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Acute and Long-Term Power Responses to Power Training: Observations on the Training of an Elite Power Athlete

Daniel Baker
Sport and Exercise Science
University of Sunshine Coast
Maroochydore DC QLD 4558
Australia

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BECAUSE OF THE LIMITED TIME frame for force application in most sports, an often desired result of the strength training process is increased power (force × velocity) (20, 22). Power development (and furthermore, how power is affected by training variable manipulation) is of keen interest to coaches, athletes, and sport scientists. The purpose of this article is to discuss the acute and long-term responses to power training in an elite power athlete.

Wilks (21) has stated that training programs need to be considered in the context of the multiyear, training year, macrocycle (long cycle), mesocycle (monthly cycle), microcycle (weekly cycle), and single training day/unit periods. The adaptations in power, and to a lesser degree strength, across these periods will be discussed, with special reference to the manipulation of training variables that may account for these changes.

The subject for this report is an elite power athlete (a springboard diver I trained for 3 years) who has competed at 2 Olympic and various international competitions. Before commencing the program discussed below, this athlete had already had an extensive training background in plyometric and acrobatic training, which is performed as part of the dry-land training for divers, as well as general experience in weight training.

During the multiyear training period, an extensive amount of data concerning maximal leg extensor power was collected with the plyometric power system, a modified Smith machine weight-training device that measures the distance and speed of barbell displacement. Software uses these data to determine the average mechanical power output for the concentric portion of a repetition during barbell jump squats (or bench press throws) (5, 6). The collection of power output data from various training and testing sessions has allowed the accurate monitoring of both the acute and long-term power responses to the training process.

Definitions Used in Power Training

Intensity for strength training is defined in a number of accepted manners (e.g., 5 repetition maximum [5RM] or a percentage of 1RM). However, intensity in power training may refer to the percentage of maximum power output. Therefore, intense power training resistances are those resistances that allow for power output to be close to the maximum possible. Consequently, an intense power training session may require that the athlete generate a power output of 80–100% of his maximum even though the resistance may be only 40–60% of his 1RM. For example, a resistance of 50% 1RM may be a very low intensity for strength training if performing squats, but it may equate to the highest intensity for power training if performing barbell jump squats. Here, high-intensity training of both strength (>80% 1RM) and power (>80% maximum power) were always aligned together (and vice versa) in the weekly cycle. As such, the term "high-intensity training week" refers to a week where strength and power training intensities were both high.

I use the term "volume" to refer to the total number of repetitions of a workout, microcycle, mesocycle, and so on. "Load" is used to refer to the resistance placed on the barbell or on the athlete during loaded vertical jumps. Load volume will relate to the volume multiplied by the load.

■ Training Philosophy

Across a multiyear period, training was directed by the philosophy of increasing the power output, initially by primarily instituting a general strength stimulus followed by a special power stimulus and finally converting this increased power into more sport-specific power. Thus training may be directed by the philosophy of general, special, and specific adaptations induced through general, special, and specific strength-training prescriptions (2, 3). The strength coach prescribes exercises, volumes, and intensities according to their diagnosis of the athlete and the intended effects of the prescription in response to the diagnosis (2). Examples of the training programs used by this athlete are detailed in previous research (1, 4).

Increases in strength largely account for increases in power in the early stages of training; however, with increased adaptation, the general strength stimulus will not provide an adequate overload in the direction that the power athlete needs to take (3, 16). This could be attributed to the fact that many sports movements typically require a concentric force production time of less than 500 ms (for example, 100 ms in sprinting [19] and 250–300 ms in jumping [12, 16]), which is typical of the times executed by this power athlete in training and competition. However, heavy squats, one of the main training exercises used for lower-body strength development, may require concentric contraction times of 1.5–2 seconds (14). Thus the neuromuscular system of the power athlete needs to be trained to produce power over a shorter time (<500 ms) than the maximal strength exercises can provide (20, 22).

Consequently, to bring about further positive adaptations in power output and vertical jumping performance, increasing emphasis may need to be placed on special exercises, such as barbell jump squats, and specific exercises, such as loaded vertical jumps (resistance 1–5 kg) (3).

