioning contraction protocols.

Acute changes in explosive bench press throw performance were determined by comparing the best of the 3 throws before each conditioning/control protocol to the best of the 3 throws following each conditioning/control protocol. The effect of performing the different conditioning/control protocols on average power output during each segment of the bench press throw was also assessed with a potentiation ratio, as defined by the highest average power postconditioning protocol divided by the highest average power output preconditioning protocol. A potentiation ratio greater than 1.0 would indicate that the conditioning protocol elicited a performance-enhancing effect.

Conditioning Contraction Protocols

Each subject performed all 3 of the conditioning protocols in addition to the control protocol. Conditioning protocol 1 involved subjects performing 1 set of bench press throws for 5 repetitions using 100% of the 5RM load (ONE). During the second and third protocols, subjects performed 1 set of 5 repetitions using 75% (SVF) and 50% (FIF) of the 5RM load, respectively. Load selection was set relative to 5RM, as it has been demonstrated that a conditioning protocol implementing a single set using a 5RM load has elicited a performance-enhancing effect (22). During each of the conditioning protocols, participants were asked to perform each bench press repetition under a controlled tempo (approximately 1.5 seconds for the concentric as well as the eccentric phase) and use the full range of motion. In the fourth protocol (CTL), subjects did not perform any conditioning contractions between the first and second series of bench press throws. The purpose of the CTL protocol was to control for any performance-altering effect that the initial series of bench press throws may have had on the second series of bench press throws.

Statistical Analyses

A 4 (conditioning and control protocols) $\times$ 2 (series: preconditioning and postconditioning) analysis of variance (ANOVA) with repeated measures on the second factor was performed for each segment of the bench press throw

Table 1. Pre- and postconditioning protocol average power and potentiation ratio produced during the initial phase of the bench press throw (mean ± *SD*).*

	Preconditioning protocol average power (W)	Postconditioning protocol average power (W)	Potentiation ratio
ONE	466.6 ± 111.9	472.0 ± 119.6	1.01 ± 0.03
SVF	475.3 ± 121.0	474.6 ± 122.8	0.99 ± 0.04
FIF	468.1 ± 128.4	471.2 ± 130.1	1.01 ± 0.05
CTL	465.5 ± 101.3	474.1 ± 116.0	1.01 ± 0.04

* ONE = 100%; SVF = 75%; FIF = 50%; CTL = control.

Table 2. Pre- and postconditioning protocol average power and potentiation ratio produced at the point of bar release of the bench press throw (mean ± *SD*).*

	Preconditioning protocol average power (W)	Postconditioning protocol average power (W)	Potentiation ratio
ONE	805.2 ± 216.4	801.0 ± 237.1	0.99 ± 0.03
SVF	797.3 ± 224.7	799.1 ± 224.4	1.00 ± 0.04
FIF	798.8 ± 241.7	807.4 ± 249.0	1.01 ± 0.03
CTL	808.4 ± 219.7	810.2 ± 233.4	0.99 ± 0.03

* ONE = 100%; SVF = 75%; FIF = 50%; CTL = control.

(the initial range of motion as well as the point of release) to determine if any differences in average power output were evident in response to the 4 protocols. To examine the differences in the potentiation ratio produced by the conditioning/control protocols, an ANOVA was performed. Test-retest reliability of the dependent variable, as determined using an intraclass correlation, was performed using a 2-way ANOVA. Intraclass correlation coefficients for the initial segment and point of bar release segment of the bench press throw were 0.97 and 0.99, respectively, with no significant differences between the mean values for each phase ($p \leq 0.05$). The alpha level for statistical significance was set at $p \leq 0.05$. All statistical analyses were conducted using SPSS 11.0 for Windows (SPSS Inc., Chicago, IL).

Results

The average power scores, pre- and postconditioning protocol, produced during the initial segment of the bench press throw are presented in Table 1. The results for the pre- and postconditioning protocol average power scores produced at the point of bar release are presented in Table 2. Briefly, none of the 3 conditioning protocols or the control protocol elicited a significant change in average power from pre- to postconditioning protocol during the starting phase ($p > 0.05$, statistical power = 0.127) or point of bar release of the bench press throw ($p > 0.05$, statistical power = 0.097). Additionally, there were no significant differences in the potentiation ratio produced by the 4 protocols ($p > 0.05$, statistical power = 0.153).

