Module 5

Strength

Introduction

The common definition of strength is the ability to exert a force against a resistance. The strength needed for a sprinter to explode from the blocks is different to the strength needed by a weightlifter to lift a 200kg dumbbell. This implies that there are different types of strength. The classifications of strength are:

- maximum strength – the greatest force that is possible in a single maximum contraction
- elastic strength – the ability to overcome a resistance with a fast contraction
- strength endurance – the ability to express force many times over.

A muscle will only strengthen when it is worked beyond its normal operation - when it is overloaded.

Overview of the strength module

In this module we look at various methods of improving strength, and provide examples of possible training sessions.

- Raphael Brandon examines how to develop your maximum strength with weight training and, at the end of the module, how to develop your elastic strength with complex training (a mix of plyometrics and weights).
- John Shepherd explains how to develop a weights programme specific to your chosen sport.
- Walt Reynolds shows how to improve elastic strength with medicine balls and how to develop your strength endurance with circuit training.
- Brian Mackenzie explains how to develop your elastic strength with plyometrics.

The articles in this module are applicable to most sports.

How to develop maximum strength

The aim of this article is to outline how to design your strength routines, in terms of intensity and content, to make sure you get the optimum gains in strength for the time spent in the gym. I will begin by discussing the best intensity and volume for strength improvements. However, throughout the article I will be discussing maximum strength-training methods, which are not the same as bodybuilding. Currently, by far the most common strength-training format would be three sets of eight to 12 repetitions of each exercise. Give or take a few minor variations on a theme, this is generally what you would see when watching many gym routines. Recently, however, research has questioned this practice of three sets of each exercise. For example, Feigenbaum and Pollock (1997) reviewed eight well controlled studies comparing variations in sets of strength routines. No studies showed two sets to be significantly superior to one, and only one study showed three sets to be significantly superior to one or two.

In the light of this, when the American College of Sports Medicine published its latest *Position Stand on Health and Fitness Training*, it recommended adults should perform one set of eight to 12 repetitions, two to three times per week, for optimum strength benefits. You may be surprised at this. Only one set? What good will that do? However, we have to examine exactly what the ACSM specifies, and I quote: 'one set of eight to 12RM or to near fatigue should be completed ... or for older persons, one to 15RM may be more appropriate.'

What this means

The key element of this recommendation is that the resistance intensity has been clearly defined as eight to 12RM. RM stands for the Repetition Maximum and refers to the number of repetitions that can be performed before fatigue inhibits the completion of a further repetition with correct form. (When we get tired we can always force a few extra ones by cheating on the technique, but this does not count when assessing RM.)

The following example should make this clear. A male athlete is tested for his bench press performance. After a warm-up trial on a suitably easy weight, plus a couple of minutes' rest, he is given a 60kg bar to bench. He performs nine repetitions with correct technique but just fails while attempting to push up the 10th repetition and requires a little assistance. Thus 60kg is the 10RM load for this athlete. According to the ACSM, this makes 60kg an ideal training weight for strength development, and if he performed one set at 60kg two to three times a week he should significantly improve his bench-press strength. After a few sessions he will be able to complete 10 repetitions without assistance, then 11 repetitions and then 12. By this stage, 60kg has become his 12RM load. To ensure the best results and to stay within the ACSM guidelines, our athlete now needs to put the weight up. This is because, for maximum strength gains, the optimal range has been proven to be eight to 12RM, or even four to eight RM for power sports. Decreasing the relative load to 12 to 20RM would favour the development of muscular endurance and muscle toning.

The key is the RM value

Thus when designing strength exercises the most important variable is the RM value for each exercise. The number of sets performed at this level seems to be less influential. As long ago as 1962, Berger showed that 12 weeks of three-times-a-week training produced a 22% increase in bench-press strength with one set of six to 10RM, 22% increase from two sets of six to 10RM and 25% increase from three sets of six to 10RM – hardly a major difference for three times as much volume. Results like this are also found in more recent studies of both upper and lower body exercises.

When you next design a strength programme, instead of three sets of eight to 12 repetitions, try one set of eight to 12RM. There is a subtle but significant difference between eight to 12 repetitions and eight to 12RM, since the latter specifies the intensity of the training. Remember that it is the intensity and not the volume of the weight training that has the largest influence on its effectiveness. As Feigenbaum and Pollock have said most recently (1999): 'One common factor in all effective strength programmes is the inclusion of at least one set of the maximal or near maximal number of repetitions for each exercise performed.'

Popular practice for athletes is to perform the usual three sets of 10, using a weight that allows the first set to be moderate, the second to feel a bit tough and the third very difficult or to fatigue. However, while this satisfies the above recommendation that at least one set is maximal, the weight intensity is probably too low. If our athlete trains at a weight intensity where he can complete three sets of 10, I would estimate that this weight intensity is at least his 15RM load, and maybe higher. This places the training intensity outside the optimum range for strength results. If we go back to our earlier bench presser, instead of the newly recommended one set to maximum at 60kg, he would perform three sets of 10 at around 45kg to 50kg. The chances are the former will give him a greater return in strength gains from less time invested.

The reason for multiple sets

So why do we all do three sets of 10 when a single set of 10RM will do just as well, if not better? What we need to remember is that, unfortunately, research studies often last no more than three months and often involve moderately trained subjects. Both the length of the training schedule and the status of the athlete are crucial to the outcome of the training programme. In other words, to be strictly correct, it is only proven that one set of eight to 12RM is best for moderately trained subjects for an initial training period.

Thus, multiple-set training programmes are recommended to ensure that the training stimulus is progressive and will continue to stress the body sufficiently so as to produce further strength improvements. Multiple-set programmes are probably most suitable. However, just because you feel you need the extra volume that multiple sets provide, do not forget that you must stay within the

optimum intensity range of four to 12RM. Practically, this means the athlete still performs each set to the maximum and takes generous rest periods to allow for multiple sets. For example, our aforementioned bench presser has now decided to up the volume of his workouts. Let us say he was currently performing one set at 65kg, which was his 10RM load. To perform a second set, he would need three to five minutes' rest. If he only took one minute's rest, having just completed one maximum set, he would be unlikely to perform more than five repetitions the second time round. Intensity is the key, so, if you do not take enough rest, you will not be able to push enough weight. Remember that there is no point increasing to multiple sets if you end up decreasing to a sub-optimal intensity. Thus the recommended protocol for multiple sets for strength gains would be two to four sets of four to 12 RM with three to five minutes' rest.

Practical issues

So far we have established, in theory, the most effective design for strength improvements. The crucial point is that the training load must be within the four to 12RM range. Initially, one set to maximum will be sufficient, but for long-term improvement for elite athletes multiple sets will be required. Having established the theory, let us now look at a few practical issues regarding the content of the workout to ensure that our strength routines are fully effective. These issues are: exercise selection, exercise order and warm-up sets.

The main point about exercise selection is the athlete's training goal. The content of the workout must relate directly to the desired training effect. The goals may vary greatly, depending on the athlete's sport, position or event. There are too many possible variations to be covered here, but I will give some examples to illustrate the point and try to pass on some useful tips.

If the training goal is for general strength development, I would suggest selecting about eight exercises that involve large muscle groups and cover as much of the body as possible. For example, the following eight exercises cover pretty well all major muscle groups: leg press, leg curls, bench press, lat pull-downs, biceps curls, triceps press, ab crunch and back extension. One would perform sets of eight to 12RM of each of these exercises.

