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Methods to Increase the Effectiveness of Maximal Power Training for the Upper Body

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summary

Power training recommendations have typically involved Olympic Weightlifting and plyometric exercise prescriptions, paying scant attention to upper body maximal-power demands. This article attempts to redress this situation by focusing upon strategies and specific techniques that can be implemented to enhance the effectiveness of upper body maximal-power training.

A cursory glance at many resistance training programs or recommendations aimed at increasing muscular power typically reveals a high proportion of weightlifting (e.g., power cleans, pulls) or plyometric exercises (e.g., jumping, bounding) (1, 20, 21). While these methods of training often produce tremendous increases in lower-body power, methods for developing upper-body power appear to be less explored. Maximal upper body pressing/pushing power is of importance to both American and rugby football players, as well as boxers and martial artists, to enhance the ability to push away or strike opponents. The purpose of this article is to outline some practical methods that have been implemented in our program to develop maximal upper-body pressing power in rugby league players. Astute coaches will be able to determine the relevance and application of these concepts and methods to the broader area of athlete preparation for other sports.

For the purpose of this paper, *maximal power* (Pmax) is defined as the maximal power output for the entire concentric range of movement/contraction (*peak power* refers to the highest instantaneous power output for a 1-msec period within a movement) (2, 4, 5, 8, 9, 11). Upper-body pressing Pmax is usually determined by measuring power output during the lifting of a number of different barbell resistances in a designated exercise (e.g., bench press [BP] or bench throws [BT] in a Smith machine) using the Plyometric Power System software (PPS; see 2, 4, 5, 8, 9, 11, 25, 26) or other software or testing modalities. The load-power curve or profile (Figures 1 and 2) that is generated for each individual from this testing can aid in prescribing training (2, 4, 5, 8, 9, 11). For example, an individual whose load-power curve is characterized by high power outputs with light resistances but also exhibits pronounced reductions in power output with heavier resistances would be prescribed more maximal power—oriented and heavy-resistance strength training.

Maximal strength has been shown to be highly correlated to Pmax in both the upper (2, 4, 5, 8, 9, 11) and lower body (10) for both elite and less experienced athletes, because the relationship between an individual's change in Pmax and change in maximal strength as a result of training is much higher in less experienced athletes than it is in elite athletes (5). However, as maximum strength is the physical quality that most appears to underpin Pmax, it is advisable that athletes who wish to attain high Pmax levels develop and maintain very high levels of strength in muscle groups important in the sport in both agonist and antagonist muscle groups. The strength of the antagonists should not be neglected for athletes who require rapid limb movements, as research has shown that strengthening of antagonists increases both limb speed and accuracy of movement due to favorable alterations in the neural firing pattern (22). It has been shown that some power training practices described below are only effective for stronger, more experienced athletes (14, 28). Once a good strength and muscle conditioning base has been established, the following practices will be most useful.

Method 1: Include Full Acceleration Exercises as Power Exercises

It is important to differentiate exercises as being used primarily for the development of strength (or hypertrophy, depending on sets, repetitions, rest periods, etc.) or power. What differentiates these classifications of strength or power exercises is whether the performance of the exercise entails acceleration throughout the range of movement, resulting in faster movement speeds and, hence, higher power outputs (23, 25–27). Power exercises are those exercises that entail acceleration for the full range of movement with resultant high lifting velocities and power outputs. Strength exercises are those exercises that entail heavy resistances and high force outputs but also pronounced periods of deceleration, resulting in lower lifting velocities and reduced power outputs (25). Performing an exercise in which acceleration can occur throughout the entire range of movement (such as a BT in a Smith machine, [Figure 3], medicine ball throws, or power pushups) allows for higher lifting speeds and power outputs (23, 25, 26). If athletes attempt to lift light resistances explosively in traditional exercises, such as BP and squats, large deceleration phases occur in the second half of the movement, resulting in lower power outputs as compared to power versions of BT and jump squats (25, 27). Thus a heavy resistance BP is considered a strength exercise, whereas the BT is considered a power exercise.

