

# Training for **SPRINTING** speed and acceleration

**A SPECIAL REPORT FROM**



**PEAK  
PERFORMANCE**

The research newsletter on  
stamina, strength and fitness



Training for  
**SPRINTING**  
speed and acceleration



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# From the editor

There is something incredibly pure about speed. In athletics or track and field, the 100m, 200m and 400m events produce exhilaration that the other events rarely match. Audiences worldwide appreciate speed, and the anticipation to see who is the fastest, who can break records, who can win race after race is exhilarating. One of favourite armchair sporting moments was watching Michael Johnson smash the 200m record in the 1996 Olympic final. Just watching that speed took my breath away more than running any 200m sprint ever did!

It is not just in athletics where sprinting and acceleration are vital. Just think of the advantages certain athletes have in their sports because of their extra pace: Thierry Henry in football, Bryan Habana in rugby, Allen Iverson in basketball, LaDainian Tomlinson in American football. A leading factor to explain why the game looks so easy for these players is because of their electrifying speed and acceleration. There truly is no substitute for pace!

This special report aims to help both track sprinters and team athletes improve their speed training. The opening chapters explain how to build a foundation for increasing your speed. The next couple of chapters take a look at specific training methods to increase acceleration and top speed, once that foundation is solid. There is an article on 'the 40', a very popular test in America judging relevant speed. The final two chapters explain how you can strengthen those legs to avoid injuries and gain even more power out of the blocks.

So if it's gold medals you're chasing or tackles your evading speed is the prerequisite. Whatever the case may be, I hope this special report will help you leave your future opponents stumbling in your trail.

A stylized, handwritten signature in black ink, appearing to read 'SB' followed by a long, sweeping horizontal line.

Sam Bordiss  
Editor



## Building speed before endurance: should athletes turn convention on its head?

### Introduction

The traditional training approach has been to progress speed athletes from slower, aerobic work through to anaerobic speed work as the season progresses. But here we argue that this methodology is outdated and that convention should be turned on its head

Until quite recently, the prevailing methodology in sprint athlete training has used a ‘long to short’ training approach. Basically, for this periodisation model, the sprinter performs slower aerobic and anaerobic work at the beginning of the training year and then progresses to faster and faster anaerobic work as the season approaches and in-season. Intensity is increased, training volume reduced, and specificity of training increases accordingly.

However, more recently a ‘short to long’ approach has become more popular. Coaches such as Charlie Francis (*see box overleaf*) have been at the forefront of such a shift in thinking. This approach emphasises speed all year round. Sprint workouts, for example, take place in what would normally be the ‘slow slog’ preliminary stages of training, when an athlete is ‘supposedly’ building base condition using slower conditioning methods. In the ‘short to long’ approach, the athlete trains at or near 100% effort throughout. Advocates of this approach claim it will:

- 1) maximise physical speed development;
- 2) optimally stimulate the central nervous system (CNS);
- 3) reduce injuries (athletes using the conventional approach

**Charlie Francis – sprint guru or sprint devil?**

Charlie Francis coached (the then fastest man in the world) Ben Johnson to the world record and Olympic title in Seoul in 1988. Johnson, as we know, was subsequently stripped of this and other titles for a doping offence. However, it would be erroneous for us to assume that Francis' athletes only won because they were drug-fuelled. Francis' sprint training methods did add that 'something extra' to the performances of those he coached, and one of these was the 'short to long' approach. Among his many other coaching accomplishments was the fact that at the 1984 Olympics, of the 14 Canadian medals, eight were won by Francis-coached athletes. Not surprisingly, his techniques and thoughts are still in demand today.

can pick up injuries when attempting to sprint after months of much slower work);

4) allow for more speed peaks;

5) minimise the negative effects of de-training on fast-twitch muscle fibre.

The 'short to long' approach to sprint training can be seen to reflect the 'undulating periodisation' (UP) theory of training planning (of which more later).

**How much of an aerobic base does a sprint athlete need?**

Aerobic fitness underpins the development of most other types of fitness. The more efficient an athlete's body is at processing oxygen, the quicker it will be able to recover between efforts. In the past it was reasoned that developing good aerobic condition in a sprint athlete would boost speed development. Thus it was not unknown for rugby and football players to go on 10-mile runs, or sprinters to run continuously for up to 30 minutes!

The logic of this approach, however, is questionable when you consider that most of the work performed by sprinters is anaerobic (*see table 1*) and too much emphasis on aerobic work can blunt speed; this results from an unnecessary increase in the oxygen-processing capabilities of slow-twitch muscle fibre and a 'blunting' of the speed and power generation capabilities of type IIa and type IIb fast-twitch muscle fibre.

**Table 1: Work performed by sprinters/other speed athletes and energy pathways**

Energy pathway	Duration/comments	Sprint activity relevance – selected examples
Immediate anaerobic	6-8 seconds Type IIb fibre emphasis Targeted by sprint and plyometric activities	100/200m sprinters – very significant 400m sprinters – significant Football goalkeepers and strikers – significant Racket sport players – significant
Short term anaerobic	8-90 seconds Type IIa and IIb fibre emphasis Targeted by sprinting, plyometrics and weight training	100-400m sprinters – very significant Field sport players – very significant Racket sport players – very significant
Aerobic	90 seconds onwards Type I fibre emphasis Targeted by steady paced running	Minimal

(Adapted from Dintiman, *Sports Speed*, (3rd edition)<sup>(4)</sup>)

Prolonged training with a specific emphasis (*ie* speed) can change fibre type<sup>(1,2)</sup>. Sprint athletes obviously require a proliferation of fast-twitch fibres – a top class sprinter’s leg muscles will possess 70-80% of fast-twitch fibres – and the ‘short to long’ approach never loses sight of this, as it maximises the opportunity of changing fibre type to express speed.