Sport-related training

If the strength training is related to a sport, the choice of exercises must be functional. This is because training effects are very specific. To ensure that the strength you develop in the gym brings about an improvement in performance, the strength exercise must be biomechanically related to the sporting movements. This is known as the 'carry-over effect'. For example, squats are a functional exercise because they train the quads, hamstrings and gluteals in a way that is related to running and jumping. In contrast, the knee extension exercise involves only knee extension, training the quads in isolation. This has no

functional relevance to running or jumping, so improving your strength on this exercise will not improve your ability to run or jump. It may, however, improve your ability to kick.

Free weights are also considered more functional because the athlete has to use the synergistic small muscles to stabilise the movement as well as the large prime-mover muscles to execute the movement. This means, for example, that an exercise such as the dumbbell lunge, if performed with correct technique encouraging good alignment and upper body pressure, should develop body core stability as well as leg strength. This also highlights the point that quality technique and instruction are paramount for optimum strength improvements.

Do not forget muscle balance

Another practical point to consider in exercise selection is muscle balance. It is essential that both sides of the body are developed evenly and that opposing muscle groups have the correct relative strength to each other. Any imbalances may lead to injury or instability during sports movements. For this reason, you should always design workouts that result in balanced strength development. For instance, with every upper body push or press exercise also include a row or pull exercise. With some sports, a major goal of strength training is to redress imbalances between sides. For example, tennis players often have a dominant arm and uneven trunk strength. One solution to this would be choosing exercises that work each side individually, thus giving the weaker side a chance to catch up.

Exercise order...

The final practical point regarding exercise selection is the order of the exercises in the workout. It is recommended that large muscle group exercises and the most important exercises in the workout should precede small muscle or single joint exercises. For example, a sprinter may be using this type of programme:

- power clean
- squats
- bench press
- dumbbell lunge
- lat pull-down
- lateral raise
- bent-over lateral raise
- triceps press
- twisted crunch.

The power clean and squats come first because they are the most functionally important exercises for the sprinter. The power clean precedes the squat because technically it is a more difficult movement. The bench, lat pull and lunge come next because they all involve large muscle mass. The shoulder and triceps exercises come next because they are single-joint movements. The twisted

crunch comes last because trunk strength is always required for good stability and technique in any exercise. Thus the trunk exercises should come at the end of a routine so that trunk muscle fatigue does not compromise technique during other exercises.

...and warm-up

The correct warm-up is also essential if weight training is to be fully effective. I recommend starting with some easy aerobic activity for about five minutes, particularly a rowing machine because it involves both upper and lower body. The next stage of the warm-up would be a choice of active mobility exercises for the whole body. The purpose of these exercises is to take each major joint through its active range of motion without any loading before the workout begins.

The most important element of warming up for strength training is to perform warm-up sets before each new muscle group or movement is trained. The purpose of warm-up sets is to gradually prepare the muscle for the maximal intensity loads to come. Remember that if you want to perform sets of four to 12RM, it means going to maximum. The correct load for the warm-up set would be about 60% of the training weight.

It is best to perform each of these warm-up sets immediately before the exercise. For example, a sprinter following the routine outlined above would start his workout with a warm-up set of power cleans. Then he would perform his training set of power cleans. He would not need a warm-up set for squats because the power clean movement would be sufficient. He would then precede both bench press and lat pull-downs with a warm-up set. The lunges, shoulder and triceps exercises would not require warm-up sets because the muscles involved would be already warm from the large multi-muscle exercises that preceded them. This is another important reason for putting large muscle mass exercises first in the routine order.

Note that there are no stretching exercises involved in the warm-up. Despite their popularity, stretching exercises are not proven to be an effective part of a warm-up. In fact, stretching may actually be inappropriate for strength training because it relaxes the muscles, reducing force development potential by inhibiting the stretch reflex.

In summary, to optimise strength gains design your workouts so that you train at the four to 12RM intensity, and take long rests to facilitate multiple sets to maximum. Think carefully about the exercises included in your workout, asking if they are functionally relevant to your training goal, and whether they will promote muscle balance and stability. Finally, design the workout using the most appropriate order of exercises so that the most important muscles are training first and the correct warm-up procedures are used.

Raphael Brandon

References

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For sporting success make your weights programme specific to your chosen activity

These days, hardly any sports performers can afford to neglect weight training. At the Manchester Commonwealth Games, even England's crown green lawn bowlers had weight-trained to improve their performance. Get this training right and you could find your place on the medal rostrum; get it wrong and you could end up at the back of the field.

Weight training for endurance

It has long been accepted that weight training (and the right strength-training programme) can improve performance for aerobic athletes. Take swimming: depending on the stroke, the arms and legs contribute different amounts of power to propel the swimmer through the water. Freestyle, for example, requires an upper body contribution of 70% and a lower body contribution of 30%. By strengthening the muscles that move the shoulder girdle, upper arm and forearm, hips and legs, it follows that, everything else being equal, performance will be improved.

But it is crucial to select the right exercises, perform them at the right intensity and place them within a progressive and carefully structured weights programme. Olympic rowing coach Terry O'Neill believes that a weight-training programme for his sport should mirror actual race requirements as closely as possible (a principle that should always be adhered to regardless of sport). This means that:

1. the exercises selected must be relevant to rowing
2. they must be performed ultimately at a pace equivalent to the actual stroke
3. they must create conditions that mirror the heart rate levels sustained during a 2K race
4. they must reflect the time it takes to complete the race distance.

In his most specific six-week weight-training microcycle, O'Neill reduces the amount of weight the rowers attempt to between 15kg and 30kg. This is so that they can complete 45 seconds of continuous rhythmic exercise at a similar rate to the stroke in a race.

At the end of each station, the athlete moves on to the next exercise without stopping, providing a total of eight minutes of work, during which time the heart rate will rise to 85% to 95% of maximum (see Table 1 on page 85 for exercises).

O'Neill gets the athletes to rest for two minutes at the end of each circuit and the aim is for them to complete three of these circuit workouts per week during the first three weeks, and four in weeks four, five and six of this microcycle. The specific exercises utilised are: high pulls, press behind neck, front curl, bent-over rowing, lateral dips (side bends) to right and left, squat, bench press, clean and press, jack-knife crunch, bench pull and hyper extensions.

The sport-specific transference from this microcycle appears considerable. By targeting primarily type I muscle fibres and the cardiovascular system, an intense physiological response would be elicited, similar to that achieved during a high-intensity, interval-style rowing workout.

This workout should also avoid the 'physiological confusion' that can arise from targeting two different physiological goals, eg strength and endurance, at the same time. (Note that it was designed for indoor rowing but was adapted from O'Neill's vast knowledge of on-water-rowing training.)

Weight training for speed/power: why bigger is not always best

Lifting progressively heavier weights will not in itself lead to improved power and speed, but many athletes and coaches still get caught up with this 'heavier and bigger is best' strategy. Too much bulk is just that: an additional load to transport around the track or into the air. If increased muscle size on its own brought the required results, then a body builder would be able to run as fast as 100m world record-holder Tim Montgomery.

It is how you develop the size and strength, and where you take it to after and during a gross strength development phase, that counts. A larger (and stronger) muscle will exert greater force and ultimately more power, but simply pushing out near maximum repetition lifts, repetition after repetition, without sport-specific channelling is a waste of time.

So how should you weight-train for explosive power?

Charles Van Commenee is UK athletics' multi-events and jumps coach and it was he who coached Denise Lewis to Sydney gold. He believes that to develop power you initially need a good strength base, and advocates the use of exercises that train the whole body. Intensity is set at 90% of one repetition maximum (1RM) and his athletes perform five to 15 sets, but only using one to two repetitions and interspersed by long recovery periods of three to four minutes.