■ Assessing the Power of an Athlete

Maximal Power Output

Monitoring of the effects of power training can take place by monitoring the maximal power output (P_{max}) (5, 6). The P_{max} for the lower and upper body can be assessed by performing jump squats and bench press throws (or incline bench press throws), respectively. The P_{max} is very highly correlated (r = 0.79–0.87) to maximal strength (S_{max}) and maximal speed (r = 0.39–0.75) (5, 6). Consequently the P_{max} would appear sensitive to changes induced by speed or strength training. By monitoring the changes in P_{max} or P_{max} per kilogram of body mass across years or training cycles, the effectiveness of the training induced stimulus can be determined.

Understanding the Load and Speed Contribution to Power: The Load-Power Curve

As the resistance to be overcome increases, there is a reduction in movement speed (17). However, the power output will increase up to a certain point, regardless of the reduction in speed, because of increased barbell mass (and hence force production) contributing to the power equation. At some point, increased resistances will result in a marked decline in speed, which will negate the increase in force, and thus power output will begin to decline (Figure 1). The barbell resistance with which the P_{max} is achieved is called the maximal power load, or P_{max} load (22). In Figure 1, the power output increases with increased barbell loads till the P_{max} is achieved with 90 kg (the maximal power load), and then power output starts to decrease with 100 kg.

Resistances below or above the P_{max} load (submaximal and supramaximal power loads, respectively) also have value in that they allow for a load-power profile to be developed, which may help monitor training. Hakkinen and Komi (11, 12) and Hakkinen et al. (13) have used an essentially similar method of analyzing the jump height–barbell load profile to monitor the effects of power, maximal strength, or competitive weightlifting types of training.

The shape and nature of the load-power curve will alter in response to the type of training undertaken. Light resistance power training, with an emphasis on speed rather than pure force, will tend to improve power primarily at the left end of the curve, where resistances are low (12, 15). Maximal strength training may only improve power at the extreme right side of the curve, where re-

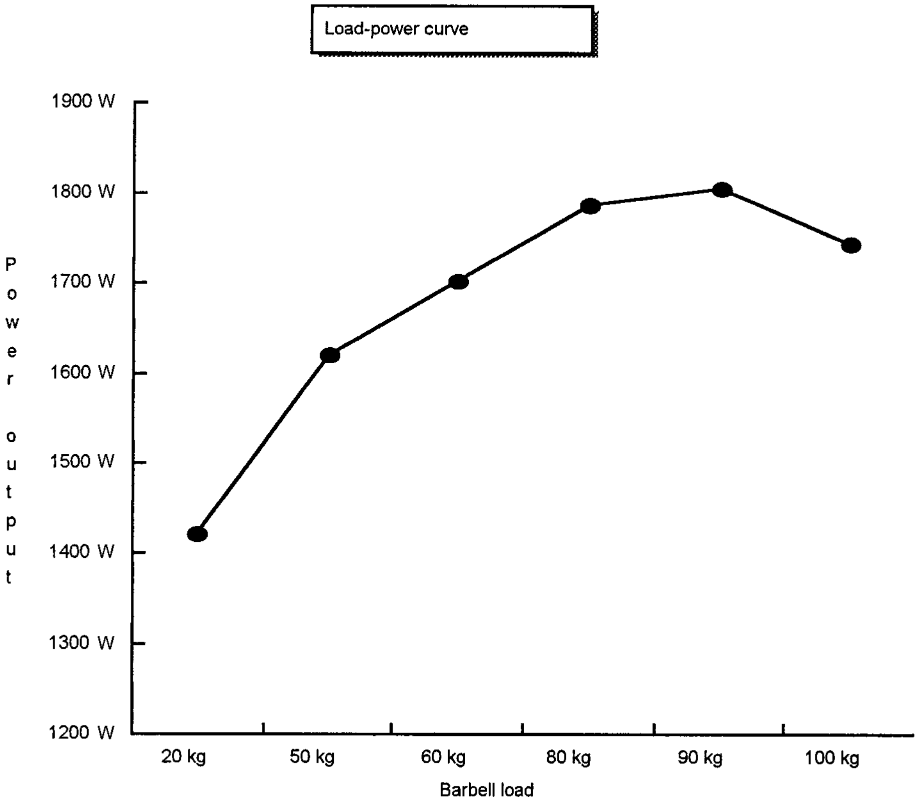

Figure 1. **The load-power curve after 12 weeks of combined strength and power training.**

sistances to movement are high (11, 15). A combined approach, which theoretically should suit most athletes, may induce improvements throughout the entire load-power curve. The entire load-power curve should shift upward and to the right as a result of a combined methodology aimed at improving S_{max} and P_{max} through general, special, and specific strength training.

