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Sport & Fitness

Strength and Conditioning for Peak Performance

Research Reviews

Volume and Intensity

Planning and Implementing Tapers for Endurance Athletes

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Tapering for Endurance Athletes

Ed McNeely, M.Sc

For many athletes a year of training comes down to one major race when strength, skill, speed, endurance and tactics all need to come together at the right time. Tapering during the final preparation for competition is both an art and a science. A taper is a period of drastically reduced training volume that lasts from seven to 21 days prior to the year's major competition (Costill et al., 1985; Houmard and Johns, 1994). The stress of preparing for a competition combined with changes in training routine and travel can make planning a taper tricky particularly when dealing with a team of athletes where different needs and personalities must be accommodated. A good understanding of the science behind

tapering will increase the chances of a successful taper and a good performance.

The Training Process

The objective of training is to induce physiological, psychological, technical and mechanical changes in an athlete so that their performance improves. Training is often thought to follow a simple process based on Hans Selye's general adaptation syndrome where a training session creates a stress that results in fatigue and subsequent decrease in performance. If sufficient time is allowed, this is followed by a recovery period and then adaptation. Performance improvements occur incrementally as this cycle is repeated session by session. While this is an attractive theory and works pretty well for single factor sports where only strength, speed, or endurance are needed and long periods between training sessions allow for complete recovery and adaptation it oversimplifies the process of developing an athlete who needs strength, endurance, speed, and power to succeed. A more realistic view of the training process has been proposed by Zatsiorsky (1995), who suggests that fatigue accumulates over time, masking the full extent of the underlying physiological and performance adaptations that are occurring. When the training stress is removed or decreased the body continues the fatigue dissipates allowing the full effect of the training period to be seen.

Dealing with different personalities during a taper can be challenging for a coach

Adaptations to a Taper

When the training stress is removed and fatigue diminishes, during a taper there is a 3-11% improvement in performance (Houmard, 1994; Johns et al. 1992; Zarkadas et al., 1994). There are many physiological adaptations that are allowed to fully express themselves once the fatigue from constant training is removed during a taper.

Aerobic Fitness Adaptations

Aerobic fitness in athletes is most often measured with VO_2 max or submaximal lactate measures to determine anaerobic threshold. Many athletes and coaches assume that VO_2 will increase during a taper, this does not appear to be the case, almost all studies show no changes in VO_2 max during the taper period. While maximum aerobic power may not be increased other measures of endurance performance indicate

that tapering can improve endurance capacity. Hemoglobin, the oxygen carrying component of the red blood cell and hematocrit, the number of cells in the blood, values have been shown to increase during the first seven days of a taper, improving the oxygen carrying capacity of the blood (Yamamoto et al. 1988). There is an increase in oxidative enzymes in the muscles (Neary et al. 1992; Sheply et al. 1992). The oxidative enzymes are catalysts for the chemical reactions that allow the body to work using the aerobic energy system. Increases in oxidative enzymes increase the amount of energy produced and the amount of work performed. Glycogen, the stored form of carbohydrate in the muscles, increases during a taper (Houmard and Johns 1994) but probably doesn't play a major role in the performance improvements athletes in events under 60 minutes long experience from a taper because these races are too short to deplete glycogen stores. Increased glycogen stores should be a major concern for endurance athletes. When glycogen is stored in the muscles there are 3-4 grams of water stored with each gram of glycogen. This can cause an increase in body weight of 2-3 lbs that may affect speed and endurance in the early part of a race.