After a couple of months' training this way, the athletes move on to a power development phase, lifting at 70% to 85% of 1RM. The number of sets performed depends on the stage of the training year, but varies between three and six. At 70% of 1RM, five repetitions are performed, and at 85%, three. As before, a good recovery is crucial to unimpaired performance.

Van Commenee explains his training methodology in terms of a specific hormonal response. At a high percentage of 1RM, testosterone is released, boosting the speed development that his athletes need. At lower percentages and using multiple repetitions (8 to 10), growth hormone release tends to predominate, which is good for general muscle building but less advantageous for power athletes whose power-to-weight ratio is crucial.

Again, as with our rowing weight-training plan, it is crucial to select exercises that have a real relevance to the sport in question, particularly during the power development phase. The direct transference of, for example, a power clean to a high jump take-off is marginal and much less direct than the physiological responses elicited by our rowing schedule.

Table 1

Exercise	Sports applicable	Sport-specific value (Why?)
Split squat with the front foot on a wobble board/medicine ball	Field sports, jumping events, running	Elicits a proprioceptive ability; improves balance and strength; can reduce injury by preparing legs for 'unstable' force transference
Single arm dumbbell bench presses/shoulder press from a fit ball	Running, field sports	The key here is the role that the core performs in having to 'straitjacket' power transference
Sprint arm action with light dumbbells	Running	Develops a powerful and technically correct arm drive
Lunges/step-up drives	Running	Although not as specific as the other moves, it follows that, as running uses one leg at a time, weight training with one leg at a time will have a greater training transference

A power clean cannot be performed at the speed of a high jump take-off, nor could the same amount of force be overcome and nor, of course, could it be performed on one leg after a curved approach to a bar.

Weight training for speed (and endurance) obviously has certain limitations. It can only take an athlete so far, and more specialised exercises like plyometrics, sports specific drills and the sport itself must be used to channel the strength gained through weight training directly into improved performance.

Weight training and open sports skills: strengthening the body

Swimming, rowing and sprinting are predominantly 'closed skills', requiring the same movement pattern to be repeated over and over again. However, football, rugby, tennis and other field or court sports require myriad 'open sports skills'. And it is in these sports that the direct contribution of weight training to performance can appear less relevant. A tennis player reacts to a serve, a goalkeeper to a shot and weight training is unlikely to condition a directly transferable movement pattern. Why? The speed of movement, balance, proprioception and specific sport skills are incredibly specific to the requirement of the movements.

So what is the role of weight training for these sports? The answer is twofold:

1. to strengthen the body and protect it from injury by strengthening tendons, ligaments and muscles (a further reason for endurance athletes to weight train)
2. to provide a base for better (stronger/less fatigued/faster) open skill performance.

Mike Antoniades, a specialist speed, power and weight-training coach who has worked with many top sportsmen and women using the Frappier Acceleration system (see earlier module), provides a further third reason why the open skills performer should not neglect weight training. He notes that footballers can lose up to 35% of their strength during a season and more if they are unlucky enough to sustain an injury. The open skills performer therefore needs a weight-training programme that maintains specific strength across a season.

Sport-specific weight-training exercises and their value

Table 1 includes highly specific weight-training exercises. Some, like the first, even contain an element of open sports skill performance because the performer has not just to perform the move but also to balance and be spatially aware.

This is similar to the requirements of a striker having to take a shot at goal while off-balance. Note that these are advanced moves and should only be attempted by well conditioned athletes who have a suitable level of prior conditioning.

Six top weight-training tips for enhancing sports performance

1. Do some 'muscle re-education' work after lifting. If you are a cyclist, for example, you could do three minutes on a spin cycle after weight training. You will have stressed the muscles through weight training and the sport-specific task that follows will help to re-coordinate the firing patterns of your muscles. A runner or games player could achieve the same by performing some light strides after a weights workout.
2. Devise a progressive weight-training programme to accompany the demands of your sport, but never lose sight of the sport itself. Weight

training is largely peripheral to performance unless it is adequately channelled into performance.

3. Select exercises, particularly during key training phases, which replicate the movement and have a similar speed element to the sport in question.
4. Take your level of maturity as well as your sport into account when devising your programme of weight training.
5. Do not turn into a gym narcissist, marvelling at your great new physique; it could turn into a burdensome suit of armour for you to haul around.
6. The more experienced the performer, the more the coach will have to work at exploring new avenues for enhancing sports performance. Revisiting a weights programme could be crucial; look closely at the transition to competitive season phases and check out whether previous strength gains really are improving sports performance.

John Shepherd

These medicine ball workouts can do wonders for running velocity and power

The medicine ball has been used as an athletic training aid for decades in Europe, but only in recent years has the value of medicine ball training been recognised in the United States. Many collegiate and professional sports teams are now incorporating this form of strength development into their training, and with proper guidance runners can also benefit from using the medicine ball.

Most medicine ball drills involve lifting, throwing, and catching the ball, but the real focal point for such activities is the muscular 'corset' which surrounds the junction between the trunk and the legs. This meeting point, called the 'core' area of the body, is coordinated and held together by the abdominal, spinal erector, hip flexor, and gluteal (buttock) muscles. This central region is also called the 'power zone' of the body, because force 'moves' through this area, from one leg to the other during the act of running and also because the core muscles must stabilise the body during foot strike, so that unnecessary motions are minimised and all the power created by the hip and leg muscles can be used to drive the body forward.

Most runners focus on the core area at least to a small extent in their training by carrying out conventional abdominal and low back exercises such as crunches and back extensions. However, during the running motion, the amount of active trunk flexion (carried out by the abdominal muscles) is rather negligible, as is the extent of trunk extension (a function of the low back muscles and gluteals). Compared with direct flexion and extension, there is much more rotational action in the trunk during running, yet most runners totally ignore workouts which would improve the rotational strength of their core muscles.

Medicine ball training, however, can give you additional specific strength, which

can be used directly during your workouts and races to improve your running velocity and overall power. The following group of exercises can provide runners competing at all distances with considerably improved core strength. Typical training weights for medicine balls range from two to 15 pounds. Larger balls (up to 25 pounds or so) are used by certain strength athletes (weight lifters, football players, body builders) but are unnecessary for runners. In fact, most runners will do very well with a set of three balls which weigh about two, four, and six pounds (approximately one, two, and three kilograms, respectively).

The exercises

1. The standing trunk twist (hammer twist)

Muscle groups emphasised: Hip and leg muscles, abdominal and oblique muscles and spinal erectors.
Value for runners: This exercise develops dynamic stability strength for all of the core muscles in a standing posture, making the exercise more specific to running than many of the conventional abdominal and low back exercises that are performed in a seated position. Strong core muscles provide for an upright and economical running posture, as well as a strong anchor point for the propulsive muscles in the legs.
Weight of ball: Two pounds for beginners, four to six pounds for advanced athletes.
Other equipment: A towel.
Instructions: Place your towel flat on the ground and then put the medicine ball in the centre of the towel. Bring the ends of the towel, one at a time, over the top of the ball to create a 'ball in a sack' effect. Start the exercise with your feet shoulder-width apart and your weight shifted on to your right foot. Twist your body to the right with your hands grasping the ends of the towel and the ball positioned behind your right shoulder. While keeping your arms straight, swing the ball out away from your body towards the front and then to the left in a wide arc, while bending your legs and 'sitting' into a shallow squat position as the ball reaches the middle of the arc in front of you. Continue this arc until you finish the swing with the weight shifted onto your left foot, with your hands still grasping the ends of the towel and the ball now behind your left shoulder. Immediately swing the ball back to the starting position, and repeat the swinging motion back and forth for a total of 10 to 15 repetitions on each side. Begin this exercise in a slow manner, and progress in speed (while still maintaining good control) over a period of several weeks. Perform two to three sets total.