Monitoring the Responses to the Prescribed Training

Multiyear Responses to Power Training

The objective of the power training process is to ensure that athletes have the muscle power to perform the tasks their sport requires to the best of their ability. The levels of performance in most sports increases every year, and consequently, performance measures such as the P_{max} or power output against certain absolute resistances must also increase across multiyear periods. It was determined for this athlete that both the P_{max} and the power output with light loads such as 20 kg (P20), during which there is a shorter foot contact time (12) and hence may be more sport specific, needed to be improved.

An analysis of the multiyear improvements in power at the completion of various strength or power phases indicates that power may still be improved in an elite athlete (Table 1). In 1993, the maximal power output was 1,448 W (produced during jump squats with 30 kg), whereas in 1995, the maximal power output was 1,811 W (produced during jump squats with 90 kg), an improvement of 25%. The power output during jump squats with a 20-kg barbell (P20) also improved 16.3%, from 1,266 W to 1,472 W.

For the power athlete described in this article (aged 26 years, body mass 74–77 kg, height 178 cm), the 5RM full squat and bench press increased from 80 and 60 kg in late 1993, to 120 and 85 kg by mid-1995. The higher level of S_{max} has allowed the athlete to perform power training with much heavier loads, resulting in increased P_{max} over the multiyear cycle. For example, in late 1993 with the full squat 5RM at 80 kg, jump squats were only performed with loads up to 20–42.5 kg (approximately 20–45% of the estimated 1RM of 95 kg). By mid-1995, the 5RM full squat was 120 kg, resulting in jump squats being performed safely and routinely with 70–90 kg, and even 100 kg on occasions

Table 1
Changes in P_{max} and P20 (W) Across a Multiyear Training Period

Variable	October 1993	November 1993	December 1993	March 1995	August 1995	December 1995
P_{max}	—	1,448	1,491	1,571	1,811	1,774
P20	1,266	1,281	1,339	1,362	1,440	1,472

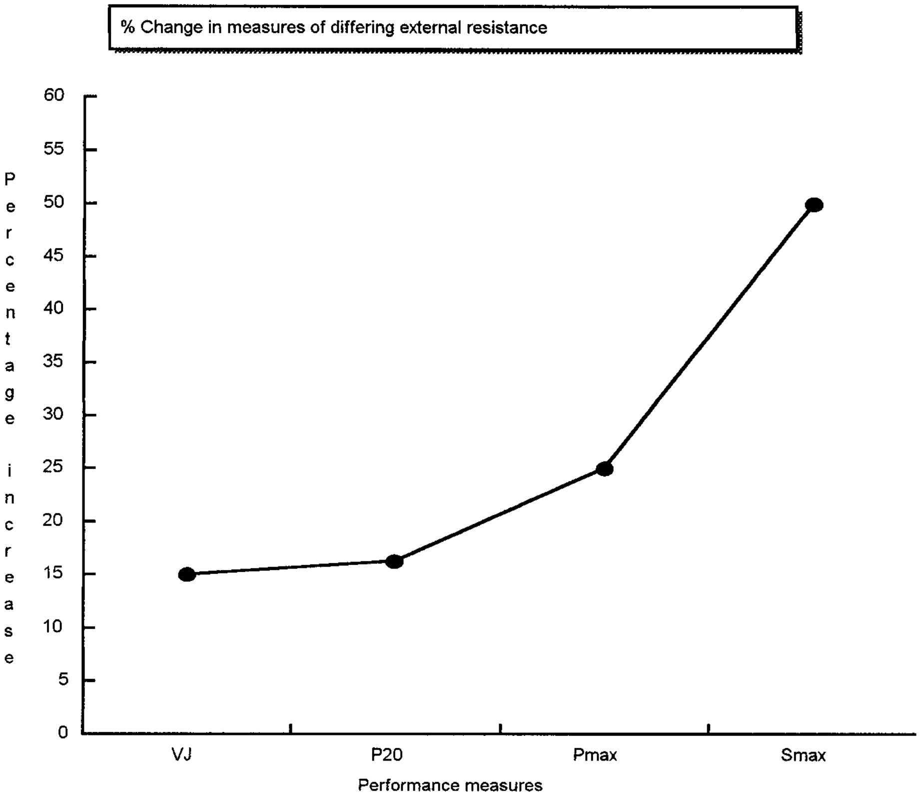

Figure 2. **The percentage change in performance measures of differing external resistance across the multiyear period. The VJ represents no external resistance, whereas the Smax represents a large external resistance (5RM full squat).**

(approximately 50–65% of the estimated 1RM of 140 kg).