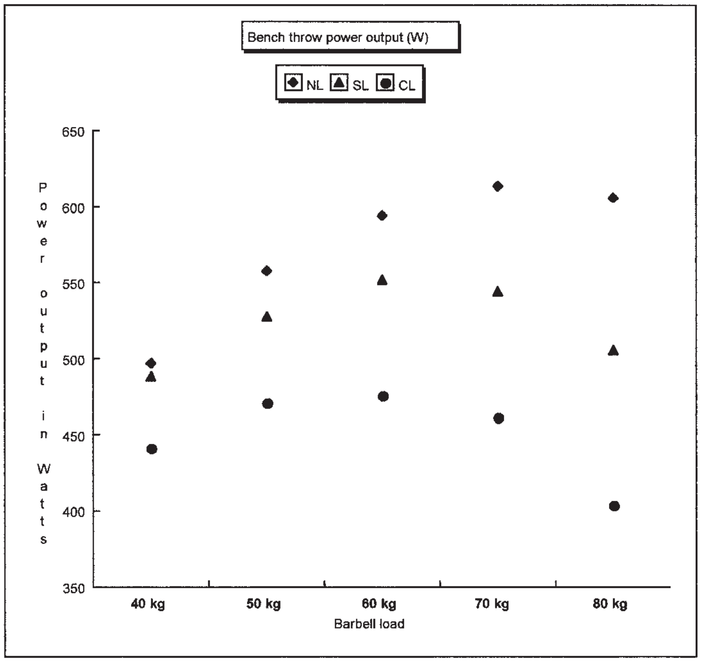

Figure 1. Load-power curves (average concentric power) for rugby league players participating in the professional National Rugby League (NL), college-aged state leagues (SL), or city based leagues (CL) (2).

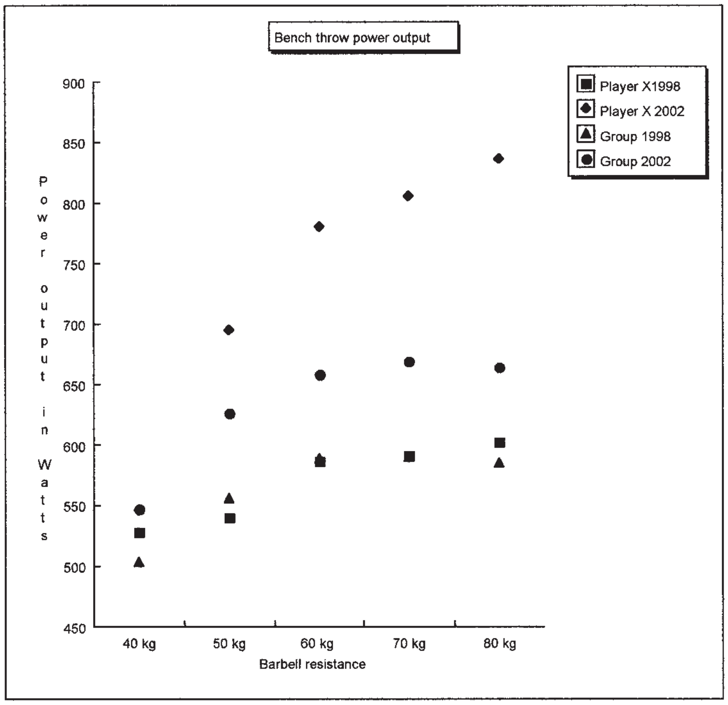

Figure 2. Change in the upper-body bench throw load-power curve (average concentric power) across a 4-year period in a group of 12 professional rugby league players, as well as for an individual who made considerable progress (player X). The change in 1 repetition maximum bench press appears to underpin the change in bench throw maximal power during this time (11).

Table 1
Zones of Intensity for Strength and Power Training

	Type and/or Goal of Training of Each Intensity Zone	
	Strength	**Power**
Zone 1: <50%	General muscle and technical	General neural and technical (<25% 1RM)
Zone 2: 50–75%	Hypertrophy training	Ballistic speed training (25–37.5 % 1RM)
Zone 3: 75–90%	Basic strength training	Basic power training (37.5–45 % 1RM)
Zone 4: 90–100%	Maximal strength training	Maximal power training (45–55 % 1RM)

Note: For strength, percentage of maximum refers to 1 repetition maximum (1RM) (100%). For power, 100% = Pmax (maximal power) resistance (circa 45–55% 1RM if exact Pmax resistance not known). Equivalent percentage ranges based upon 1RM are included in parentheses for cases in which exact Pmax resistance is not known (modified from reference 2).