2. Hanging body flex

Muscle groups emphasised: Abdominal, oblique and hip flexor muscles.
Value for runners: This exercise strengthens the integrative action of the muscles, which raise the thighs and stabilise the pelvis. This provides for a powerful knee drive and an economical running posture.
Weight of ball: Two pounds for beginners, four to six pounds for advanced athletes.
Other equipment: A horizontal/chin-up bar.
Instructions: Start from a hanging position with your arms overhead and your legs extended straight down towards the floor. The medicine ball should be placed between your feet and held there firmly by squeezing the feet and legs together. Raise your knees towards your chest (with knees bent) while maintaining a firm grip on the ball with your feet and ankles. Flex your toes and feet up towards your knees throughout the entire movement. Return to the starting position by extending your legs back down towards the ground under control. Perform the movement at a slow speed during the first few sessions and progress to a moderate speed over time. Use 10 to 15 repetitions and two to three sets per workout.

3. Walking trunk twist

Muscle groups emphasised: Hip and leg muscles, abdominals, obliques and spinal erectors.
Value for runners: This exercise develops stability of the core muscles, much like the hammer twist (exercise 1), but the walking twist also incorporates the integrated muscular action required during rhythmic movement. As the right leg moves forward, the trunk twists to the right, following the same oppositional pattern found in running (right leg forward, left arm forward). The added momentum gained by swinging the ball creates increased tension in the stabilising core muscles, thus strengthening them.
Weight of ball: Two pounds for beginners, four to six pounds for advanced athletes.
Other equipment: A towel.
Instructions: Start from a standing position with your feet parallel and the ball secured firmly within the towel and held up behind your right shoulder. Step forward with your left leg and simultaneously swing your arms through a wide arc in front of you. Continue the swing until your arms are shifted to the left and the ball has stopped behind your left shoulder. Continue the exercise by stepping forward with your right leg while simultaneously swinging the ball back behind your right shoulder. The swings should be fairly slow as you learn the exercise but will progress to a moderate (but controlled) speed over time. Repeat the action (stepping and swinging) for a total of 10 to 20 repetitions (five to 10 swings on each side) before resting for a few moments. Repeat for a total of two to three sets.

4. Jump and pick up

Muscle groups emphasised: The hip and leg muscles.
Value for runners: This exercise activates both the extensors and flexors of the hip during the jumping phase of the drill and thus improves explosive leg power for both the push-off and leg-swing or knee-drive portions of the running stride.
Weight of ball: Two pounds for beginners, four to six pounds for advanced athletes.
Training note: To lessen the chance of injury, perform this drill on a resilient surface such as a wood floor, synthetic track, or grass.
Instructions: Start with your feet flat on the ground and the ball held firmly between your ankles. Your knees should be bent slightly so that you are in a shallow squatting position. From this position, perform an explosive jump upward and lift the ball in front of you by pulling both knees up quickly towards your chest to near chest level. Catch the ball with both hands in front of your chest as your feet land on the ground. Squat down and place the ball between your ankles before repeating the action for a total of six to 10 repetitions. Perform two to three sets.

5. Knee throw and lunge

Muscle groups emphasised: Hip flexors and quadriceps are utilised for the throwing action, quadriceps, gluteals, and hamstrings are used for the lunge, and core stabilisers are involved in both the throw and the lunge.
Value for runners: This exercise develops explosive knee lift, eccentric leg strength and coordination. The knee-drive action is followed immediately by an energy-absorbing landing in the lunge position. This combination of throwing and lunging requires both strength and coordination to complete.
Weight of ball: Two pounds for beginners, four to six pounds for advanced athletes.
Instructions: Start in a standing position with your left foot forward and your right foot two to three feet back (standing start position). Your left arm will hang relaxed at your side while your right hand supports the medicine ball on the front upper third of your right thigh. The knee throw takes place as you step forward with your right foot and drive your right knee forward and explosively upward. Essentially, you are releasing the ball with your right hand and 'throwing' the ball forward with your knee. Your motion continues forward until your right foot lands on the ground in front of you, leaving you in a wide lunge position with your trunk held upright. A wall or partner can return the ball to you. Perform 10 to 15 repetitions with the right leg before switching over to the left. Perform two sets with each leg.

6. Squat, throw, fall and chase

Muscle groups emphasised: Leg muscles, abdominals, spinal erectors and shoulders are utilised for the squat and throw actions. Leg, abdominal, chest and shoulder muscles are stressed during the fall and chase movements.

Value to runners: This drill is the most dynamic of the six exercises. The squat and throw actions develop overall power in the muscles of the hips, legs, back and shoulders, muscles which contribute to a strong push off and proper posture during running. The fall action improves coordination and whole body control, as well as upper torso, abdominal and leg strength. Although some runners may laugh at the idea of practising falling, knowing how to fall can prevent injuries during workouts and races. Most runners will fall at some point in their careers, and for runners in more northerly areas, where ice and snow cover the roads during the winter, slipping and falling is rather commonplace. Also, it is important to be able to recover from falls in race situations (remember Mary Slaney's unfortunate tangle with Zola Budd and subsequent tumble during the 1984 Olympic Games?). The chase part of the exercise teaches you to get back on your feet as quickly as possible after a spill and develops strength and coordination in the shoulders, chest, abdominal area, back, hips and legs.
Weight of ball: Four pounds for beginners, six pounds for advanced athletes.
Training note: Perform this drill on grass or other soft surface to minimise impact forces. Allow yourself at least 15 to 20m of space to sprint forward during the chase action.
Instructions: Start by performing a shallow squat with the medicine ball held in front of you at chest level. Explode forward by extending both legs and arms and pushing (throwing) the ball out in front of you at approximately a 45-degree angle. Continue falling forward and catch yourself by driving one knee forward, landing with your body weight on your lead knee, foot and both hands. Rise as quickly as possible and sprint forward until you catch up with the rolling ball. Strive to keep your momentum moving forward throughout each phase of the exercise, never coming to a complete stop at any time. Walk back to the starting point with the ball, and repeat the overall exercise for five to 10 repetitions. Perform two sets per workout.

General training guidelines for medicine ball workouts

Medicine ball exercises represent a form of strength training and are typically performed with other strength exercises, when you are relatively fresh and non-fatigued.

Perform all twisting and lifting exercises slowly and deliberately while you are learning the movements. After a few training sessions, the actions may then be speeded up to a moderate speed, but remember to maintain good control at all times.

Focus on developing good form while using light balls early on; progress to heavier balls after three to four weeks.

Core strengthening exercises can actually be carried out frequently (four to six times per week) for relatively brief periods (10 to 15 minutes). The sample

programme given below is a guide for including core exercises in your overall training programme (many other programmes are possible).

Monday	Medicine ball exercises 1 and 2 (after a tempo workout)
Tuesday	Traditional core exercises such as abdominal crunches, back extensions, etc (after your usual weight-training routine)
Wednesday	Medicine ball exercises 5 and 6 (after your speed work)
Thursday	Break day – no core training
Friday	Traditional core exercises (after long, moderate exertion)
Saturday	Medicine ball exercises 3 and 4 (after weight training)
Sunday	Rest day – no core training

Walt Reynolds

An excellent way to build strength endurance

During the past few years, endurance athletes in a number of sports have added resistance exercises to their training programmes in an effort to boost their muscle power and decrease their risk of injury. Scientific studies have linked resistance training with a reduced rate of injury in athletes. This is probably because resistance work fortifies leg muscles and strengthens 'weak links' in athletes' bodies, including the often-injured hamstrings and shin muscles, as well as abdominal and low back muscles.