Strength and Power Adaptations

Sport specific muscle power increases during a taper (Johns et al., 1992) are greater than the improvement in aerobic fitness and account for most of the taper induced performance improvement. Following a taper there are increases in the strength, speed of contraction and power of both fast twitch and slow twitch muscle fibers (Trappe et al, 1998) High volumes of aerobic training and strength and power improvements are incompatible, aerobic training inhibits nervous system

Table 1. Minor Taper

Taper	Day 1	Day 2	Day 3	Day4	Day 5
One Day Taper	OFF				
Three Day Taper	OFF	5 x 150 m, followed 20 minute steady state	3 x 250 m, followed 20 minute steady state		
Five Day Taper	3 x 1500m just below race pace	45 minute steady state	5 x 100m sprints, 3 x 500m, 1x 1500m, 20 minute steady state	4 x 500m, 30 minute steady state	4 x 250m, 30 minute steady state

mechanisms that are responsible for strength and power production and prevents the increases in muscle mass needed to increase strength. The demands of aerobic high intensity or high volume aerobic training cause muscle tissue to be broken down for energy. This muscle damage can be measured by an accumulation of an enzyme, creatine kinase (CK), in the blood. Endurance athletes have chronically elevated levels of CK during the training year, which is reduced by half during a taper (Costill et al. 1986; Yamamoto et al. 1988), indicating that the muscles are fully recovered because of the reduced training volume.

Designing Your Taper

Not every athlete will benefit form a taper. Before you get too excited about tapering you should consider your need for a taper. Novices, with limited training experience will not see much improvement from a taper. Novice athletes will probably benefit more from a continued higher volume of training leading into a race followed by 1-2 days off just prior to the race. This is because most novices haven't mastered the technical skills of their sport to the point that they are going to be limited by their fitness. A higher volume of skill and tactical work leading into a race will probably pay bigger performance dividends than a taper.

Athletes who are training less than six hours per week will not benefit much from a true taper. These athletes can take a day or two off immediately before a race and be sufficiently recovered to race at their best. If you fall in to this category you may want to plan a short sprint training session about mid week before the competition, focusing on starts and sprints of up to 500m. This would be the last training day of the week before taking two days off prior to the race.

Choosing your races for the year is one of the first steps in designing your training program. Tapers can be used before most competitions or important tests that are part of team selection but you should make judicious use of tapers using one major taper, 2-3 moderate tapers and no more than 3-4 minor tapers per year. Tapering more frequently than this will decrease your yearly training volume to the point that performance will be negatively affected.

If you are going to do more than eight races per year, treat the extra races as hard training sessions. Focus on a specific technical, or tactical aspect of the race rather than just wins and losses. For instance you may want to work on your start or your ability to make a move in the final kick. Learning about your ability in different parts of the race will help you refine your training program and let you create a better race plan for your major competition.