The majority of the improvement in power could be attributed to the introduction of a methodical strength/power training process, with an increased emphasis on heavy full squats and jump squats. In 1993, it was assumed that the athlete needed a higher level of maximal strength so that the conversion to maximal power could take place. He already possessed extensive training in plyometrics; thus the first stage of the multiyear plan was to increase S_{max}. Furthermore, S_{max} had to occur, initially by emphasizing the contractile elements of the musculature but without significant hypertrophy; jump ability is negatively correlated to body mass (7).

Research conducted in 1994 on elite male divers, which included this athlete (4), has indicated that over 50% of the improvement in a sport-specific vertical jumping movement could be attributed to the change in the contractile contribution to jumping (the concentric-only squat jump measure). Thus, to improve performance, the contractile components of the musculature needed to be emphasized by heavy resistance training in power athletes whose training history had been marked by low-resistance, high-speed training (e.g., plyometrics).

Although the S_{max} and P_{max} level are of considerable importance, it should be remembered that power performance with light resistances and at higher speeds is also important for a number of sports (for sports where the resistance to movement is lower and speed higher than may occur during the achievement of the P_{max} load). Consequently, the power developed with light resistances and at higher speeds also provides information pertinent to the speed aspect of the power equation. Loads of 15–40 kg require only 300–350 ms for the concentric execution time (12), which is typical of the times used by this athlete in competition.

Thus, although the overall load-power curve has shifted upward and to the right, the degree of change at different points of the curve has varied across the multiyear period. S_{max} has increased by approximately 50% and P_{max} has increased by 25%, whereas P20 has increased by 16.3%. Of importance is the fact the jump and reach score improved from 63 to 74 cm in this time, a 15% increase. Thus, the larger the magnitude of the external resistance, the greater the increase in performance over the multiyear period. This is not unexpected, as the athlete already possessed a far greater training history in plyometrics and acrobatic drills (e.g., somersaults), as compared with heavy resistance training, and should therefore improve less in this fast end of the power curve relative to the improvement possible in S_{max} and P_{max} levels.

Accordingly for this power athlete, the most fundamental change across a multiyear training period was the increase in P_{max}, which may be largely attributable to an increase in S_{max}. The use of higher loads in typical power exercises such as jump squats resulted in marked improvements in maximal leg power and in corresponding increases in various vertical jumping performance measures.

Yearly Responses to Power Training

Across any training year, there may be a number of competitions at which the athlete needs to perform at a high level. The strength coach may only receive the athlete for a short cycle (4–6 weeks) or for a longer macrocycle (12 weeks), depending on the competition calendar or the coach's decisions. Consequently, the training year and competition calendar may affect the choice of overall micro-, meso-, and macrocycle structure to be implemented.

Performance measures therefore vary according to the state of training of an athlete within a yearly cycle. P_{max} and various other measures can fluctuate, depending on whether the athlete is at peak, at midcycle, or at the beginning of a macrocycle, or depending even on how long a macrocycle is. Consequently, an athlete's progress must take these factors into account. It is not prudent to implement a test battery midway through a training cycle and expect an elite athlete to be at peak levels of performance.

The phases of volume and intensification inherent in any periodized training plan appear to impact acutely on muscle power. By analyzing the results of testing in 1995, it is clear that P_{max} increases at the end of a training cycle when the athlete is tapered, and decreases after intense sports competitions and the ensuing active recovery phase, which coincides with the start of the next macrocycle (Table 2). This is, of course, not unexpected.