Training to maximize upper-body pressing/pushing power should entail both heavy resistance, slower speed exercises for strength development and exercises that entail higher velocities and acceleration for the entire range of movement for power development (e.g., BTs, medicine ball chest passes, plyometric pushups, and other throwing exercises, and ballistic pressing/pushing exercises) (1, 2). This approach should result in the musculature contracting both forcefully and rapidly.

Method 2: Alter the Kinetics of Some Strength Exercises to More Favorably Affect Rapid-Force or Power Output

Because heavy-resistance strength exercises such as bench press typically entail slow movement speeds and low power outputs (23, 25), they alone are not specifically suited to developing Pmax (23). This phenomenon has been the subject of considerable research attention. There are power-specific adaptations in terms of the neural activation, muscle fiber/contractile protein characteristics, and muscle architecture (12) that must be considered. As previously discussed, lifting a light resistance on the BP explosively also results in large deceleration periods (25). However, there are a number of strategies that the strength coach can implement to alter the force profile or lifting speeds of strength exercises to make them more suitable to rapid-force development.

For example, the performance of the BP can be modified by adding chains to the end of the barbell to alter the kinetics of the exercise so that the acceleration phase can be extended further into the range of movement. When the barbell is lowered to the chest, the chains are furled on the floor and only provide minimal resistance (Figure 4). As the barbell is lifted, the chains unfurl and steadily increase resistance throughout the range of motion (Figure 5). A lighter resistance (e.g., 50–75% 1 repetition maximum [1RM]) can be lifted explosively off the chest. As the additional resistance (+10–15% 1RM in chains) is added by the constant unfurling of the chain links off the floor, the athlete can continue attempting to accelerate the bar but it will slow due to the increasing mass, rather than the athlete consciously reducing the push against the barbell. This action alters the kinetic profile of the strength exercise to become more like a power exercise (acceleration lasts longer into the range of motion). A similar strategy is to use rubber tubing resistance (power bands) on the ends of the barbell to increase resistance throughout the range of motion. In this case the athlete pushes upward in the bench press and stretches the large rubber bands attached to each end of the barbell. The greater the range of motion, the more the bands stretch, and therefore the greater the elastic resistance. Similar to the chains example, using rubber tubing allows the athlete to explode upwards and continue to apply high force much later into the movement.

Another strategy is the use of functional isometric (FI) training (23). An FI exercise can be performed for the top half of a movement in a power rack or Smith machine, altering the force characteristics considerably (23). Other methods of altering the kinetic profile include partial repetitions in the top half or maximal force zone of the lift (24). Weighted adjustable hooks (periscope type design) that are constructed to fall off the barbell when the base of the apparatus contacts the floor during the lowest portion of the BP can also alter barbell kinetics within a repetition. Their use allows for heavier eccentric and lighter concentric phases, conceivably resulting in enhanced concentric lifting velocities. The use of chains, power bands, FI, partials, hooks, and other devices to alter the resistance/force production (and acceleration) throughout the barbell trajectory, and particularly the end of the range of movement (so that it more closely mimics power exercises), can be applied to any free-weight barbell exercise used in upper-body training.

Method 3: Use Complexes of Contrasting Resistances or Exercises

A method of training in which sets of a heavy-resistance strength exercise are alternated with sets of lighter-resistance power exercises is known as a complex (14–18, 28) or contrast training (2, 6, 14). This type of training has been shown to acutely increase explosive force production or jumping ability when implemented for lower body power train-

Table 2
Actual Sample Training Content for Bench Press and Bench Throws Across the Last 4 Weeks of a Preseason Strength-Power Training Cycle for an Elite Professional Rugby League Player. Testing Occurred in Week 5.