Table 2. Duration of Major Taper

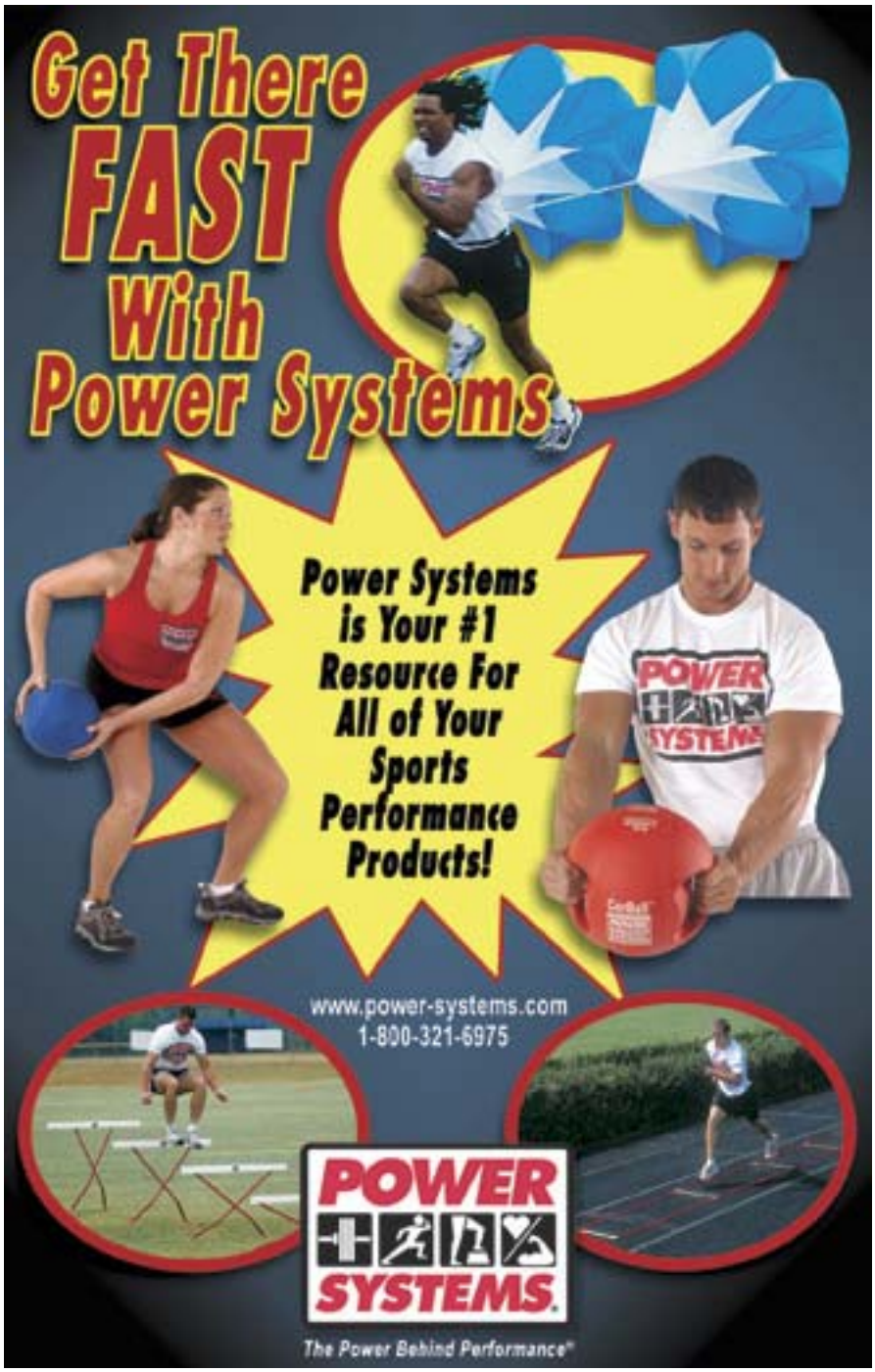
Training Hours/Week	Duration of Major Taper
6-10	7 days
10-15	14 days
15+	21-30 days

Minor Taper

The minor taper is used prior to tests and less important races like club events that aren't used as qualifiers. The design of the minor taper depends on normal

training volume. Athletes who are training 6-10 hours per week will take one day completely off before the test or race, those training 10-15 hours per week will use a three day taper, and those training more than 15 hours per week will use a five day taper. A minor taper for an athlete in a race that lasts 45 minutes or less can be seen in Table 1.

continued on page 10



Fun Facts

If all the blood vessels in your body were laid end to end, they would reach about 60,000 miles.

Your tongue has approximately 3,000 taste buds.

Locusts can eat their own weight in food in a day. A person eats his own body weight in about half a year.

The fastest bird is the peregrine falcon. It can fly at a speed of 168-217 miles per hour.

Research Reviews:

the Science of Training

Acute Hormonal and Neuromuscular Responses and recovery to Forced vs. Maximum Repetitions Multiple Resistance Exercises

Ahtiainen, J.P., A. Parkarinen, W.J. Kraemer, and K. Hakkinen.
International Journal of Sports Medicine. 24: 410-418, 2003.

Whether the goal of a strength training program is to increase strength, muscle mass, athletic performance, or a combination of each, there are numerous techniques that can be used to keep the muscle adaptations the athlete has made from nose-diving and to prevent them from stagnating. Forced repetition training is one such technique that has been used with some success, at least anecdotally. This training technique involves the help of a spotter to perform one or more extra repetitions after the muscles have fatigued. Although the technique is routinely used by powerlifters and bodybuilders, there is little information to confirm its effectiveness. A recent study put forced repetition training to the test and the results were somewhat promising.