So how much aerobic training is necessary in a speed/sprint training programme? Charlie Francis recommends that for training a ‘mature’ 100, 200 or 400m runner, the development of base fitness with an aerobic element requires relatively little attention<sup>(3)</sup>. He advocates only a short six-week period at the beginning of the training year.

Training immature athletes (less than five years of consistent sprint training) will require a slightly greater aerobic conditioning emphasis and Francis identifies an 8-12 week development phase at the beginning of the training year. Both these durations should allow sufficient time to plan a double or even a triple periodisation sprint programme using much more specific training (of which more later).

Instead of slow, long distance, tempo running is used as a

more appropriate base builder; these runs provide a more relevant anaerobic base of fitness, whilst improving aerobic condition. A typical tempo running workout would be something like three sets of 100m/200m/100m with 50m walk recovery between each run and 300m walk between sets. The runs would be performed at 75% of maximum speed.

### **Maintaining speed in-season for speed athletes**

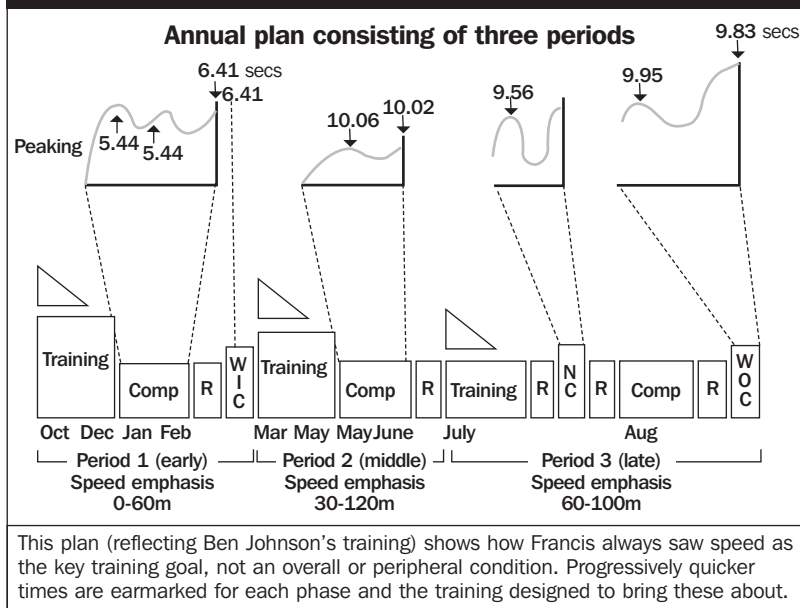
Undulating periodisation (UP) is probably the sport sprint coach's most effective way to maximise the playing condition of his or her athletes. UP basically mixes and matches all of the relevant training ingredients into one training mix. Strength, power, agility, endurance, speed, specific individual and collective playing skills and flexibility are all carefully overlapped and fused together to keep the athlete in peak playing condition.

This requires careful and consistent athlete appraisal on the part of the coach (something that Francis emphasises with his sprint training). It is crucial that coaches are aware that no two athletes will have exactly the same training needs and that individual training programmes will therefore have to be produced (although this may be more difficult for those involved in team games). It should also be noted that athletes from certain sports, such as a football midfielder, will need greater levels of aerobic conditioning than others to allow them to cope with the energy pathway demands of their games. However, even then, anaerobic training is the most important (*see table 1*).

### **Intensity, not volume, is the key to improved sprint performance**

Although nearly all athletes increase the volume of their training as they progress from year to year, for sprint athletes it is training intensity that is critical. Intensity should increase while volume may remain unchanged or even decrease. The coach needs to monitor carefully the volume of intense work being performed by the athlete and ensure adequate recovery to allow progression and reduce injury risk.

**Figure 1: Example of a triple periodisation programme for a sprint athlete**



Source: *The Charlie Francis Training System* (p101)<sup>(3)</sup>

The 'short to long' approach allows the athlete to remain close to absolute sprint condition at any time in the training year. This is why, for sprint athletes, double and even triple periodisation is advocated.

A triple-periodised training programme allows an elite sprint athlete to peak for the indoor season, mid-outdoor season and late outdoor season for Olympic or World Championships. Each peak can elicit a higher level of performance than the previous one, whereas the conventional 'long to short' approach may fail to achieve three optimum speed peaks, as too much time is lost returning to previous speed levels rather than building on them. An exacting sprint coach should attempt to blend all the ingredients of perfect sprint performance into the third peak (acceleration, absolute speed and speed endurance – see figure 1).