Resistance work can also improve tendon and ligament strength and increase bone density, effects that should help to lower injury rates. In addition, resistance workouts heighten body awareness, upgrade coordination, reduce body fat levels and improve self-esteem, all of which can contribute to improved performance during competition.

For athletes, the general preparation period before the beginning of actual competitions is an ideal time to initiate a resistance-training programme. A four to eight-week period of sound resistance training helps to develop a nice foundation of suppleness (mobility), strength, and stamina (endurance), to which athletes can add speed and racing skill just before the competitive season begins.

'Circuit training' is an excellent way to build strength and stamina simultaneously. The circuit training format utilises a group of strength exercises (usually six to 10 or more) that are completed sequentially (one exercise after another). Each exercise is performed for a specified number of repetitions or for a prescribed time period before moving on to the next exercise. The exercises within each circuit are separated by brief, timed rest intervals, and each circuit is separated by a longer rest period. The total number of circuits performed during a training session may vary from two to six depending on your training level, your period of training (preparation or competition) and your primary training

objective (You may be developing total work capacity, boosting your power, or engaging in 'active rest', for example.)

I have designed this special circuit training with the following objectives in mind:

1. The circuit work will increase your general work capacity by improving your ability to tolerate increasing levels of muscular fatigue (stamina improvement).
2. Over time, the circuit training will have shorter and shorter rest intervals between exercises, thus maintaining elevated heart rates during the circuit workouts and helping you to upgrade your cardio-respiratory capacity (stamina improvement).
3. Circuit efforts will enhance your overall body strength, including the strength and resiliency of muscles, tendons and ligaments, the integrity of your joints, and the strength and density of your supporting bone structures (strength improvement).
4. The circuits will improve your movement skill and body awareness, because you will perform exercises that utilise body weight as the primary form of resistance (skill improvement).
5. The circuit programme will increase your lean muscle mass by a moderate amount and decrease your body fat levels through high levels of energy expenditure (body composition improvement).

The basic training circuit: recommendations

Your basic training circuit can easily be combined with the mobility training described in an earlier module to form a well rounded training session. A full mobility-plus-circuit workout, including warm-up, mobility training, circuit work and a 10-minute cool-down, can be completed in about an hour or less.

Is that too much time for the busy athlete? No. For one thing, you only need to complete the overall workout twice weekly during your base conditioning period. In addition, the payoffs from circuit training are great. Whether you are a cyclist, a race walker, a runner, a rugby player, a swimmer, or a participant in racquet sports, you will improve your strength, mobility and stamina through circuit training. As a result, you will move much more powerfully as you take part in your sport.

Bear in mind, though, that for best results the circuit training sessions should not be performed on consecutive days. If you are carrying out other intensive training on the same day as the circuit work, undertake the intensive work before the circuit training, since fatigue levels from the circuit might well interfere with training intended to develop speed, power, or event specific endurance. Better yet, carry out circuit training on days during which other training is of low intensity. Do not do your circuit training on a rest day, however; rest really means rest.

Here is your sequential format for each circuit:

1. Total body exercise
2. Upper body exercise
3. Lower body exercise
4. Core/trunk exercise
5. Total body exercise
6. Upper body exercise
7. Lower body exercise
8. Core/trunk exercise.

Notice that each part of the body is emphasised twice during each circuit. The amount of rest between exercises and the total rest between circuits is described below.

The basic training circuits: how long to work and rest for each exercise

Exercise	Moderate circuit (work/rest ratio)	Moderate/hard circuit (work/rest times)	Hard circuit (work/rest)
1. four-count squat thrusts	15 sec:15 sec	20 sec:20 sec	30 sec:30 sec
2. push-ups	15 sec:15 sec	20 sec:20 sec	30 sec:30 sec
3. scissor step-ups	15 sec:15 sec	20 sec:20 sec	30 sec:30 sec
4. abdominal sit-backs	15 sec:15 sec	20 sec:20 sec	30 sec:30 sec
5. squats to presses	15 sec:15 sec	20 sec:20 sec	30 sec:30 sec
6. body weight rows	15 sec:15 sec	20 sec:20 sec	30 sec:30 sec
7. one-leg squats	10 sec for each leg: 20 sec rest	15 sec for each leg: 30 sec rest	20 sec for each leg: 30 sec rest
8. low-back stabilisers	15 sec:15 sec	20 sec:20 sec	30 sec:30 sec
Rest between circuits	2 minutes	2 minutes	3 minutes

Perform the exercises in the order indicated, starting with four-count squat thrusts and then proceeding to push-ups etc. When you finish each circuit by completing the low back stabilisers, rest for the indicated amount of time and then cycle back to the four-count squat thrusts. Note that work/rest times vary for the three different types of circuits – moderate, moderate/hard and hard.

Circuit training progression: making your circuit training more difficult over time

Week	Circuit type	Number of circuits/workout	Total work (seconds)
1	moderate	2	250
2	moderate/hard	2	340
3	hard	2	500
4	moderate	3	375
5	moderate/hard	3	510
6	moderate/hard	4	680
7	hard	3	750
8	moderate/hard	3	510

The eight exercises in your circuit

For each circuit, do the following exercises:

1. Four-count squat thrusts

- Stand with your arms held at your sides, and then squat down, placing both hands in front of you on the floor.
- With arms straight and your weight resting on both hands, quickly extend both legs backward (hop backward), ending in a front support position.
- Return legs forward (hop forward), ending in a low squat position with hands on the floor.
- Finally, jump into the air and return to a standing position. Repeat each of these four steps, in order, to a rhythmic 1-2-3-4 count, without pausing between counts or repetitions.

How will this exercise benefit you?

The high degree of amplitude (joint motion) at your hips and knees, combined with the resistance provided by your body weight, will develop strength and mobility in your knee and hip joints, important for high-speed movement. The front support position develops stability and strength in the upper trunk, abdominal and pelvic regions, strength that is necessary to control torso movements during the running stride or when you strike a ball. The jump added to the exercise as you return to a standing position greatly increases your cardiac demand, hikes the power of your leg muscles and increases the impact forces (upon landing) as well, fortifying the bones in your legs and feet. Use caution, though; perform the movements on a gym floor or grass, not on concrete.

2. Push-ups

- Start in the front support position with your hands and toes on the floor and trunk, hips and legs extended.
- Bend your arms and lower your chest to the floor. Then push your body upward as you straighten your arms, returning to the front support position.
- Repeat this action rhythmically and continuously without stopping for the allotted time.

How does this benefit you?

Push-ups are well known for increasing upper body strength, but their value in developing abdominal and hip flexor stability is often ignored. This improved stability helps to control hip, trunk and shoulder movements as you move quickly and also promotes balance between the upper and lower body.

3. Scissor step-ups

- Use a step or bench which is approximately mid shin to knee height. Put your left foot on the step, with your right foot on the floor and your arms at your sides.
- Then push down with your left leg and drive your body upward rapidly, switching support (hopping) from left foot to right foot as your body reaches its maximal vertical height.
- With your right foot supporting your body, lower the left foot to the floor rapidly but under control.
- Repeat this action continuously, back and forth from foot to foot, without pausing at the top or bottom positions.

How can this help you?

The scissor step-up develops leg strength, power and dynamic balance control (coordination), without which you can not move quickly, whether it is from one end of the football pitch to the other, from the baseline to the net on a tennis court, or from the start to the finish of a 10K race. Cardiovascular benefits of this exercise can be increased by speeding up your stepping cadence or by increasing the height of the step. Step heightening also enhances leg muscle power and improves mobility of the hip and knee joints.