In The Lab:

Scientists from the University of Jyvaskyla (Finland) had 16 recreationally trained males perform two lower body weightlifting protocols that were each separated by two weeks. The maximum repetition workout (MR) consisted of 4 sets of leg press, 2 sets of squats, and 2 sets of leg extensions - all for 12 reps taken to failure with 2 minutes rest between sets. The forced repetition workout (FR) consisted of the same exercises and sets as MR, but with 15% heavier weight so that the subjects would have to rely on assistance from a spotter to complete the 12 reps. An electromechanical dynamometer was used to measure maximal voluntary isometric force of the bilateral leg extension action at a knee angle of 107° before, after two and four sets of leg press, after squats and after knee extensions, and at 24, 48 and 72 hours after the workouts. Electromyographic activity (EMG) of the vastus lateralis and vastus medialis of the right leg was measured during the maximal isometric action. Blood samples were taken at various time points before, during and following each workout, and measured for testos-

terone, free testosterone, growth hormone (GH), cortisol, lactate, and creatine kinase.

They discovered that both workouts effectively raised testosterone and free testosterone levels, with little difference between the two different training techniques. Growth hormone on the other hand was increased more significantly in the FR group as compared to the MR group. But cortisol also increased more significantly following the FR training than the MR training. They also found that the decrease in muscle force following the FR training was almost 20% more that the decrease following MR training, and the decrease in muscle force was still significant in the FR group after three days of recovery. In addition the FR training led to a decrease in EMG activity of the vastus lateralis and medialis that corresponded to the decline in mucle force. Arkers for muscle damage, however, showed little difference between groups.

On the Field:

These data for the FR group led the researchers to conclude that forced rep training may produce higher levels of central and peripheral fatigue, which may result in the higher levels of GH and cortisol that they experienced. Due to the greater GH response, coupled with the fact that isometric force and neural activation (EMG data) decreased so much more in the FR group, they concluded that forced rep training may be a beneficial technique for athletes to use for the development of muscle strength and muscle size. However, they caution that due to the lowered recovery of muscle force production in the FR group, there may be an increased tendency for overtraining if frequency and/or volume are too high. To use this technique effectively, it is suggested that you perform only one or two forced reps of an exercise only on the last set of that exercise. You should also allow at least 4-5 days of recovery for muscle groups that were trained with forced rep training. And you should only perform forced rep training periodically for short cycles of 4-6 weeks, as part of a well planned periodized training program.

Jim Stoppani, Phd

Science Editor Muscle and Fitness and Flex

Major Taper

The major taper is used prior to the year's major competition. Because of it's duration the major taper can only be used once a year

Duration

For those who are training more than 6 hours per week and are not novices your major taper needs to be planned according to your work volume. Table 2 gives some guidelines for the duration of a taper depending on how many hours per week you train.

Volume

During a taper your volume of training will progressively decrease by about 70%. In other words if you are normally training 10 hours per week and will be doing a 7 day taper you will only train about 3 hours that week. Keep in mind that the decrease in volume is not accomplished in one cut; it is progressive. If you are doing a longer taper you may want to consider the following progression (table 3).

Frequency

The number of workouts per week does not decrease during a major taper. The decrease in volume is accomplished by decreasing the duration of each workout. The focus of a taper is recovery and regen-

Table 3.Percentage Decreases in Volume While Tapering

Training Volume	Week 1 Training Hours	Week 2 Training Hours	Week 3 Training Hours
6-10	Decrease by 70 %		
10-15	Decrease by 45%	Decrease by 70 %	
15+	Decrease by 30%	Decrease by 50%	Decrease by 70 %

eration, it is easier to recover from a short workout because it does not full deplete energy stores. Longer less frequent sessions do not allow the athlete to fully recover or adapt to the training they are doing, particularly since the intensity is increasing during the taper. Decreased training frequency during a taper will have a negative effect on technical performance. Athletes start to lose the "feel" for their sport when they decrease their training frequency.