		Weeks				
		1	2	3	4	Test Result
Bench Throws						
D1	Power Wt	573 W @ 40 kg	599 W @ 50 kg	696 W @ 70 kg	683 W @ 70 kg	755 W @ 80 kg
%BT	Pmax	76	79	92	91	= 100%
D2	Power Wt	588 W @ 40 kg	605 W @ 50 kg	722 W @ 70 kg	746 W @ 80 kg	
%BT	Pmax	78	80	96	99	
Bench Press						**Test Result 1RM BP**
D1	Wt S × R	130 kg 3 × 5	135 kg 3 × 5	140 kg 3 × 5	150 kg 3 × 3	=170 kg
% 1RM		76.5	79.4	82.4	88.2	
D2	Wt S × R	105 kg 3 × 5	110 kg 3 × 5	125 kg* 5 × 3	125 kg* 5 × 3	
% 1RM		61.8	64.7	73.5	73.5	

W = power output in watts, Wt = resistance in kilograms, S × R = sets × repetitions, Pmax = maximal power, BT = bench throw, BP = bench press, D1 = Heavier, strength-oriented training day with BP performed before BT, D2 = Medium-heavy, power-oriented training day consisting of contrasting resistance complexes (alternating sets of BP and BT, same sets and repetitions).
* Denotes 110 kg barbell load plus 15 kg in chains attached to the sleeves of barbell. See text for a description of this bench press plus chains exercise. Grip width was altered to a narrower grip for all D2 BP workouts.

ing (3, 14, 18, 28), presumably through stimulating the neuro- or musculo-mechanical system(s) (14, 18, 28). Recent research also illustrates that it is effective for acutely increasing upper-body power output (6). This research found that bench presses with 65% 1RM alternated with bench throws (30–45% 1RM) resulted in an acute increase in power output (6). An agonist-antagonist complex may also warrant consideration from the coach, as speed of agonist movement may be improved in these situations (13, 22). Thus a strength coach has a choice of implementing agonist strength and power exercises or antagonist and agonist strength and power exercises in a complex to increase power output.

It is recommended that if upper-body resistance training is performed twice per week, then 1 day of the training week should emphasize strength development with heavy resistance training and the other training day should emphasize power development with training complexes alternating contrasting sets of light resistances (30–45% 1RM) and medium-heavy resistances (60–75% 1RM) (2, 6).

Method 4: Periodize the Presentation of Power Exercises and Resistances

Many authors have suggested the periodization of resistance training exercises to enhance power output (2, 20). While prescribing resistances in a periodized manner is not a novel idea in relation to training for power as has traditionally been used with weightlifting-style exercises, it has not been fully utilized for simpler, upper-body power exercises such as the bench throw. Baker has previously suggested that the resistances used for the upper-body (or lower-body jumping) power exercises be periodized (2) to effectively stress the multifaceted nature of muscle power (20). Table 1 outlines 4 power training zones and their analogous strength training zones. Across a training cycle the power training resistances can progress from lighter resistances, in which technique and ballistic speed are emphasized, to the heavier resistances that maximize power output (about 50% 1RM = 100% Pmax). Table 2 details the last 4 weeks of an elite athlete's bench press and bench throw training cycle, aimed at simultaneously maximizing strength and power output. The progression in power training resistances (from 40 to 80 kg in bench

Figure 3. Bench throw exercise performed in a Smith machine. The loss of hand contact with the barbell ensures acceleration throughout the entire range of movement.

throws) and concomitant increase in power output from 573 to 755 W can be seen.

If coaches do not have access to technologies that can measure the actual Pmax and the resistance at which it occurs, it is recommended that coaches assume it to be 50–55% 1RM BP for most athletes, 45% 1RM BP for very strong athletes (e.g., 1RM BP $\geq$150 kg), and greater than 55% 1RM BP for less experienced or strong athletes (2). This means that a resistance of 50% 1RM BP equals 100% Pmax (and hence this resistance is the Pmax resistance).

It is important to note that, for example, training with a 50% Pmax resistance does not mean the athlete will attain only 50% of their maximal power output. For example, from Table 2 it can be seen that the athlete's Pmax resistance is 80 kg for bench throws, but that 40 kg, representing 50% Pmax resistance, actually allows for the athlete to attain a power output of 76–78% of the maximum. During week 2, training with a resistance of 50 kg (representing 63% of his Pmax resistance of 80 kg) allows the athlete to attain power outputs of around 600 W or 80% of maximum. Therefore an athlete can attain very high power outputs at lower percentages of the Pmax resistance. Because of the plateauing of power output around the Pmax (Figure 1), the use of resistances of around 85% or more of the resistance used to attain Pmax will usually result in the athlete's training at or very close to Pmax (e.g., 70 kg in Table 2 = 84% Pmax resistance but results in power outputs of up to 96% Pmax).