4. Abdominal sit-backs

- For this exercise, use a step, bench, or chair which does not have a vertical support for your back. Sit with your legs bent and your arms extended in front of you, and then recline your trunk backward at the hips by about 45 degrees. That is your starting point for the exercise.
- To do the sit backs, raise both arms simultaneously overhead while maintaining tight abdominal muscles and a straight chest. Then simply return your arms to the extended position in front of you, without moving your trunk or legs.
- Repeat this back and forth arm action in a smooth, continuous fashion without pausing at any point during the movement.

How will this exercise benefit you?

The increased abdominal stability gained from sit backs carries over to improved posture and better core stability as you run. A strong pelvic girdle and trunk provide the anchor point for a strong pair of legs, allowing you to use your legs in a maximally powerful manner during quick sprints or during sustained, vigorous running.

5. Squats to presses

- Use two dumbbells, each weighing approximately 10% of your body weight (eg if you weigh 150 pounds, each dumbbell should be 15 pounds).

Individuals with less strength-training experience may start with dumbbells which weigh 5% of body weight, while stronger athletes can use dumbbells checking in at 20% of body weight. You may need to experiment a bit, using a weight that makes the exercise challenging but achievable. If dumbbells are unavailable, a barbell of comparable total weight can be utilised.

- To do the exercise, stand upright with your feet spaced about hip- to shoulder-width apart and your hands supporting the dumbbells in front of your shoulders.
- Squat down until your thighs form an angle of 90 degrees with your shins (a half squat), while maintaining a reasonably upright posture with your torso and while keeping your hands in front of your shoulders.
- Then rise quickly from the squat position while pressing (pushing) the dumbbells overhead simultaneously. Both arms and legs should reach full extension at the same time (you will end up standing tall with legs straight and arms straight overhead).
- Lower the dumbbells in a controlled fashion to the starting position.
- Repeat this three-count movement smoothly and continuously.

How can this help you as an athlete?

Squats to presses increase strength and power in your legs, hips, low back, abdominals, shoulders and arms. The whole body involvement of the squat to press increases your cardio-respiratory requirements, compared to the more commonly used, isolated pressing exercises, such as bench and shoulder presses.

6. Body weight rows

- For this one, you will need a horizontal bar or beam which is sturdy enough to support your body weight. Set the bar at approximately the height of your navel (when you are standing straight up).
- To start the exercise, lie under the bar, and grip with both hands at slightly wider than shoulder width. Your heels should be on the floor and your body should be straight and rigid from your shoulders to your ankles.
- Then, with your feet acting as a fulcrum, pull your chest up to the bar by bending your elbows and pulling them backwards.
- Return to the starting position by straightening your arms in a controlled manner and repeat the overall action for the time period specified in the chart.

How can this exercise help you?

The body weight row does for the back-side of the body what the push-up does for the front-side. Body weight rows improve pulling strength of the upper back, shoulder and arm muscles, but they also serve to increase stabilising strength in the low back, gluteals and hamstrings, all of which are critically important for quick movement whenever you participate in your sport. You will achieve a balance between lower and upper body strength by performing this exercise.

7. One-leg squats

- You will need a bench or step six to eight inches in height. Stand with your left foot flat on the floor and your right foot behind you and elevated on the step. The distance between your feet should be approximately the length of your shin, and most of your weight should rest on the heel of your left foot.
- To do the exercise, bend your left knee and lower your body until the left knee makes an angle of 90 degrees between the thigh and lower leg.
- Return to the starting position by straightening your left leg, while maintaining an upright posture with your trunk.
- Repeat this action with the left leg for the specified amount of time, and then switch to the right leg.

How do one-leg squats help you?

This exercise develops muscle strength in the quads, hamstrings and gluteals, the muscles which provide much of your power while running. The actual motion of the one-leg squat closely resembles the 'front side' mechanics of the hip and knee during the actual running stride. By strengthening your hip and knee joints in a coordinated and integrated fashion, your leg strength and running power should improve tremendously. One-leg squats can also help you improve your vertical jumping ability.

8. Low back stabilisers

- For this exercise, you will need a bench, padded table, or 'Roman Chair' bench.
- Lie face down with your body extended and your hips at the edge of the supporting surface of the bench. Your arms should be extended straight down towards the floor in front of you. For added stability, it helps if your feet are wedged between the end of the bench and a wall.
- Smoothly raise both arms over your head simultaneously while maintaining your trunk in full extension (your body should be horizontal to the floor and held straight as an arrow), and then return both arms to the starting position.
- Repeat this action over and over again for the prescribed time period.

How can this exercise benefit you?

Heightened low back strength provides for proper posture while running and also provides excellent 'motion control' of the torso and hips throughout the running stride. As a result, you will move more quickly, whether it is to return a serve on the tennis court or to reach the football in time to score a goal.
Remember that improvements in how your body functions can occur whenever you overload your body's systems. This circuit programme provides an overload of your cardio-respiratory system (especially the hard circuits), taxes your

muscular system by forcing it to work against increased resistance, and forces the key joints involved in moving your body to go through a wider range of motion than they commonly encounter. The result, I believe, will be better, more powerful performances.

Walt Reynolds

Jump to it to develop elastic strength

Introduction

Speed and strength are integral components of fitness found in varying degrees in virtually all athletic movements. Simply put, the combination of speed and strength is power. For many years coaches and athletes have sought to improve power in order to enhance performance. Throughout this century, and no doubt long before, jumping, bounding and hopping exercises have been used in various ways to enhance athletic performance. In recent years this distinct method of training for power or explosiveness has been termed plyometrics. Whatever the origins of the word, the term is used to describe the method of training which seeks to enhance the explosive reaction of the individual through powerful muscular contractions as a result of rapid eccentric contractions.

Muscle mechanism

The maximum force that a muscle can develop is attained during a rapid eccentric contraction. However, it should be realised that muscles seldom perform one type of contraction in isolation during athletic movements. When a concentric contraction occurs (muscle shortens) immediately following an eccentric contraction (muscle lengthens) then the force generated can be dramatically increased. If a muscle is stretched, much of the energy required to stretch it is lost as heat, but some of this energy can be stored by the elastic components of the muscle. This stored energy is available to the muscle only during a subsequent contraction. It is important to realise that this energy boost is lost if the eccentric contraction is not followed immediately by a concentric effort. To express this greater force the muscle must contract within the shortest time possible. This whole process is frequently called the stretch shortening cycle and is the underlying mechanism of plyometric training.

Choose the method to fit the sport

The golden rule of any conditioning programme is specificity. This means that the movement you perform in training should match, as closely as possible, the movements encountered during competition. If you are a rugby player practising for the line-out or a volleyball player interested in increasing vertical jump height, then drop jumping or box jumping may be the right exercise. However,

if you are a javelin thrower aiming for a more explosive launch, upper-body plyometrics is far more appropriate.

Plyometric exercises

The following are examples of lower-body and upper-body plyometric exercises.

Lower body

Drop jumping: This exercise involves the athlete dropping (not jumping) to the ground from a raised platform or box, and then immediately jumping up. The drop down gives the pre-stretch to the leg muscles and the vigorous drive upwards the secondary concentric contraction. The exercise will be more effective the shorter the time the feet are in contact with the ground. The loading in this exercise is governed by the height of the drop, which should be in the region of 30cm to 80cm. Drop jumping is a relatively high-impact form of plyometric training and would normally be introduced after the athlete had become accustomed to lower impact alternatives, such as two footed jumping on the spot.