Table 2
P_{max} (W) Levels Across Different Stages of 1995

Time	Macrocycle	Pretest	Posttest
January–February	1	NT	1,571
May–August	2	1,426	1,811
October–December	3	1,661	1,774

Note: Macrocycle 1 lasted 5 weeks; macrocycle 2, 12 weeks, and macrocycle 3, 10 weeks. NT = not tested.

The P_{max} was not measured early in 1995, as this was during the competitive in-season; however, a short cycle of power training was implemented immediately after these early competitions. At the completion of this short cycle, the P_{max} was 1,571 W. However, after the athlete competed in more competitions and had a phase of active recovery, the P_{max} was reduced to 1,426 W, 91% of the previous peak P_{max}. This is also not unexpected because of the effects of intense competition and the cessation of the strength/ power training stimulus.

Significantly, the following strength/power macrocycle was the longest strength/power macrocycle of the athlete's career; the athlete was preparing for international competition. Consequently, the P_{max} increased markedly, up to 1,811 W. With the commencement of the last macrocycle of the year, which commenced after competition and active recovery, again the P_{max} was lowered to a level of 92% of the previous peak P_{max}. However, after 10 weeks of training, it was again back to virtually the same peak level of 1,774 W (a slight reduction in body mass of 1 kg meant the P_{max} per kilogram of body mass was the same as in the preceding macrocycle).

The importance of this information is that it reveals the peak and valleys in P_{max} and power output in relation to the peaks in intensity and cessation of the strength/power training macrocycles. However, with increased exposure to power training, the troughs in P_{max} can actually be higher than the peaks from preceding macrocycles. For example, the starting P_{max} of macrocycle 3 was 1,661 W, which is 5.7% higher than the peak P_{max} of 1,571 W from macrocycle 1. Also, the intense competition and cessation of strength/power training resulted in the P_{max} being reduced to about 90–92% of the previous peak P_{max}. This level may indicate the residual or base level of power from which athletes tend to launch into a peaking cycle.

As body mass for this athlete varied only 2.5 kg (3.3%) over the year, these changes in muscle power must be ascribed as attributable to other factors, such as changes in the neural firing of the muscles (12) or fiber changes gravitating the muscle to more inherently powerful contractions (20). Thus analysis of the data reveals not only the general upward trend in P_{max} but also the temporary negative impact following intense competition and cessation of the strength/power stimulus.

Macrocycle Responses to Power Training

Of interest is the effect of the acute manipulation of training volume and intensity on the P_{max} and power output against submaximal loads across a macrocycle. Macrocycle 2 of 1995 has been chosen for analysis because the athlete

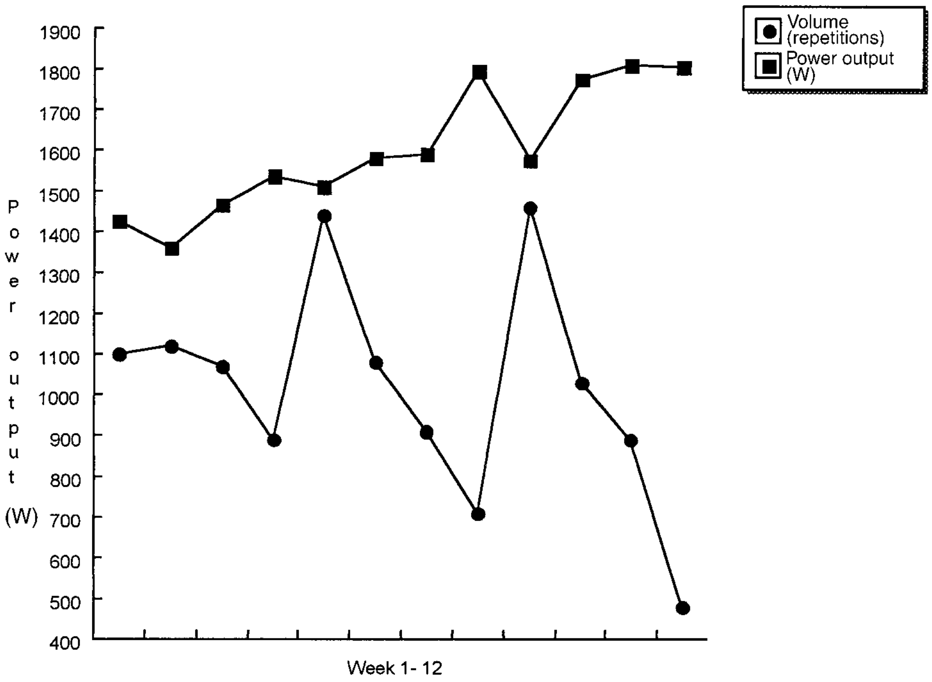

Figure 3. **Relationship between training volume (total number of repetitions) and power output (W) across a 12-week macrocycle. When training volume is higher and intensity is lower, power output is usually reduced, and vice versa.**