Intensity

Intensity increase throughout the taper as the training volume decreases. Steady state pieces are gradually replaced with higher intensity intervals, short sprints, and starts. By the final week almost all the training will be done at or above anaerobic threshold. A final week of a taper may look something like that in table 4.

The sprint work in the last two days is as much a psychological factor as it is a physiological factor. Sprints will give the athlete feelings of speed, power, and confidence that they can take with them into race day. This means it is important to have a good final training session that leaves the athletes energized not fatigued. Ideally this final training day is done on the race course so that the athlete has time to familiarize themselves with the course.

Special Considerations During a Taper

A taper should be practiced at least once before the major competition of the year. It is not necessary to practice a full 21 day taper but the final week must be tried at least once, during a less important competition. This will give you the opportunity to adjust the taper to your individual needs and experiment with different combinations of intervals and sprints during the final week.

The taper period can be a time of high psychological stress for both the coach and athlete. Coaches tend to worry about the training that was done during the season, the duration of the taper, and many

Table 4. The Final Week of the Major Taper

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
40 minutes easy steady state	4 x 5min above AT, 10 minutes rest between	5 x 2 min, 30 minutes easy steady state	OFF	4-6 x 250 m sprints with 10 minute easy between	4 x 12 min at race pace, 5 minutes between	Race

other things that arise prior to a major competition. It is important at this time of the year that the coach projects confidence both in what has been done during the season and in the taper. If the coach is openly worried about the athlete's preparation or starts making changes to a planned taper the athletes may begin to question their preparedness and ability to win.

Athletes handle the decreased training volume differently. Many athletes will enjoy the feelings of speed, power and renewed energy. Others have a tough time dealing with the decrease in volume. They worry about detraining and don't know how to cope with the extra time as a result of the decreased volume. A coach needs to be aware of the responses of each athlete, and be prepared to deal with the worriers.

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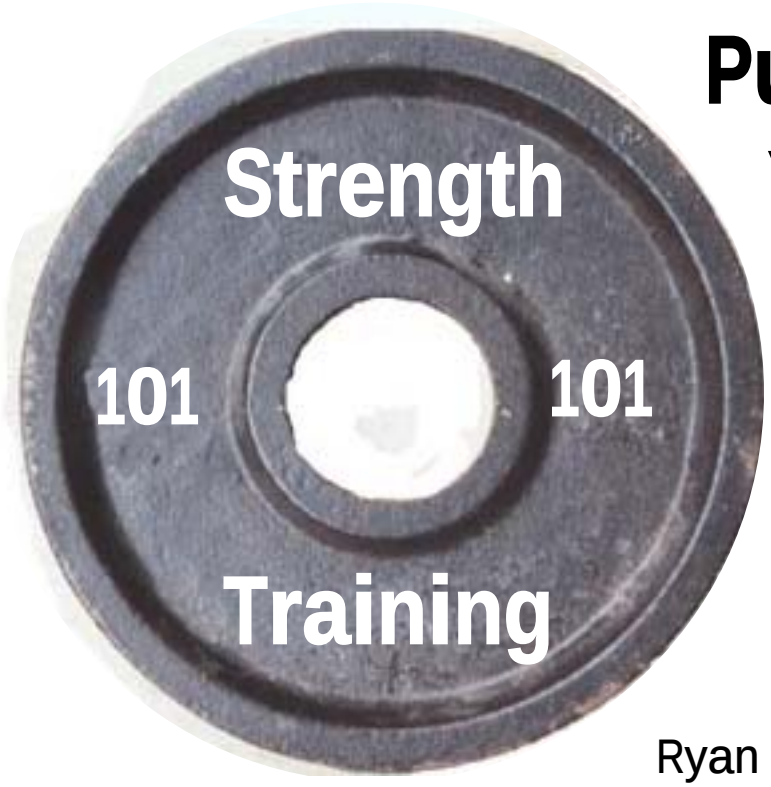
Exercise of the Month: Resisted Sprints