Bounding and hurdling: If forward motion is more the name of your game, try some bounding. This is a form of plyometric training, where over-sized strides are used in the running action and extra time spent in the air. A two-legged bound reduces the impact to be endured, but to increase the intensity one-legged bounding, or hopping, can be used. Bounding upstairs is a useful way to work on both the vertical and horizontal aspects of the running action. Multiple jumps over a series of obstacles such as hurdles are a valuable drill for athletes training for sprinting or jumping events.

Examples of lower body plyometric exercises with intensity level:

Exercise	Intensity level	Examples
Standing-based jumps (on-the-spot)	Low	Tuck jumps, split jumps
Jumps from standing	Low to medium	Standing long jump, standing hop, standing jump for height
Multiple jumps from standing	Medium	Bounds, bunny-hops, double-footed jumps over low hurdle, double-footed jumps up steps
Multiple jumps with run-in	High	11-stride run + two hops and a jump into a sandpit, two-stride run-in + bounds
Depth jumping	Very high	Jumps down and up off a box (40cm to 100cm) bounding up a hill
Eccentric drop and hold drills	Very high	Hop and hold, bound/hop/bound/hop over 30m (athlete stops and holds on each landing before springing into the next move), drop and hold from a height of 1m

Upper body

A variety of drills can be used to make the upper body more explosive:

Press-ups and hand clap: Press-ups, with a hand clap in between, are a particularly vigorous way to condition the arms and chest. The pre-stretch takes place as the hands arrive back on the ground and the chest sinks, and this is followed quickly by the explosive upward action. Once again, to get the best training effect keep the time in contact with the ground to a minimum.

Medicine ball: Another means of increasing upper body strength popular with throwers is to lie on the ground face-up. A partner then drops a medicine ball down towards the chest of the athlete, who catches the ball (pre-stretch) and immediately throws it back. This is another high-intensity exercise and should only be used after some basic conditioning.

Planning a plyometric session

The choice of exercises within a session and their order should be planned. A session could:

- begin with exercises that are fast, explosive and designed for developing elastic strength (low hurdle jumps, low drop jumps)
- work through exercises that develop concentric strength (standing long jump, high hurdle jumps)
- finish with training for eccentric strength (higher drop jumps).

An alternative session could:

- begin with low hurdle jumps
- progress to bounding and hopping
- continue with steps or box work
- finish with medicine ball workout for abdominals and upper body.

Warm-up

A thorough warm-up is essential prior to plyometric training. Attention should be given to jogging, stretching (static and ballistic), striding and general mobility, especially about the joints involved in the planned plyometric session. A cool-down should follow each session.

How many?

It is wise not to perform too many repetitions in any one session. Since it is a quality session, with the emphasis on speed and power rather than endurance, it's best to split the work into sets with ample recovery in between.

Where to do it and what to wear

For bounding exercises use surfaces such as grass or other resilient surfaces. Avoid cement floors because there is no cushioning. Choose well cushioned shoes that are stable and can absorb some of the inevitable impact. All athletes should undergo general orthopaedic screening before engaging in plyometric training. Particular attention should be given to structural or postural problems that are likely to predispose the athlete to injury.

Conditioning for plyometrics

Higher than normal forces are put on the musculoskeletal system during plyometric exercises so it is important for the athlete to have a good sound base of general strength and endurance. Most experts state that a thorough grounding in weight training is essential before you start plyometrics. It has been suggested that an athlete be able to squat twice their body weight before attempting depth jumps. However, less intensive plyometric exercises can be incorporated into general circuit and weight training during the early stages of training so as to progressively condition the athlete. Simple plyometric drills such as skipping, hopping and bounding should be introduced first. More demanding exercises such as flying-start single-leg hops and depth jumps should be limited to thoroughly conditioned athletes.

Young athletes

Some authors suggest that moderate jumps can be included in the athletic training of very young children (Lohman, 1989). However, great care needs to be exerted when prescribing any training procedures for pre-adolescent children. Because of the relatively immature bone structure in pre-adolescent and adolescent children, the very great forces exerted during intensive depth jumps should be avoided (Smith, 1975).

Summary

Plyometric-type exercises have been used successfully by many athletes as a method of training to enhance power. In order to realise the potential benefits of plyometric training, the stretch shortening cycle must be invoked. This requires careful attention to the technique used during the drill or exercise. The rate of stretch rather than the magnitude of stretch is of primary importance in plyometric training. In addition, the coupling time or ground contact time must be as short as possible.

The challenge to you as coach or athlete is to select or create an exercise that is specific to the event and involves the correct muscular action. As long as you remember to stay specific and to ensure there is a pre-stretch first, the only limit is your imagination. Plyometric exercise and weight training can be combined in complex training sessions to further develop explosive power.

Brian Mackenzie

Jumpers, throwers and sprinters can improve their results by using the Complex system

Traditional strength workouts usually consist of a selection of resistance exercises that target the large and sport-specific muscle groups. Particular training systems can vary, but essentially strength work involves moderate to heavy resistance, 75% to 90% of maximum, with a training volume of three to five sets per exercise. There are two main training effects that come about from this kind of strength routine. The first is an increased neural activation, and this will improve within a few weeks. Increased neural activation means that the maximum amount of muscle fibre recruitment is enhanced, together with the efficiency with which the motor units are activated. All this makes for an increased strength potential. The second training effect is hypertrophy or increased muscle mass. This normally occurs after two to three months of training. Hypertrophy leads to strength improvement because of an increase in the cross-sectional area of the muscle fibres, and thus more force can be exerted when the muscle fibres contract.

The increased strength that results from strength training has been shown to improve sports performance, particularly in terms of sprinting, jumping and throwing, or the speed strength events. However, good as strength training is, one must always remember that it will only go so far in improving speed strength performance. The problem is that the neural activation effects described above are mainly confined to untrained subjects. Once an athlete becomes an experienced lifter, they will benefit from less and less neural activation, particularly in rate-of-force-development (RFD). RFD is simply the speed with which force is achieved during a movement. Thus the greater the RFD, the more explosive and powerful the movement, which is why RFD is crucial for success in speed strength events.

As the neural improvements tail off, any further strength gains from traditional strength work are mostly due to increases in muscle mass. This is not necessarily desirable, because strength gains due to hypertrophy tend to involve high forces at slow speeds, and this is not useful for sports performance. For example, it takes around 400 milliseconds to develop maximum force during a squat exercise, but the foot-ground contact time during sprinting is around 90 milliseconds, so there is not time to produce maximum force during sprint running. Thus, during speed strength events such as sprinting, it is the RFD that becomes more important than absolute strength, so that as much force as possible can be developed in the limited time available.

Supercharging your type IIb fibres

As traditional strength training falls short in developing RFD, there comes a point in an athlete's training when the need to develop maximum strength is replaced by the need to develop power and RFD. When it comes to RFD, the muscle fibres that must be targeted are the type IIb fibres, as these are the ones

that produce force most explosively, allowing for maximum power. However, actually training these supercharged type llbs is harder than you might imagine. Even bodybuilders and power lifters, who do masses of strength work, have highly developed type lla fibres but are not powerful or explosive because they have not trained their type IIbs.

The sorts of exercise that target the type llbs are speed strength exercises such as weighted squat jumps, or plyometric exercises such as drop jumps and hops, etc. These exercises involve lower forces than traditional strength work but are performed at much faster speeds, thus targeting the type IIbs. The training effects from these exercises are increased power and RFD. Many athletes include regular plyometric or speed strength workouts in their schedules and are well aware of the benefits. However, it is slightly less well known that the combination of traditional strength with power and/or plyometric exercises together results in even greater type llb recruitment and consequently greater improvements in power and RFD. Hence the development of a training system that is called Complex training, which is quite simply the combination of weight-training exercises with speed or plyometric exercises within the same workout.