made considerable improvement in P_{max} in this cycle, despite the starting P_{max} being at 92% of the preceding P_{max} from macrocycle 1. Most improvement could be expected to be from the acute affects of manipulating the exercise selection, volume, and intensity, rather than the simple reconditioning or regain of the neuromuscular system back to normal levels that appears to account for most improvement when athletes have long layoffs.

Figure 3 depicts the general inverse relationship between training volume and power output. In this example, the volume refers to the total number of lower-body repetitions (loaded vertical jumps, jump squats with barbells, and full squats). When the volume is high, the intensity is proportionally lower, and power output is lower. However, when volume is sharply decreased and intensity increased, there is generally a large increase in power output. This was very clear in weeks 4, 8, and 10–12, in which drops in training volume and increases in intensity gave rise to an increase in power output. Conversely, in week 9, where there is a sudden increase in volume and a decrease in intensity, a drop in power output was clearly visible.

Thus the pattern in power output mirrored fairly closely the pattern of the periodization of the macrocycle. In each of the fourth weeks of the 3 mesocycles within the 12-week macrocycle, there was a large drop in volume and an increase in intensity, resulting in an increase in power output. A higher volume, lower intensity training week would always follow these weeks (i.e., weeks 5 and 9), and power output was always reduced during these weeks. This is especially noticeable in week 9, as the athlete was in very good shape and hence more affected by the acute manipulation of volume and intensity (as opposed to the early weeks of a cycle when it is relatively easy to regain strength lost because of the cessation of resistence training). Of importance is the fact that week 9 was also a shock week in terms of the sport training. In this context, "shock" refers to a large increase in sports training volume and difficulty (i.e., the total number and degree of difficulty of dives within the training week). This shock week, in terms of sports training and strength/power training, serves as the last volume-oriented training stimulus before commencing the tapering of volume with the concomitant rise in intensity and technique, in preparation for competition.

By examining the data across a macrocycle, it is evident that the power output is susceptible to acute manipulation of volume and intensity. The highest power outputs are associated with training weeks of reduced volume and increased intensity. High-volume training, both from the strength/power and sports training orientations, causes a temporary decrease in power output. These sudden increases and decreases in power output may be attributed to neural-related alterations, fiber-related alterations, or both (20).

Mesocycle Responses to Power Training

Within a mesocycle (a period of 3 or 4 weeks), power output increases in accordance to decreases in training volume and increases in intensity. Figure 3 displays 3 mesocycles with clear increases in power output coinciding with decreases in volume. Although this is clearly evident, what is not clear is the effect of varying the method of increasing intensity in power training. In training for increased muscle power, increased intensity may be deemed to occur through increased speed of lifting or through increased mass being lifted.

Thus it is sometimes argued that power training mesocycles need not include exercises that emphasize the strength contribution to power output and that increased intensity can occur through purely a speed orientation to the power output after the strength base has been established. This would entail light jump squats and plyometrics and no heavy resistance squats. Although this power via speed methodology does theoretically intensify the power training process, in my experience, it may not be the best method to increase power (see Newton and Kraemer [16] and Tidow [20] for reviews).

My experience is that a mesocycle emphasizing very light, speed-oriented training, such as light jump squats (20–30 kg), loaded jumps, and plyometrics have less effect on power performance than does a mesocycle with a more holistic training content, such as heavy and light jump squats, loaded vertical jumps, full squats, and power shrug jumps. A unidirectional training content probably neglects parts of the multifaceted nature of muscle power. Very light, high-speed training or very heavy strength training are both examples of unidirectional training insofar as they attempt to improve performance through only one avenue (speed or strength). A combined methodology would appear to offer more avenues for increasing power output (16, 20).