## **The importance of power**

Power is also crucial for a sprinter, and the ‘short to long’ method keeps power on the boil. Francis ensures that complementary training takes place at all times e.g. by maximum strength work in the gym during tempo running phases and even workouts. He doesn’t advocate combining flat-out sprint work with near maximum weight lifting, due to the contraindications of the two training methods and the ‘strain’ that this would place on the CNS. Interestingly, neither does he recommend a weight-training ‘channelling’ phase (where, after general strength is developed with ‘slower’ exercises, sport-specific weights exercises are performed with increasing speed). Instead, Francis sees sprinting plus plyometrics exercises as the ultimate ‘channeller’.

## **Sprint speeds as conditioning ingredients**

In order to develop optimum speed, the coach and athlete need to carefully blend sprint speeds. We have noted, for example, that aerobic conditioning becomes much less of a concern for nearly all power athletes as they become more mature. In terms of absolute speed, it is generally recommended that running intensities never fall below 75% of maximum speed. Speeds slower than this will not produce a sufficiently strong stimulatory effect on fast-twitch muscle fibre. Many coaches fail to divide up (in terms of their effects) the percentages of speed that can be generated between 75 and 105% of maximum speed (105% refers to the speed that can be generated through the use of over-speed techniques, such as downhill running and the use of bungees - see chapter three).

Various terms have been applied to sprint running speeds based on percentages of effort, such as tempo runs, speed endurance, lactate endurance/maximum speed and over-speed runs. Table 2 (*above right*) defines the key types:

## **Speed-endurance training**

Speed endurance is crucial to a multitude of athletes and a lack of it will result in reduced sports capability. A rugby player short

*‘The ‘short to long’ approach should be used when developing speed endurance, as well as out and out speed’*

**Table 2: Sprint speeds as a percentage of maximum speed**

Name of speed	Description and comments	Typical workout
<b>Tempo runs</b>	75-85% of max speed, run over 100-300m distances on the track (Francis recommends total weekly distances of 2,000-2,400m)	6 x 200m at 75% effort (speed) concentrating on form. Five minutes recovery between runs
<b>Speed-endurance speed</b>	Sprints over 60-120m designed to improve the sprinter's ability to maintain flat-out speed. This type of training is very intense and should be used with caution, due to its stress on the CNS. Regeneration of the athlete is paramount	2 x 120m 100% sprints – full recovery
<b>95% effort speed</b>	These runs are performed just below flat out. They will blend in flawless technique without over-stressing the athlete and in particular their CNS	3 x 120m with seven minutes recovery between runs
<b>Out-and-out speed</b>	These runs are performed at 100% effort, they are intense and will stress the CNS	2 sets of 4 x 40m sprints from block start – full recovery between runs
<b>Over-speed speed</b>	These runs are performed at 105% of top speed using downhill methods or bungees to achieve this. High level of CNS strain	4 x 30m downhill runs with full recovery

of speed endurance may be intercepted and hauled to the ground after making a 60m break for the line, while a 200m runner may have built up a seemingly commanding lead off of the bend, only to be reeled in and passed in the last five metres of the race. In field sports, players make repeated short-lived but intense efforts; the athlete with a high level of speed endurance will experience less 'fade' during a match or workout and will be able to maintain high power outputs. Speed-endurance workouts are therefore crucial to their training.

The 'short to long' approach should be used when developing speed endurance, as well as out-and-out speed. How much of an emphasis the coach places on this will be dependent on the training maturity of the athlete, the point in the season and the specific playing requirements of the athlete's

**Table 3: Eight-week speed-endurance programme**

Week	Workout	Routine and distance	Reps	Rest interval
1	1	Jog 15yd, stride 15yd (75% speed), jog 15yd, walk 15yd	5	No rest between reps; the 15yd walk acts as the recovery phase
2	3	Jog 20yd, stride 20yd (90% speed), jog 20yd, walk 20yd	5	As above
3	9	Jog 25yd, stride 25yd, sprint 25 yd, walk 25yd	7	As above
4	11	Sprint 20yd, jog 20yd, sprint 20yd, walk 20yd	7	As above
5	14	Sprint 20yd 300yd sprint Run on the spot to exhaustion	10 1 2	Walk 10-30 secs 3-4 mins 1 min
6	15	Sprint 40yd 300yd sprint Distance hop to exhaustion	8 2 1 each leg	Walk 10-30 secs 2-3 mins 1 min
7	19	Sprint 20yd, jog 20yd, sprint 20yd, walk 20yd 300yd sprint	15 3 4	Walk is the recovery phase 2.5 mins
8	21	440yd sprint		4-5 mins

Adapted from Dintiman, *Sports Speed* (3rd edition) page 151/152 <sup>(4)</sup>

sport. For example, a midfield football player will require greater speed-endurance capability than a goalkeeper, who needs more ‘immediate anaerobic pathway’ conditioning. George Dintiman is another one of the world’s leading speed training experts and he has devised an eight-week speed-endurance training programme designed to increase both immediate and short-term anaerobic fitness. Table 3 provides some sample workouts from this programme and shows how it fits with the ‘short to long’ theory of speed development.

## Conclusion

The ‘short to long’ approach, as stressed, never loses sight of the need to move at maximum speed. It is totally focused on developing this quality. It strips out all the intensities, exercises

and energy pathway training methods that are seen to be detrimental to achieving this goal. And crucially, it is very carefully constructed to allow the athlete and his or her CNS to adapt optimally.