Resisted running is a greqat training method to increase running speed and the ability to maintain speed while fighting off an opponent. Two athletes with comparable speed sare-paired up for this drill. Begin with one partner lined up in front of the other, a Power Builder strapped around their waist. The lead partner begins to sprint forwards as fast as possible. The second athlete provides enough resistance to slow their sprint but not so much that running form is compromised. Focus on correct posture and maximal effort at all times. Maintain straight body alignment while sprinting; do not bend at the waist. Concentrate on driving the knees high for maximal hip flexion and fully extending the hips to increase stride length. Maintain efficient arm action by keeping the elbows bent at 90^{o} at all times and driving them straight forward and back. To minimize the risk of injury, decelerate slowly once the drill has been completed.



Putting Your Strength Training Program in Order

Ryan Koleyak, CSCS

Without a doubt, two of the most important variables in resistance training are volume and intensity. Nine times out of ten the manipulation of these two variables will determine whether you reach your training and performance goals.

Defining Terms

Volume, in weightlifting term, refers to the total amount of wrok tht is performed in a training session. In most cases it is calculated by multiplying the number of reps and sets of an exercise or group of exercises. The more sets or reps that are performed, the greater the volume. In some cases the total tonnage or amount of weight lifted is used to calculate volume. This method has the advantage of tracking the total amount of work performed. To calculate total volume of a set or workout you must multiply the sets by the reps by the weight. The total tonnage method is most often used with strength athletes who train in a very narrow rep range. For the purposes of this article we will assume that volume refers primarily to sets and reps, and to manipulate volume, we will manipulate these two variables.

The weight lifted, determies the intensity of the exercise or workout. Intensity in resistance training is traditionally described as the percentage or a repetition maximum that is lifted. If an individual is lifting their one rep max (RM), then they are said to be working at 100% intensity of their 1RM. Likewise, if they are lifting their max weight or 6 reps, then they are also considered to be working at 100% of their 6RM max. From this it is easy to calculate, for example, that someone with a 400 lb bench press max, doing single reps at 300 lbs, is working at 75% of their 1RM.

Manipulating the Variables

Now that we know what we are referring to with respect to volume and intensity, how do these terms play a role in resistance training workouts? As with any training, resistance training must have a goal, and it is this goal that will dictate how volume and intensity are used. The two most typical goals of resistance training are to get really big, and get really strong. Referred to as hypertrophy and strength respectfully. Depending on your personal goal, volume and intensity will play different roles in your workout.

A hypertrophy oriented workout, which is typical of bodybuilders, is characterized by high volumes. While there are many theories to explain exercise induced muscle growth, hypertrophy programs are normally high volume. Typically a bodybuilder will perform 3-4 sets of 12-15 reps of 4-5 different exercises for one body part. The large volume is thought to cause significant amounts of tissue and muscle fiber damage, although the role of muscle damage in hypertrophy is unclear, it is often assumed to play a role in muscle growth. High volume sets, 10 reps or more have also been shown to increase blood levels of growth hormone, which may promote protein synthesis and tissue growth. Compared to a lower volume workout, this sort of high volume training requires longer recovery periods between training sessions. If

High volume training is typical of many bodybuilders

muscle damage is extensive recovery can take up to 10 days. While high volume training is effective at increasing muscle size and enhancing strength endurance, you are not able to work at as high an intensity (% of 1RM), than you could if you were performing fewer sets and reps. This means that you will likely not see the same gains in absolute (1RM) strength with a high volume workout as you would with a higher intensity workout.