Two mesocycles with different content were therefore chosen for analysis. The final 3-week mesocycle of a 9-week macrocycle in 1993, which emphasized the speed and light load method (no strength training exercises such as full squats) resulted in the P_{max} improving from 1,458 W to 1,491 W, a change of only 2.3%. However, a 4-week mesocycle performed in 1995 and emphasizing the holistic approach to power development, which included heavy and light jump squats, loaded vertical jumps, depth jumps, and full squats, appeared to garner better results. The P_{max} improved from 1,537 W to 1,793 W, an increase of 16.7%. It is of interest that advanced strength-power athletes usually improve less with increased exposure to training (10, 13), but this elite athlete improved considerably more.

The more holistic approach to power training within a mesocycle would offer more avenues through which the complex nature of power development may be addressed (16). Thus, although a mesocycle may be deemed to be either a "basic strength" or "peak power" mesocycle according to the tenements of fundamental strength periodization (18), this does not mean that the training content of that mesocycle should be solely unidirectional. For a power athlete, a mesocycle may contain elements that emphasize the general, special, and specific nature of strength/power (2, 3). What probably needs to be altered in each mesocycle is the number of general, special, and specific exercises and the exact amount of volume and intensity thereof.

Microcycle Responses to Power Training

Power output will be acutely affected by the manipulation of volume and intensity within a training week. In strength/power training, there is usually a methodical system of altering the volume and intensity within a week. For example, if the athlete performs lower body strength-power twice a week, then 1 day is the prescribed heavy day and the other the light day (although in actuality, it is a medium day, which feels lighter in comparison to the heavy day). For 3-day-a-week training, the prescription is usually heavy-light-medium. These differences in training intensity provide a form of contrast in loading that appears to be effective for power development.

The rationale for these contrasting load methods is that the heavier loads superstimulate the nervous system so that the lighter loads feel lighter and hence can be moved with more force and speed (i.e., the force required for lifting the heavier loads is applied to the lighter loads), resulting in greater power outputs (8, 9). Conversely, the lighter loads, which are moved at far greater speeds (17), may have the effect of stimulating faster movement with the heavier loads. With very heavy loads, the main factor resulting in diminished power is the marked decrease in lifting speed (17).

For this athlete, strength-power training was performed twice per week with the heavy-light system of applying overload in jump squats. Typically, the first day, which was the designated light day, would entail a straight sets method of overload whereby the barbell load is held constant (e.g., 4 × 4 at 45 kg). The second day, the heavy training day, would typically entail the use of more sets and also contrasting loading that entailed exposing the athlete to alternating sets of heavier and lighter barbell loads (e.g., 3 × 4 at 30 kg alternated with 3 × 4 at 70 kg).

In the example above, the best

Table 3

Power Output During Barbell Jump Squats in Response to Variations in Overloading Within the Weekly Training Cycle

Variable	Day 1 (5 × 4)	Day 2 (6 × 3)
Set 1		
Power (W)	1,496	1,615
Resistance (kg)	40	50
Set 2		
Power (W)	1,578	1,718
Resistance (kg)	40	60
Set 3		
Power (W)	1,539	1,728
Resistance (kg)	40	70
Set 4		
Power (W)	1,555	1,626
Resistance (kg)	40	50
Set 5		
Power (W)	1,557	1,696
Resistance (kg)	40	60
Set 6		
Power (W)	-	1,774
Resistance (kg)	-	70

power outputs generated during training with those loads within the training week were 1,565 W at 45 kg, 1,492 W at 30 kg, and 1,750 W at 70 kg. Therefore, there is marked contrast in power outputs within the microcycle between the light (1,565 W) and heavy (1,750 W) training days as a result of varying the barbell load. Accordingly, power is trained across the spectrum of the load-power curve.

Another method of loading that can be used in the later weeks of a meso- or macrocycle is the wave method, which is also a method of contrast loading. Table 3 depicts an example of this method of weekly overloading performed in week 10 of a 12-week macrocycle. This trend is evident in the power outputs listed in Table 3 for the day 2 (heavy day) workout. The second sets of jump squats, performed with the lighter 50-kg and heavier 70-kg weights, both increased, although by only small amounts, most likely because of posttetanic potentiation of the neural system (9). However, such small increases in power output may result in a larger cumulative effect across time.