**John Shepherd MA is a specialist health, sport and fitness writer and a former international long jumper**

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## **Twitch and you're gone – all you need to know about developing fast-twitch muscle fibres**

### **Introduction**

Let's get out of the blocks straight away, with our fast-twitch fibres blazing; on the 'B' of the bang, as Colin Jackson once put it! There are more than 250 million muscle fibres in our bodies and more than 430 muscles that we can control voluntarily. Fibres are, in fact, bundles of cells held together by collagen (connective tissue). Each fibre consists of a membrane, numerous nuclei and thousands of myofibrils (inner strands) that run the length of the fibre.

In order to perform a sport skill numerous muscles and muscle fibres have to interact. The process is controlled by the brain, which sends out electrochemical messages to the muscles via the spinal cord. These signals are received in the muscles by 'anterior motoneurons', whose role is to stimulate muscular contraction. Muscular force is generated through the interaction of two protein filaments that constitute the myofibril: actin and myosin.

Anterior motoneurons and motor units can be likened to a car's starter motor, while the brain is like the key; the former kicks the muscle fibres into action (or rather 'contraction') after the latter has been turned. Some muscles have large numbers of motor units and relatively few fibres, which enables them to execute highly precise movements. One such muscle is the eye, which has one motor unit for every 10 muscle fibres. By contrast, the gastrocnemius (calf muscle), which performs

larger, more powerful movements, has 580 motor units to 1.3 million fibres.

The interaction that occurs at muscular (and tendon and joint) level is two-way, since there are built-in feedback and control mechanisms to prevent muscles from damaging themselves by over-contracting. Proprioceptive (feedback mechanism) components of motor units, joints and ligaments continually monitor muscular stretch and swing into action if, for example, a limb is moved beyond its normal range. This is achieved by muscle spindles ‘pulling back’ on muscle fibres to reduce the stretch. This ‘stretch/reflex’ is a vital component of our body’s muscular safety mechanism, but it can also play a significant role in developing greater fast-twitch muscle power (*see table 2*).

Fast-twitch fibres, also known as ‘white’ or ‘type II’ fibres, contract two to three times faster than their slow-twitch counterparts, producing 30-70 twitches per second, compared with 10-30 for slow-twitch.

There are two basic types of fast-twitch fibre:

- Type IIa, aka ‘intermediate’ fast-twitch fibres or ‘fast oxidative glycolytic’ (FOG) fibres because of their ability to display, when exposed to the relevant training stimuli, a relatively high capacity to contract under conditions of aerobic or anaerobic energy production;
- Type IIb fibres, the ‘turbo-chargers’ in our muscles, which swing into action for a high-performance boost when needed. These are also known as ‘fast glycogenolytic’ (FG) fibres, since they rely almost exclusively on the short-term alactic/glycolytic energy system to fire them up.

Slow-twitch fibres, aka type I, red or slow oxidative fibres, are designed to sustain slow but long-lived muscular contractions and are able to function for long periods on aerobic energy.

Most coaches and athletes will be familiar with type IIa and type IIb fast-twitch fibres, but it should be noted that other types have been identified. Former national athletics coach Frank Dick has described a further seven sub-divisions, although the

differences between these are not considered significant enough for them to have a crucial effect on sports conditioning<sup>(1)</sup>.

Fast-twitch fibres are thicker than slow ones and it is the former that grow in size (hypertrophy) when activated by the ‘right’ training.

Activating fast-twitch motor units is the key to improved strength, speed and power. Unlike slow-twitch motor units, which are responsible for most of our day-to-day muscular activity, fast-twitch units are quite lazy and tend to slumber until called to action.

While typing this article, the slow-twitch motor units of my fingers and wrists were getting a good workout. As indicated, they are designed for repeated submaximal, often finite, contractions. It was only when I picked up the computer, the desk it sat on and the 30 reference books I was using to help me write this piece, and hurled the whole lot out of the window in abject frustration at my writing ability, that my larger fast-twitch motor units contributed anything!

*‘It is often assumed that those blessed with great speed are born with a higher percentage of fast-twitch muscle fibres’*

## **The role of mental energy**

To recruit these units takes powerful movements, possibly fuelled by an excited hormonal response associated with increased adrenaline and neural stimulation (as with my desk throwing). In terms of producing more power, this works because the increased mental energy boosts the flow of electrical impulses to the muscle, generating increased muscular tension.

It should be pointed out that extreme levels of this ‘neuronal stimulation’ can lead to impaired sports performance. For example, a golfer relies on the synchronous firing of fast-twitch motor units during the ‘swing’; but if he becomes overly aggressive and ‘tries too hard’ a poor stroke usually results, even though his fast-twitch motor units could be capable of expressing more power because of their increased state of tension.

Fast-twitch muscle fibre is recruited synchronously – *ie* all at the same time – within its motor unit. This is, in part, a

physiological manifestation of a neural activity – sports skill learning. Let's use sprinting to explain this. Carl Lewis had a wonderful silky sprint action. His finely-honed technique allowed his fast-twitch motor units to fire synchronously and apply power. The end result was championship and world record-breaking form. In short, Lewis's neural mastery of sprinting form allowed his fast-twitch motor units to fire off smoothly, operating like cogs in a well-oiled machine. It also allowed him to recruit the largest, and therefore most efficient, power-producing units. This latter ability is a further key element in developing optimum fast-twitch motor unit power.