Method 5: Use Low Repetitions When Maximizing Power Output

Low repetitions are necessary to maximize power output. High repetition, high workload, hypertrophy-oriented training acutely decreases power output (7) and should not precede or be combined with maximal power training. It would appear important to avoid fatigue when attempting to maximize power output, and a simple method for achieving this is to use low repetitions for power exercises (and obviously ensuring the appropriate rest period is utilized).

Anecdotal evidence from training hundreds of athletes with the PPS shows that power output markedly decreases after 3 repetitions when using resistances that maximize power output (around 45–50% 1RM BP) during the BT exercise. For power exercises it is usually recommended that only 2–3 repetitions be performed when training in the maximal power zone, 3–5 in the general power and ballistic power zone, and higher repetitions (e.g., 8–10 repetitions) are only performed when using lighter resistances in the technical/neural zone (learning technique or warming up).

Method 6: Use Clusters, Rest-Pause, or Breakdown Techniques for Some Strength or Power Exercises

To increase force output and velocity and reduce fatigue within a set, some specific methods have evolved over the years (23). Recent research indicates that, compared to the traditional manner of performing repetitions, repetitions presented using clusters (19) or the "rest-pause" or "breakdown" methods (23) can increase force or velocity. Clusters are a method in which a set of higher repetitions is broken down into smaller clusters of repetitions that allow a brief pause between each of these clusters. For example, 8 repetitions can be performed as 4 clusters of 2 repetitions with a 10-second rest between clusters. The rest-pause system is similar but typically entails the breakdown of a lower repetition set (for example, 5RM) into single repetitions with a short pause (for example, 2–15 seconds) between repetitions. A *breakdown* (also known as *stripping*) set consists of small amounts of resistance being taken from the barbell during short pauses between repetitions. This reduction in resistance to accommodate the cumulative effects of fatigue results in a decreased degree of deterioration in power output across the set, as well as increased force in the initial repetitions as compared to the traditional manner of lifting a heavy resistance (23).

Figure 4. Bench press exercise kinetically modified by adding heavy chains to the sleeves of the barbell. In the bottom of the lift the chains are furled upon the floor, providing little additional resistance.

Method 7: Use an Ascending Order of Resistances when Maximizing Power Output

Whether the resistances should be presented in an ascending (working up in resistance) or descending (working down in resistance) order during power training has been cause of some debate (2). A recent study examining the effects of ascending or descending order on power output during bench throws reported that an ascending order resulted in the highest power output during BT (2). An ascending order of resistances with the inclusion of a lighter down set may be an effective method of presenting power training resistances.

Rest Periods

The rest period between sets or even repetitions will depend upon the objective of that set, the number of repetitions being performed, the intensity of the resistance, the type of exercise, the training state of the athlete, and the periodization phase. When the objective of the set is to maximize the power output that can be generated with the selected resistance, the rest

Figure 5. As the barbell is lifted through its range of movement, the continuous unfurling of the chains from the floor provides additional resistance acting upon the barbell.

period between sets of a power exercise should be 1–2 minutes, or long enough to ensure that the objective is met. When performing a complex series of a strength and power exercise, anecdotal evidence suggests a 4-minute turn-around period (e.g., a set of bench press, then 90-second rest; a set of bench throw, then 120-second rest before repeating the complex) has been shown to be adequate as demonstrated by the power outputs measured by the PPS. Shorter rest periods (e.g., <1 minute between sets of a power exercise or <3 minutes for a complex) result in reduced power outputs, diminishing the effectiveness of the entire power-training process.

Long-term Progress

Maximal upper body pressing power can still be quite readily increased over the long term, even in advanced trainers. Changes in the load-power curve for a group of 12 elite rugby league players, as well as the individual progression of 1 young rugby league player (player X), across a 4-year period is depicted in Figure 2 (11). While only the 1998 and 2002 data are presented, a relatively gradual increase in power output over the whole 4 years was observed, which paralleled the increases in maximal strength. It is clear that even for advanced trainers such as this group, progression can still be quite pronounced, especially in power output against heavier resistances. The load-power curve for the group as a whole, as well as for player X, has shifted upwards and slightly towards the left. From the graph it is visible that, while power output generated while lifting a resistance of 40 kg (BT P40) changes only slightly, power outputs with heavier resistances of 60–80 kg increases markedly, a favorable situation considering the strong relation between high power outputs generated while lifting 70 and 80 kg in the bench-throw exercise and progress into the elite professional rugby league ranks (2). As power output with lighter resistances improved relatively less than power output with heavier resistances, it is obvious that increases in strength rather than speed accounted for the majority of change. Statistically Pmax is more related to maximal strength rather than speed in these athletes (2).