Thus, within a microcycle, power may be trained across the load-power spectrum by varying the barbell load, and this may cause the entire load-power curve to be shifted upward rather than merely elevating one end of the curve (e.g., through strength-oriented training or speed-oriented training).

Training Unit Responses to Variations in Loading

As discussed above, 2 main methods of applying overload were used within a training unit: the constant load method and variations of the alternating or contrast loading method. The contrasting load method was seen as the most effective method for the long-term stimulation of the neuromuscular system of an athlete well accustomed to plyometric and jump training (8, 9).

In earlier training of young elite female divers, it was found that the use of a set of heavier full squats between sets of light jump squats resulted in an average increase of 17% in jump height (1). This result seemed to validate the effectiveness of contrast loading on performance. However, with young female divers unaccustomed to strength training, it may be relatively easy to achieve this rapid increase in jump squat height, as their initial performance may be hindered to a degree by inhibitory feedback. It could be argued that the heavy full squats may result in the disinhibiting of the inhibitory feedback of the tension receptors (Golgi tendon organ and Renshaw cell), resulting in a sudden increase in myoelectrical output, and as a result an increase in jump squat height. It is doubtful that such large increments in performance could be expected by athletes who are accustomed to strength/power training. Nonetheless, the effectiveness of contrast loading within a training session for power development needs to be more thoroughly investigated and validated.

Recently, it has been shown that a set of heavy half-squats or a series of maximal isometric contractions in between jumps resulted in a much smaller (approximately 2%), though significant, increase in jump height (9, 23).

To determine the effects of contrast loading within a training unit on an advanced athlete, the results for an entire macrocycle were examined. Ten workouts contained contrast loading during

Table 4
Results for Power Output in Response to Contrast Loading Within a Training Unit Across 10 Observations (Mean ± Standard Deviation)

	Power output (W)	
Load	**Set 1**	**Set 2**
Light (mean, 31.5 kg)	1,480 ± 126	1,517 ± 153
Heavy (mean, 46.0 kg)	1,567 ± 156	1,582 ± 165

Note: Set 1 of a light load is followed by set 1 of a heavy load, then set 2 of a light load, etc.

jump squats (heavy and light jump squats), and the results of the effects of this method of loading on power output are summarized in Table 4. It was found that the power output of the second set of light jump squats, performed after a heavier set of jump squats, increased by an average of 2.7% across the cycle. The second set of heavier jump squats increased by only 1%. As the athlete had already completed an extensive warm-up and had also performed 4 to 6 sets of other jumping exercises, such as loaded vertical jumps, it is doubtful that these acute changes in power output could be attributable to a simple warm-up effect.

Given this result, it would appear that the performance of a set of heavier load jump squats in between sets of lighter load jump squats results in a significant increase in power output for the lighter load jump squats. This may be attributable to the stimulating or disinhibitory effect of the heavier load on the neuromuscular system (9). However, the lighter, faster set appears to have less influence on an increase in performance of the heavier set.

It should be noted that if the power produced against a certain load needs to be increased, then this load probably needs to be the lighter load. A heavier contrast load is then utilized as a tool to superstimulate the neuromuscular system so that the performance with the lighter load is improved. In this example, across the macrocycle, the light load averaged 31.5 kg, whereas the heavier load averaged 46.0 kg. Thus it might not be necessary to always use heavy squats to provide a contrast in loading within a training unit. A slightly heavier version of the basic movement may suffice in this regard.

On the basis of these results, it can be shown that the acute manipulation of training intensity may affect the power output in subsequent sets. Therefore, the use of alternating loads that are in contrast may prove an effective training unit method for power training.

Conclusion

The power responses of an elite power athlete to strength/power training across a number of different training periods and cycles has been presented and discussed. The data presented illustrates that power output is clearly affected by the acute and long-term manipulation of training variables such as exercise selection, volume, and intensity.

Power output is generally highest when training intensity is highest and volume concomitantly lowest. Specific variations in loading, such as the use of contrast loading, may have a significant acute effect on power output. Changes in S_{max} and P_{max} generally underlie the changes in other performance measures, such as vertical jumping performance. There would also appear to be a diminishing transfer of the improvements induced by training from the strength end to the speed end of the load-power spectrum. ▲

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Daniel Baker is affiliated with the department of Sport and Exercise Science, University of Sunshine Coast, Maroochydore, Australia.