By contrast, slow-twitch muscle motor units are recruited asynchronously, with some resting and others firing when carrying out endurance activity. Fast-twitch motor units are recruited according to the 'size principle', in that the more power, speed or strength an activity requires, the larger the units called in to supply the effort. It would, however, take a flat-out sprint or a near PB power clean to fully activate them. This means that power athletes have to be in the right frame of mind to get the most out of their fast-twitch motor units. There is no such thing as an easy flat-out sprinting session or power-lifting workout.

By contrast, the endurance runner could go for a 60-minute easy 'tick-over' effort and drift mentally away from the task while still giving his or her slow-twitch motor units a decent workout.

It is often assumed that those blessed with great speed or strength are born with a higher percentage of fast-twitch muscle fibres, and that no amount of speed work (or neuronal stimulation) will turn a cart-horse into a race horse. But, in fact, fast-twitch fibres are fairly evenly distributed between the muscles of sedentary people, with most possessing 45-55% of both fast- and slow-twitch varieties.

Thus few of us are inherently destined for any particular type of activity, and how we develop will depend mostly on two factors:

- The way our sporting experiences are shaped at a relatively early age;

**Table 1: Fast-twitch muscle percentages compared**

<b>Subject</b>	<b>Fast-twitch muscle fibre (%)</b>
Sedentary	45-55
Distance runner	25
Middle distance runner	35
Sprinter	84
Cheetah	83% of the total fibres examined in the rear outer portion of the thigh (vastus lateralis) and nearly 61% of the gastrocnemius were fast-twitch

Adapted from Dick page 109<sup>(1)</sup> and Williams (97)<sup>(2)</sup>

- How we train our muscle fibres throughout our sporting careers.

The table above compares fast-twitch muscle percentages in selected sports activities with those of sedentary individuals - and a very speedy animal. Note the extremes of muscle fibre distribution. The right training will positively develop more of the fibres needed for either dynamic or endurance activity, although the cheetah may not be aware of this!

Ross et al studied motor unit changes in sprinters and concluded that positive adaptations of muscle to sprint training could be divided into:<sup>(4)</sup>

- Morphological adaptations, including changes in muscle fibre type and cross-sectional area – *ie* the ability of fast-twitch muscle fibres to exert more power by increasing in number and/or size;
- Metabolic adaptations to energy systems to create more speed – *eg* a greater ability to complete short repeated maximal efforts, acquired through an improvement in the short-term alactic/glycolytic energy system which is, in turn, gained from the creation and replenishment of high-energy phosphates.

Similar finding were made by Abernethy and his team, who

**Table 2: The best training methods for fast-twitch motor units**

Method	Comments
<b>Lifting weights in excess of 60% 1RM</b>	The heavier the weight, the greater the number and size of fast-twitch motor units recruited. A weight in excess of 75% 1RM is required to recruit the largest units
<b>Performing a physical activity flat-out – eg sprinting, swimming, cycling as fast as possible</b>	Good recoveries are needed to maximise effort. The short-term anaerobic energy system will positively adapt. The minimum speed needed to contribute towards absolute speed <b>rowing or</b> development is 75% of maximum
<b>Training your muscles eccentrically</b>	Research indicates that this form of training increases fast twitch motor unit recruitment. <sup>(6)</sup> An eccentric muscular contraction generates force when muscle fibres lengthen ( <i>see plyometric training, below</i> )
<b>Plyometric training</b>	These exercises utilise the stretch-reflex mechanism, allowing for much greater-than-normal force to be generated by pre-stretching a muscle (the eccentric contraction) before it contracts. A hop, bound or depth jump is an example of a plyometric conditioning drill; a long jump take-off is an example of a plyometric sport skill.
<b>Complex training</b>	This can induce greater recruitment of fast-twitch motor units by lulling the protective mechanisms of a muscle into reduced activity, allowing it to generate greater force. Complex training involves combining weights exercises with plyometric ones in a systematic fashion. A good example is: 1 set of 10 squats at 75% 1RM followed, after a 2-minute recovery, by 10 jump squats, repeated 3 times
<b>Over-speed training</b>	This will have a transferable neural effect only if the athlete consciously moves his own limbs at the increased pace. It includes downhill sprinting and hitting or throwing sports using lighter implements
<b>Good recovery</b>	24-48 hours' recovery should be taken between very intense plyometric/complex training and speed work sessions. A further 24-36 hours' recovery will result in an over-compensatory peak – ie opportunity for a peak performance
<b>Sport specific warm-up</b>	This will reduce the risk of injury, increase the receptivity of the neuromuscular system to the ensuing work and reduce the potentially contradictory effects of non-specific preparation on fast-twitch motor units
<b>Mental preparation</b>	Maximum fast-twitch motor unit recruitment can result from specific mental preparation before and during competition

compared sprint training methods with those used by endurance athletes<sup>(4)</sup>.