During this time, player X progressed from playing in the city-based leagues into the ranks of the full-time professional national rugby league. His BT Pmax increased 39%, from 603 to 836 W, while his 1RM BP increased from 135 to 180 kg (33%) at a relatively constant body mass of 110 kg. For the group of 12 subjects as a whole, the BT Pmax increased from 611 to 696 W. This 14% increase appears to be underpinned by a similar change of 14.3 % in 1RM BP (from 129.6 to 148.1 kg) (11).

Table 3
Sample Workout for Combined Bench Press and Bench Throws on a Power-Oriented Training Day During the Peaking Maximum Strength/Power Phase for an Athlete Possessing a 1RM Bench Press of 130 kg.

	Sets	1	2	3	4
1a. Bench throws (Smith machine)	**Wt (kg)**	40	50	60	70
	Reps	5	4	3	3
1b. Bench press + chains*	**Wt (kg)**	60	100*	100*	100*
	Reps	5	1,1,1	1,1,1	1,1,1

1a, 1b. = Alternate exercises as a contrast resistance complex. 1, 1, 1 = 3-repetition cluster sets, rest 15 seconds between each clustered repetition. * = 85 kg barbell resistance + 15 kg in chains attached = 100 kg resistance at lockout.

From this evidence it would appear that the concept of combining maximum strength and power training, using the methods outlined above, can result in enhanced upper-body power output over long-term training periods.

Practical Applications

A number of practical methods used for increasing the effectiveness of upper-body power training have been presented. It is not necessary to use all of these methods at one time to effectively develop maximal upper body pressing power. However, it is not difficult to implement a number of these methods simultaneously. For example, a BP and BT workout to maximize pressing power that entails 6 methods (full acceleration exercise, kinetically altered strength exercise, contrasting resistance complex, low repetitions, ascending order of resistances for the power exercise, and clustered repetitions) is detailed in Table 3. Variation and periodization should influence if, when, and how any of these strategies are implemented.

This paper has mainly addressed the training for maximal power production and especially may be of value for athletes who must overcome large external resistances, such as the body mass of opponents (e.g., football, rugby league and union, wrestling, judo, mixed martial arts). Athletes who require a greater speed contribution rather than pure strength contribution in their power production (e.g., boxing and related martial arts, tennis, javelin) may need to modify their training accordingly, and their load-power curves would reflect this by perhaps showing increased power output with lighter resistances of 10–40 kg. However, many of the methods described above would be applicable to many sporting situations, and it is the job of the astute coach to modify and implement them accordingly. ♦

References

1. Baker, D. Selecting the appropriate exercises and loads for speed-strength development. *Strength Cond. Coach.* 3(2):8–16. 1995.
2. Baker, D. A series of studies on the training of high intensity muscle power in rugby league football players. *J. Strength Cond. Res.* 15(2):198–209. 2001.
3. Baker, D. Acute and long-term power responses to power training: Observations on the training of an elite power athlete. *Strength Cond. J.* 23(1):47–56. 2001.
4. Baker, D. Comparison of maximum upper body strength and power between professional and college-aged rugby league football players. *J. Strength Cond. Res.* 15(1):30–35. 2001.
5. Baker, D. The effects of an in-season of concurrent training on the maintenance of maximal strength and power in professional and college-aged rugby league football players. *J. Strength Cond. Res.* 15(2):172–177. 2001.
6. Baker, D. The acute effect of alternating heavy and light resistances upon power output during upper body complex power training. *J. Strength Cond. Res.* 17(3):493–497. 2003.
7. Baker, D. The acute negative effects of a hypertrophy-oriented training bout upon subsequent upper body power output. *J. Strength Cond. Res.* 17(3): 527–530. 2003.
8. Baker, D., and S. Nance. The relationship between strength and power in professional rugby league players. *J. Strength Cond. Res.* 13(3):224–229. 1999.
9. Baker, D., S. Nance, and M. Moore. The load that maximizes the average mechanical power output during explosive bench press throws in highly trained athletes. *J. Strength Cond. Res.* 15(1):20-24. 2001.
10. Baker, D., S. Nance, and M. Moore. The load that maximizes the average mechanical power output during jump squats in power-trained athletes. *J. Strength Cond. Res.* 15(1):92–97. 2001.
11. Baker, D., and R.U. Newton. Adaptations in upper body maximal strength and power output resulting from long-