Discussion

The objectives of this investigation were to determine if the performance of upper-body explosive movement was enhanced when it was preceded by a conditioning contraction of dynamic resistance exercise and, if so, if there was an optimal resistance that should be used during the conditioning protocol. The results showed that upper-body power, as measured during concentric-only bench press throw performance, was unaffected when it was preceded by dynamic resistance exercise conditioning protocols that incorporate loads of 100, 75, or 50% of 5RM.

With reference to the first objective, the results indicate that the performance of explosive upper-body movement was not augmented following the completion of a single set of dynamic upper-body resistance exercises. These findings support those of related research conducted by Hrysomallis and Kidgell (13) as well as Ebben et al. (6), who also failed to demonstrate an acute increase in upper-body explosive performance when it was preceded by a single set of 5RM or 3–5RM bench press throws, respectively. The magnitude of the conditioning loads used in these studies was similar to the ONE conditioning protocol used in the present study and can be classified as a high-load conditioning protocol (1). Previous research has suggested that the intensity of a conditioning protocol that incorporates dynamic resistance exercise must be high in order to elicit PAP (22). Young et al. (22) observed a small but significant improvement in loaded countermovement vertical jump performance following a set of squats using a 5RM load. The present study does not support this finding, as a set of 5 bench press repetitions at 100% of the 5RM load failed to yield an improvement in bench press throw performance.

A proposed explanation accounting for the lack of improvement in upper-body power production following conditioning protocols using heavy loads such as those used during the ONE conditioning protocol is the presence of fatigue (1). Conditioning contractile activity appears to acutely influence the neuromuscular processes responsible for potentiation as well as the mechanisms responsible for the fatigue of a muscle (9). Consequently, the quality of muscle performance following contractile activity depends on the balance between the degree to which the muscle is fatigued and the degree to which the muscle is potentiated (9, 19). Supposedly, performance should be enhanced when the level of potentiation exceeds the amount of fatigue. However, if the amount of fatigue equals the amount of potentiation, performance will remain unaltered. This was observed by Gossen and Sale (9), whereby maximal effort dynamic knee extensor performance was slightly depressed following a 10-second maximal voluntary contraction, and yet evoked muscle twitch force was enhanced, indicating that potentiation was present. The researchers concluded that although potentiation was present, as indicated by the acute increase in evoked twitch force, dynamic knee extensor performance was not enhanced because of the offsetting effects of sufficient fatigue (9). In the present study, bench press throw performance was similar prior to and following the dynamic heavy resistance conditioning exercise. Although measures of fatigue were not included in this study, it is plausible that a single set of 5 repetitions using 100% of the 5RM load produced enough fatigue to counter any potentiating effects that the high-load conditioning protocol may have produced.

As previously mentioned, the quality of muscle performance following conditioning contractile activity is dependent on the extent to which the contractile mechanisms are fatigued and the extent to which they are potentiated (19). The balance between these 2 "states" depends on the rate of recovery from fatigue and the rate at which potentiation dissipates (19). If the time course of these 2 recovery processes is different, the length of recovery between the conditioning activity and the explosive performance will affect the quality of performance. In the present study, 4 minutes separated the conclusion of the conditioning protocol with the onset of the final series of bench press throws. As in similar studies, 4 minutes was selected to allow for the complete or near-complete recovery of the phosphagen energy system while an attempt was made to minimize the decay of a heightened neuromuscular system (14). Results from the present study indicate that a 4-minute recovery following a conditioning activity of dynamic resistance exercise may not be sufficient to augment subsequent power performance. Support for this was provided by Jensen and Ebben (14), who failed to observe an increase in countermovement vertical jump performance each minute for up to 4 minutes following a single set of a squat exercise using a 5RM load. Perhaps if a longer interval had been provided between the completion of the conditioning protocol and the subsequent series of bench press throws, an improvement in performance would have been observed.

The negating effects of fatigue on potentiation may be further pronounced if consideration is given to the involvement of the fast twitch motor units in both the ONE conditioning protocol and the execution of the bench press throw. As the ONE conditioning protocol required the subjects to lift a heavy load for 5 repetitions with the fifth repetition ending in muscle failure, it is reasonable to propose, on the basis of the principle of motor unit recruitment, that the highly fatigable, fast twitch motor units were active during this task. Additionally, the performance of brief-duration, maximal effort muscle voluntary muscle contractions, like the bench press throw, is dependent on the maximal activation and functioning of the fast twitch motor units (19). If the level of functioning of the fast twitch motor units was compromised because of the heavy nature of the ONE conditioning protocol, so, too, would have been the ensuing performance of the bench press throw.