Table 2 summarises the best methods for enhancing fast-twitch motor units. Conversely, the wrong training – and even what might in some cases seem to be the ‘right’ training – can compromise their development. Returning to the sprint training research of Ross and his team<sup>(3)</sup>, they believed that volume and/or frequency of sprint training beyond what is optimal for an individual can induce a shift towards slower muscle contractile characteristics. Basically, this means that if a sprinter were to perform too many under-speed track reps, his top speed would be impaired.

### **What’s best for power athletes?**

For 100% power athletes (such as 100m sprinters) and even those involved in sports where occasional maximal or near maximal quick flashes of power are required, such as golf, baseball (pitching and batting) and football (goal keeping), it may well be that high-intensity training sessions, interspersed with long periods of rest, are best for the optimum development of fast-twitch motor units, particularly in-season.

In-season it may be far better for them to condition themselves using sprints, medicine ball work and autogenic training (a form of mental conditioning). Think of the cheetah in our muscle fibre distribution table. What does this fastest land animal do? It lies around all day, exploding into action every now and again: fast-twitch fibre development heaven - but hell for its prey!

In support of this point, Ross’s team noted that detraining appeared to shift the contractile characteristics of fast-twitch motor units towards type IIb, thus providing them with more potential oomph. This effect can often be seen in power athletes who sustain minor injuries after a good period of training and are then obliged to train lightly for 2-3 weeks. Afterwards, to their complete surprise, they often produce a PB because the enforced rest has facilitated the fibre shift and upped their fast-twitch potential. Other research has indicated that a decrease

in weight training after a prolonged period of training can have a similar effect <sup>(5)</sup>.

Note, though, that too long a lay-off can produce less positive effects, due to muscle shrinkage (atrophy) in sports where muscle size is also important, *eg* for shot putters and American football line-men.

**John Shepherd MA is a specialist health, sport and fitness writer and a former international long jumper**

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## Is over-speed training over-hyped?

### Introduction

The goal of over-speed training is to allow an athlete to move his or her limbs faster by using special training techniques to increase limb speed such as hill descents or assisted propulsion from elasticated bungee cords. However, there's confusion about just how effective over-speed training is and how best to implement it for maximum benefit.

The general consensus among athletes and coaches is that the regular and systematic use of over-speed training methods increases unassisted speed by recruiting more muscle (in particular fast-twitch muscle fibre) and through improvements in stride length and stride frequency. These benefits are believed to have physical and neural components.

In physical terms, the increase in speed generated by over-speed training methods has a lasting effect on muscles' ability to generate force, particularly during the foot strike and drive phase of sprinting. Put simply, muscles become more powerful and faster at contracting. From a neural perspective, advocates of over-speed training believe that the brain will literally 'learn' to fire faster and control more muscle (in particular fast-twitch muscle fibres) to achieve greater speeds.

Over-speed training therefore starts from the relatively logical premise that providing an athlete with the conditions to move more quickly than normal must improve speed, and some of the early research does indeed seem to support this notion.

For example, research by Finnish scientists in the 1980s addressed the relationships between ground reaction forces,

electromyographic (EMG) activity, elasticity and running velocity at various running speeds, including over-speed running<sup>(1)</sup>. The team discovered that ground reaction forces, maximal force, average force and power were all significantly greater in a horizontal direction and that maximal and average forces were also greater in a vertical direction when over-speed running.

In the male subjects the relative change in stride rate correlated with increased EMG activity, in the eccentric phase between maximal and over-speed runs (the eccentric phase occurs on foot strike, when the sprinting muscles, notably the calf and quadriceps muscles, lengthen as they contract, just prior to performing a concentric contraction to propel the athlete forward). This led the researchers to believe that over-speed methods could improve unassisted sprinting, by recruiting more muscle fibre and increasing specific sprinting strength and EMG activity. However, some inconsistencies were already apparent; for example, it was noted that the increased EMG activity was only attributable to the male sprinters.

As research into over-speed training progressed numerous other researchers identified further problems. For example, American researchers concluded that there were no benefits to be gained from elasticised tube (towed) acceleration sprints<sup>(2)</sup>. Nine collegiate sprinters ran two 20-metre maximal sprints (MSs) and towed sprints (TSs). These were recorded on high-speed video.

When compared, the MSs and the TSs conditions displayed significant differences between horizontal velocity of the centre of mass (CoM) of the sprinter's body, stride length (SL) and horizontal distance from the CoM of the foot to the CoM of the body. However, there was no significant difference in stride rate between the MSs and TSs conditions.

### **Adverse effects of towing**

This led the researchers to conclude that 'Elastic-cord tow training resulted in significant acute changes in sprint

### **The history of over-speed training**

Type 'over-speed training' into your computer's search engine and you'll be confronted by a plethora of purveyors of over-speed training kit and programmes, many of which are North American in origin and which claim to cut 40-yard time, improve acceleration and dynamic agility. Because of this, you might be led to believe that the concept of over-speed is a relatively new (and American) development. It's not. Over-speed techniques have in fact been around for over 50 years, albeit in more rudimentary formats. There are numerous examples of athletes being towed behind motorbikes, scooters and cars. The latter method was used by 1956 Melbourne Olympic 10,000m bronze medallist Al Lawrence, who ran over-speed by holding on to a rigid bar attached to the back of the vehicle. Coaches from around the world, most notably from track and field, have used over-speed methods regularly, at least from the 1970s, whilst the author has actually experienced bungee and pulley towing methods over 20 years ago.

kinematics in the acceleration phase of an MSs that do not appear to be sprint specific (and that) more research is needed on the specificity of TSs training and its long-term effects on sprinting performance'. Simply put, the towing condition negatively affected sprint technique, meaning that there was a strong probability that non-beneficial effects would be transferred to unassisted sprinting.