Complex by name, simple by design

The main essence of Complex training is that the content of a training session and the quality to which it is performed are the two important variables, not the volume of weights lifted. By adding explosive exercise to the traditional strength work, Complex training makes the whole session more functional and thus the training adaptations will actually benefit the athlete in terms of sports performance. As an athlete, you need to know that what you do in the gym is going to make a difference on the track, field, pitch or court. Spending months improving your squat and bench press PBs, only to discover that your 100m time is still the same, is not a productive use of your precious training time. However, by using the Complex training system you can be confident that your time in the gym will be time well spent.

Although Complex by name, these workouts are really very simple by design. Complex training is basically a workout comprising matched pairs of exercises, a resistance exercise followed by a plyometric or speed exercise. The main condition is that the pair of exercises must involve the same muscle groups. For example, a pair for the legs could be squats followed by squat jumps, and for the upper body we could match bench press with medicine ball chest pass. The rationale behind these matched pairs is that, in layman's terms, the resistance exercise gets the nervous system firing on all cylinders so that the muscles are at maximum potential to perform the plyometric exercise. In effect, the preceding resistance exercise enables you to recruit more type IIb fibres during the explosive exercise, hence the greater training benefit.

Low- and high-level intensity

A Complex workout can be designed at two levels of intensity. The low level would be performed at the preparation phase of the training cycle and the high level during pre-competition and competition phases. The low-level Complex workout involves a range of weight exercises followed later by some matched plyometric exercises. In contrast, the high-level workout involves super-sets of weight and plyometric pairs. This means the athlete performs the weights exercise, eg a set of squats, followed immediately by a set of plyometrics, eg hops, whereupon the athlete rests. This super-set would be performed three to four times.

The purpose of the low-intensity Complex workout is that it allows the athlete to train at a relatively high volume, which is what is required in the preparation stage. However, by adding some plyometric work in to the routine, the athlete is not neglecting their type llb fibres. This kind of workout would also be suitable for beginners and junior athletes.

The resistance levels in the low-intensity workout should be 60% to 75% of 1RM. The volume of the weights exercises should be three to five sets of six to 10 repetitions and the rest periods should be around one minute between sets. There should be a rest period of at least three minutes between the weights exercise and its matched plyometric pairing, but no longer than 10 minutes. A practical way to achieve this is to perform three to five sets of your leg weights exercise, followed by three to five sets of an upper body weights exercise, by which time three to five minutes will have passed and the leg plyometric exercise can be performed. The following table gives a sample low-intensity session that can be used in the preparation period.

Exercise	Sets/repetitions	Rest
Squats	3 x 6-10	1 min
Bench press	3 x 6-10	1 min
Vertical jumps	3 x 10	90 secs
Medicine ball chest pass	3 x 10	90 secs
Dumbbell lunge	3 x 8	1 min
Lat pull-down	3 x 6-10	1 min
Step jumps	3 x 16	90 secs
Medicine ball overhead pass	3 x 10	90 secs
Abdominal crunch	4 x 20	1 min
Glute ham raise	3 x 15	1 min
Medicine ball sit-up and throw	3 x 10	90 secs

On to high quality

The high-quality Complex workout involves a smaller volume but a higher intensity of weights. In this workout the resistance and plyometric exercises are in super-set pairs, which facilitate the recruitment of type lIb fibres. This means the athlete performs the sets of weights exercises and then immediately follows

this with the plyometric exercise. During this period of training, the choice of plyometric exercises must be more intense and sports specific, so that maximum power is achieved and the session is as relevant as possible. The resistance levels in the high-intensity workout should be 75% to 90% of 1RM. The volume of the weights exercises should be two to four sets of three to six repetitions and the rest periods should be minimal between matched pairs but three to five minutes between sets. The following table gives an example of a high-quality Complex workout performed in the pre-competition period.

Exercise	Sets/repetitions	Rest
Squats, drop jumps	3 x 5	3-5 mins
	3 x 6	
Barbell step-ups, hops (each leg)	2 x 10	3-5 mins
	2 x 5	
Bench press, plyo press-up	2 x 6	3-5 mins
	2 x 5	
Barbell lunges, box jump	2 x 10	3-5 mins
	2 x 10	
Single-arm row, medicine ball backwards throw	3 x 6	3-5 mins
	3 x 6	

In the competition period the volume should drop even further as the quality of the workout ever increases. For example:

Exercise	Sets/repetitions	Rest
Power cleans (unpaired)	2 x 3	3 mins
Squats, hops (each leg)	2 x 4	5 mins
	2 x 6	
Barbell lunges, speed bounds	2 x 8	5 mins
	2 x 10	

Concentrate on quality

It is very important when performing Complex workouts to make them very tough sessions in terms of quality. To get the best out of them, you need to be physically fresh and mentally motivated. This means no tough aerobic or anaerobic training for at least 48 hours before a Complex session. It also means that you must concentrate and perform the exercises to the best of your ability. Type IIb fibres are not magically recruited just by doing a particular training routine; it is up to you to focus and perform the exercises as explosively as possible. The structure of the Complex training session provides an advantage, but this will not be capitalised on unless you push it. To ensure this quality is maintained, you must observe the correct rest periods. A further practical tip to bear in mind is that once the training has started no static stretching exercise should take place, because this will relax the muscles and reduce force production potential. In fact, it is arguable that no static stretching at all should

take place in the warm-up for the same reason. Light aerobic activity and active mobility exercise combined with suitable warm-up lifts are more effective.

To sum up, strength training is great, but ultimately it is not the best way to improve performance. Instead, plyometric and speed strength exercises must be included in the training routine. The Complex training system provides a way of combining the two training methods to enhance the training benefit in power and RFD. The Complex workout should follow the usual periodisation cycle, with high-volume, low-intensity and general workouts gradually being replaced by low-volume, high-intensity and specific training.

A brief neuromuscular explanation

The most effective speed strength performance depends on the RFD, the quickness with which force can be achieved during a particular movement. For a rapid RFD, an athlete must recruit their type lIb fibres. These fibres are packaged together in motor units. A motor unit comprises a single motor neuron that is connected to a large number, about 1000, of these type lIb fibres. It is the motor neuron that switches on the fibres in the motor unit, where one single neuron innervates many fibres. Other types of motor units comprise neurons connected to type IIa fibres and neurons connected to type I (slow-twitch) fibres; however, in these motor units the motor neurons generally connect to fewer muscle fibres. Because of their larger size, the type IIb motor units have a high excitation threshold, which means they are more difficult to turn on, or recruit, than the smaller slow-twitch motor units. This means that to utilise your type lIb fibres you need a maximum level of activation of the corresponding motor neuron for the lIb muscle fibres to be switched on.

It has been shown that after a very high-intensity voluntary contraction, the level of excitation in the motor unit is increased, and this increased excitation can last for several minutes. This is termed a 'post tetanic potentiation' and essentially means that a better recruitment output is achieved for the same neural input. Or, to put it simply, more fast-twitch fibre recruitment for the same voluntary effort.

This has been shown experimentally by H-reflex studies. The H-reflex is the amount of EMG activity innervated by an electric shock. After muscle stimulation, the H-reflex is shown to have increased; thus more muscle fibres have been recruited for the same level of activation. It is this effect that we are capitalising on during Complex training. The weights exercises provide the initial stimulus for the muscles, exciting the nervous system and allowing more muscle recruitment. In particular, more type lIb recruitment, which as we have seen is more difficult. Then, when the plyometric exercise is performed, more type lIb fibres can be recruited and thus more training benefits are achieved. This is why studies have shown that Complex training brings about greater RFD improvement than plyometric training alone.

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