term resistance training in experienced strength-power athletes. *J. Strength Cond. Res.* In press.
12. Blazevich, A.L., N.D. Gill, R. Bronks, and R.U. Newton. Training-specific muscle architecture adaptation after 5-wk training in athletes. *Med. Sci. Sports Exerc.* 35(12):2013–2022. 2003.
13. Burke, D.G., T.W. Pelham, and L.E. Holt. The influence of varied resistance and speed of concentric antagonist contractions on subsequent concentric agonist efforts. *J. Strength Cond. Res.* 13(3):193–197. 1999.
14. Duthie., G.M., W.B. Young, and D.A. Aitken. The acute effects of heavy loads on jump squat performance: An evaluation of the complex and contrast methods of power development. *J. Strength Cond. Res.* 16(4):530–538. 2002.
15. Ebben, W.P., R.J. Jensen, and D.O. Blackard. Electromyographic and kinetic analysis of complex training. *J. Strength Cond. Res.* 14(4):451–456. 2000.
16. Ebben, W.P., and P.B. Watts. A review of combined weight training and plyometric training modes: Complex training. *Strength Cond. J.* 20(5)18–27. 1998.
17. Fleck, S., and K. Kontor. Complex training. *NSCA Journal.* 8(5):66–69. 1986.
18. Gulich, A., and D. Schmidtbleicher. MVC-induced short-term potentiation of explosive force. *New Stud. Athletics.* 11(4):67–81. 1996.
19. Haff, G.G., A. Whitley, L.B. McCoy, H.S. O'Bryant, J.L. Kilgore, E.E. Haff, K. Pierce, and M.H. Stone. Effects of different set configurations on barbell velocity and displacement during a clean pull. *J. Strength Cond. Res.* 17(1):95–103. 2003.
20. Haff, G.G., A. Whitley, and J.A. Potteiger. A brief review: Explosive exercises and sports performance. *Strength Cond. J.* 23(3):13–20. 2001.
21. Hydock, D. The weightlifting pull in power development. *Strength Cond. J.* 23(1):32–37. 2001.
22. Jaric, S., R. Ropert, M. Kukolj, and D.B. Ilic. Role of agonist and antagonist muscle strength in rapid movement performances. *Eur. J. Appl. Physiol.* 71:464–468. 1995.
23. Keogh, J.W.L., G.J. Wilson, and R.P. Weatherby. A cross-sectional comparison of different resistance training techniques in the bench press. *J. Strength Cond. Res.* 13(3):247–258. 1999.
24. Moorkerjee, S., and N. Ratamess. Comparison of strength differences and joint action durations between full and partial range-of-motion bench press exercise. *J. Strength Cond. Res.* 13(1):76–81. 1999.
25. Newton, R., W. Kraemer, K. Hakkinen, B. Humphries, and A. Murphy. Kinematics, kinetics and muscle activation during explosive upper body movements. *J. Appl. Biomech.* 12:31–43. 1996.
26. Newton, R., A. Murphy, B. Humphries, G. Wilson, W. Kraemer, and K. Hakkinen. Influence of load and stretch shortening cycle on the kinematics, kinetics and muscle activation that occurs during explosive bench press throws. *Eur. J. Appl. Physiol.* 75(4):333–342. 1997.
27. Wilson, G., R. Newton, A. Murphy, and B. Humphries. The optimal training load for the development of dynamic athletic performance. *Med. Sci. Sports Exerc.* 23:1279–1286. 1993.
28. Young, W., B.A. Jenner, and K. Griffiths. Acute enhancement of power performance from heavy load squats. *J. Strength Cond. Res.* 12(2):82–84. 1998.

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