Further research focusing on kinematic (energy requirements) and postural characteristics (sprint technique) analysed the relevance of both downhill and uphill sprinting to on-the-flat speed<sup>(3)</sup>. Eight male physical education students were filmed while sprinting maximally on an uphill-downhill platform under each of three conditions:

- Uphill at 3 degrees
- Downhill at 3 degrees (the over-speed condition)
- Horizontally

Running speed, stride rate, stride length, stride time, contact time, flight time and selected postural characteristics of the sprinting action were analysed.

Unsurprisingly, it was discovered that running speeds were 9.2% faster during downhill and 3.0% slower during uphill

sprints, compared with horizontal sprint running. During downhill and uphill sprint running, stride length was the main contributor to changes in running speed. This increased by 7.1% for downhill sprinting and was associated with significant changes in posture at touchdown and take-off.

These results led the researchers to conclude that the interaction between the acute changes in stride length and posture when sprinting on a sloping surface may detract from the specificity of training on such surfaces.

Given that research has concluded that over-speed training at best may lack the specificity required to improve sprint performance and at worst may even produce negative effects, is it possible to actually identify the conditions where over-speed work can succeed?

### **Maximising over-speed training methods**

The following section provides an overview of the main over-speed training methods in use and indicates the most suitable conditions for implementing over-speed training in practice.

A number of these recommendations are based on the work of George Dintiman<sup>(4)</sup>, Professor emeritus of health and physical education at Virginia Commonwealth University in the US and one of the world's leading speed coaches.

#### **Outdoor downhill over-speed method - Ideal set-up**

Use a dry, non-bumpy grass area that allows you to sprint 20m on the flat (to accelerate to near maximum speed), sprint 15m down a 1-degree slope and then sprint 15m on the flat (to allow for the continuation of increased speed, without the assistance of gravity). Progress gradually – for example, by running at 75% effort in preliminary workouts and by not wearing spiked shoes until you've adapted to the demands of over-speed running.

#### **Towing methods, including bungees – Ideal set-up**

Use a bungee 20-25m long and secure it tightly around your waist and to an immovable object (such as a football goal post). Walk back to tension the bungee. The further you walk back,

## **General factors that affect the success of over-speed training**

Having identified how best to implement the more common over-speed methods, what other factors can help produce better results from over-speed training?

### **Perform unassisted runs in the same workout**

Unassisted runs should always be performed in the same training session as over-speed work to help you learn how to fire your muscles at increased speeds, rather than simply being 'dragged' to achieving remarkable sprint times. Research indicates that you'll run faster unassisted immediately after over-speed runs. However, this window of opportunity may only exist for 10 minutes or so, which means you shouldn't delay.

### **Keep over-speed speed to within 10% of unassisted speed**

This should provide the best conditions to ensure that your neuromuscular system is optimally stimulated by your own effort. Achieving greater than 10% over-speeds is non-productive because a) you won't be fully in control of what you're doing and b) you'll be forced to adopt an incorrect sprinting posture in an attempt to stop yourself falling.

### **Master sprint technique**

Following on from the first two points, it is crucial that you approach any over-speed training with a well-honed and relaxed sprint technique. Many sports scientists and coaches believe that, particularly at the upper echelons of speed sports, it is the ability to relax whilst moving flat-out that is key to optimum and improved performance.

### **Rest and recovery**

Only perform over-speed training when you're rested, with a maximum of 2-3 sessions a week. Too much speed and over-speed work can be counter-productive as the neuromuscular system needs plenty of time to recover and regenerate.

### **Optimum angle of over-speed descent**

Research indicates that to optimise downhill over-speed work the maximum angle of descent should ideally only be 1% and certainly no more than 2.0% <sup>(4)</sup>.

the greater the tension produced, but 25m is a good starting point allowing runs at 75% effort to be performed.

Progress until sufficient confidence and condition is developed to sprint flat out and eventually over-speed. As with downhill running, wear spikes only once suitable confidence and condition is developed. To develop the over-speed condition the athlete should back up 30-35m to create the

**Over-speed training and eccentric muscular damage**

Over-speed methods are likely to create eccentric muscular damage. This results in painful, tender-to-the-touch soreness, particularly in the quadriceps muscles of the thigh. To minimise this effect over-speed training should be introduced progressively and combined with a good level of pre-conditioning, such as sport specific drills, weight and plyometric training. However, despite these precautions it is still likely that eccentric muscle damage will occur, especially for those who have no prior over-speed training familiarity. But the good news is that one bout of the exercise that caused the soreness in the first place can 'inoculate' against further muscle damage for a period of up to about six weeks afterwards, even if that method of exercise is not practised regularly

necessary tension in the bungee.

Towing behind motor vehicles, either by rope or by hanging on to a suitable platform is best avoided because of potential dangers. Patented pulley based towing systems that allow athletes to tow each other or be towed to over-speed performance offer greater safety than bungees, primarily because they afford the athlete the opportunity to 'bail out' safely on a run. However, these can be very expensive.