This leads into the training goal of maximal strength development. Research continually shows that the most effective way to develop absolute strength (1RM) is to train at levels very near to or actually above your maximal level. This ensures maximal fiber recruitment and consequently maximal force production. This intensity of training teaches the muscle to recruit the maximum number of fibers possible to perform a movement. Whereas working at a lower intensity requires a smaller number or fibers to perform the movement, and therefore teaches the body that maximal fiber recruitment is not always necessary. This is why you will rarely see powerlifters train using rep ranges higher than 6, and quite often they will not perform more than 2 or 3 reps at a time.

How you manipulate volume and intensity will depend on your training objectives. Normally over the course of a year you will use some period of high intensity training and other periods of high volume training. Traditionally this has been done in a linear fashion where the year is started with hypertrophy oriented training and intensity is gradually increased week by week while training volume is decreased. Recently more attention has been paid to non linear variable manipulation where periods of high intensity/low volume and high volume/low intensity are alternated throughout the year. It seems that for athletes who need to combine both muscle mass and strength non linear manipulation is more effective.

Table 1 summarizes the relationship between volume, intensity and training outcome. As with all aspects of training, nothing is set in stone, and no one thing works for everyone. Try manipulating some of the things you do in your training to see if you can achieve some additional gains.

Fitness Fact

Most of the athletes competing in the Olympics will have put in more than 1000 hours of training over the past year.

Table 1. Relationship Between Volume, Intensity and Training Outcomes

Phase	Hypertrophy	Strength	Strength and Power	Peaking	Power Endurance
Sets	3-10	3-5	3-5	1-3	1-5
Repetitions	15 seconds	4-6	2-3	1-3	25-200
Days/wk	3-4	3-5	3-5	1-5	2-3
Times/day	1-3	1-3	1-2	1	1
Cycle	2-3/1	2-4/1	2-3/1	----	3/4-1
Intensity (% 1RM)	60-80	75-85	85-90	90-100	30-50
Volume (reps/exercise)	30-40	20-30	10-15	3-10	200

Ryan Koleyak is currently a Graduate Student/Assistant at Florida International University. He has a Bachelor of Physical Education Degree from the University of Alberta, and is an NSCA Certified Strength and Conditioning Specialist (CSCS).

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This four session lecture-workshop will provide each participant the skills and knowledge needed to develop explosive power programs. Examining both historical perspectives and the newest, scientific approaches for developing power the workshop will consist of approximately 50% of the time being devoted to lecture and 50% to practical application hands on applications, allowing participants to bridge the gap between science and practice.

Session 1: The Strength-Speed-Power Continuum

This lecture session will introduce participants to the physiological basis of power development and the Strength-Speed Power continuum. To develop optimal power one must first know whether that power is strength based or speed based. The continuum allows the participant to analyze the power demands of a sport or activity and determine the proportions of strength and speed needed to excel. Other topics covered include:

- Muscle and Nervous system physiology

- Force-velocity curve
- The length-tension curve
- Acceleration, Torque and Impulse
- Elastic energy, the stretch reflex and momentum
- Dynamic Power Expression
- The trade – off between strength and speed
- Where does optimal sport specific power lie?
- Sport and position specific power analysis

Session 2: Developing a Power Profile

During this practical workshop participants will be lead through a series of specific and general strength, speed, and power tests. They will learn to administer the test protocols, interpret the results and set training priorities and goals based on the testing and how the results match the strength-speed-power continuum analysis.

Session 3: The 5 Step Power Program

This lecture session provides the program variables and theoretical framework for designing specific power programs. The 5 step model provides participants with a simple, effective means of ensuring that they are covering ever aspect of power development. Topics covered include:

-

Training muscles vs. training movements
- Replication and skill transfer
- The weight training paradox
- Power periodization cycling
- Antagonistic power combinations
- Volume-intensity relationships
- Overload
- Acceleration and deceleration

Session 4: Power Techniques

Building on the previous session, this hands on session features the drills, exercises and training methods discussed in the previous lecture. The group will be broken into smaller groups and cycle through four different stations where participants will learn and learn to teach ten different exercises and drills for a total of 40 new exercises ranging from releases and throws to plyometrics and Olympic lifts.

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