Although fatigue may have been a contributing factor to the lack of bench press throw improvement following the ONE conditioning protocol, it is less likely that fatigue contributed to the similar observations following the lower-intensity conditioning protocols of SVF and FIF. The second objective of the present study was to determine the effect of conditioning protocols that incorporate different loading intensities on subsequent bench press throw performance. Recently, Baker (1) observed a 4.5% improvement in bench press throw power 3 minutes after performing 6 bench press repetitions with 65% of 1RM. The acute improvements in bench press throw performance were, in part, attributed to the use of moderate submaximal loads that could be lifted at a faster speed than heavy loads, which necessitate a slower lifting speed (1). Baker (1) speculated that the high lifting speeds attained while using 65% of 1RM readied the neuromuscular system for the ensuing bench press throws.

Acute improvements in vertical jumping ability were also detected following a warm-up protocol that included submaximally loaded half-squats performed as quickly as possible (10). Similar to the explanation forwarded by Baker (1), the acute increases in vertical jump performance were attributed to more effective neural activation as a result of the fast lifting speeds incorporated into the half-squat warm-up activity (10). The results of the present study, which indicate that the low-to-moderate intensity loads (SVF and FIF) used during the conditioning protocols failed to augment bench press throw performance, contradict the findings of both Baker (1) and Gourgoulis et al. (10). One possible factor that could account for the lack of increase in bench press throw performance in response to the submaximal conditioning protocols (SVF and FIF) of the present study in comparison to the warm-up protocols used by Baker (1) and Gourgoulis et al. (10) is the lifting speed used during the SVF and FIF protocols. In the present study, regardless of the load used during each conditioning protocol, participants were instructed to perform each repetition at a controlled tempo. Although the relationship between force and the velocity of movement would suggest that the participants could have performed the SVF and FIF protocols faster than the ONE protocol, the instructions to lift the loads in a controlled manner prevented this from occurring. Thus, if fast movement speed is necessary to prepare the neuromuscular system for subsequent activity, the lack of improvement observed following each of the 3 conditioning protocols in the present study may be attributed to the controlled lifting tempo.

Finally, the results of the present investigation contradict previous research that has indicated PAP may be greatest in those individuals who are accustomed to resistance training (22). It seems noteworthy that, although the subjects in the current study possessed previous recreational resistance training experience, none of the subjects was familiar with explosive-type training or competition. Perhaps if the subjects of the current study had been power athletes, as in the study performed by Baker (1), the results would have been different.

Another potential limitation of the present study was that the effectiveness of the different conditioning protocols was established by comparing changes in pre- to post-conditioning protocol bench press throw average power and not peak power. With respect to performance in explosive-type movements as well as to the monitoring and evaluation of training programs to improve power, peak power, rather than average power, may be the more relevant variable. It is possible that bench press throw peak power responded to the conditioning protocols differently (either increased or decreased) from the way in which average power responded (no change). Alternatively, an additional variable pertinent to power training and performance in explosive events is the velocity of movement (4). In the present study, average power was determined by measuring the velocity of bar movement during the starting phase and at the point of bar release of each bench press throw. Although the actual velocities attained in the bench press throw are less than the movement velocities achieved during explosive actions found in athletic events, the acceleration and velocity profiles do resemble each other (4, 17). Newton et al. (17) demonstrated that the highest accelerations and the highest velocities during a bench press throw occur during the initial segment of the movement and at the point of bar release, respectively. With that in mind, average power during each bench press throw was assessed during the starting segment and at the point of bar release. The acute influence of PAP on voluntary movements that are explosive in nature has been suggested to be an increase in the rate of force development, which would translate into enhanced acceleration and velocity during the movement (19).

Thus, if PAP were present after any of the protocols, it follows that average power, as determined in the starting segment and at the point of release, would have increased.

Results from the present study indicate that performing a single set of controlled, dynamic resistance exercises does not offer any performance advantage when performed prior to an explosive movement using the upper body. The results also show that a single set of resistance exercises was not detrimental to explosive performance. As the controlled lifting tempo used in all the conditioning protocols may have contributed to the lack of improvement in bench press throw performance, future studies may want to examine the acute effects of conditioning protocols that incorporate high-speed resistance exercise.

Practical Applications

The lack of evidence of PAP in the present study indicates that there is no functional advantage to performing a conditioning protocol of dynamic resistance exercise prior to upper-body explosive activity. However, as there was no reduction in upper-body explosive performance, it would seem that methods of training that combine and alternate between resistance exercise and plyometric-like exercise in a single training session (complex/contrast training), at the very minimum, offer a time-efficient training strategy that may not compromise the training quality of the plyometric-like exercises.

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