Bungees can also be used to develop multi-directional speed, which can greatly assist those in field and racket sports, where quick turning, darting and fast feet ability are required. To achieve multi-directional over-speed, position yourself backwards or sideways to the direction of pull then move in the direction of the pull, performing the requisite sport's skill.

**Treadmill methods - Ideal condition**

The decline of the treadmill should be 2% or less<sup>(4)</sup>. You'll need plenty of time to adapt to the different demands of treadmill running/sprinting before over-speed returns can be maximised. It is also necessary to continue with normal 'ground surface' running to optimise the transference of treadmill running to other sports.

The potential advantages of treadmill running include:

1. Speed can be systematically and progressively controlled

throughout a workout and across the developmental training programme;

2. A coach can stand alongside the athlete, whilst they are in full flow and provide immediate verbal feedback;

3. Some speed treadmills enable the coach to physically correct the athlete from the side, eg by the use of a carefully placed hand to the small of the athlete's back whilst they are in motion to help keep the athlete's hips 'high' (a key aspect of sprint technique) and assist them with keeping up with the required belt speed.

*NB - ideal conditions for downhill outdoor and towing methods are adapted from Dintiman <sup>(4)</sup>*

## **Conclusion**

Over-speed training methods offer speed athletes an opportunity to increase their speed potential. However, both coach and athlete must implement them carefully into any training programme in order to maximise returns.

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## Accelerating performance – how athletes can make a quick getaway

### Introduction

Acceleration is crucial to winning performance across numerous sports. Here we analyse what makes for a quick getaway from a technical point of view and identifies the best training methods to develop this crucial aspect of sport performance.

Forget top speed. Athletes that can increase their speed (*ie* accelerate) more rapidly than their rivals can gain an incredible and often unassailable performance advantage. The most obvious example is the 100m sprinter, who might not attain the highest top speed, but reaches the finish line first because he or she is able to attain their top speed before the other competitors. The same is true in racket and field sports; rugby players and footballers may breach the defence with a searing burst of pace that leaves the opposition for dead, while a racket sport player may accelerate to retrieve a shot that his opponent ‘thought’ was a winner.

### What makes for great acceleration technique?

In order to study this, researchers from New Zealand studied the ground reaction forces (GRF) involved in the acceleration sprint phase<sup>(1)</sup>. Thirty-six athletes performed maximal-effort sprints from which video and GRF data were collected at the 16-metre mark. The team discovered that the faster accelerating athletes displayed less vertical impulse in their acceleration phase *ie* more force was directed horizontally, thus pushing them forward. The quicker accelerators also had faster

ground contact times. Although acceleration requires greater foot/ground contact times when compared to maximum speed sprinting (to impart sufficient force to overcome inertia), the research indicates that better acceleration derives from quicker ground contacts.

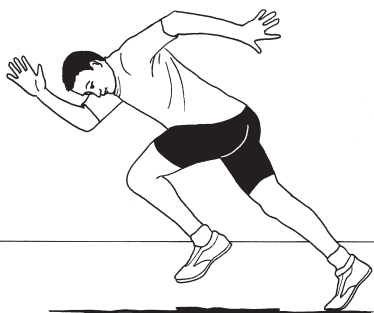
### **Acceleration and sprinting**

In sprinting, a low body position is desirable when leaving the blocks because it enables the athlete to maximise their acceleration. This phase of the race is often described as the part when the sprinter is sprinting with their legs 'behind their body' and contrasts with the main 'flat-out' part when work is done 'in front of the body'.

The arms should be pumped vigorously backwards and forwards as the athlete drives from the blocks to gain momentum. Coaches vary in the way they teach the leg movement; some argue for a 'driving back' movement of the legs, while others advocate bringing the thighs to the chest in a piston like manner. In both cases however, the body should remain inclined, until around the 15-metre mark, when the sprinter's torso moves into an increasingly upright position (*see figure 1*).

**Figure 1: Body alignment during acceleration**

**Alignment during initial phase of acceleration**



**Alignment as top speed is approached**



In field sports however, it's obviously far more difficult to execute such a precise accelerative technique. Players will often be off balance and/or may have a ball at their feet or held under their arm. Additionally they may be playing on a soft and slippery surface, which will significantly hamper power generation. Nevertheless, field and racket sport athletes and their coaches can learn much from the techniques harnessed by sprinters for maximum acceleration – notably the low body position and centre of gravity that enables the legs to supply optimum propulsive drive from static position.

However, coaches from these sports should also develop accelerative practices that involve turns. An example of an accelerative practice for field and racket sport players involves two players standing 2m apart. On a command, they turn through 180 degrees and sprint 5m. As a variation, the drill can be performed with 90-degree turns, with players turning in opposite directions.

## **Training for increased acceleration**

It's often argued that the most specific sports improvements are derived from training practices that closely replicate the movement patterns of the sport in question. This would mean, for example, that plyometric muscular action exercises (such as hopping and bounding) should have a greater relevance to the majority of sports than the more usual concentric/eccentric type of muscular action. However, when it comes to conditioning acceleration, research indicates that it's not so simple.

## **Concentric training and acceleration**

Researchers from Canada investigated the relationship between sprint start performance (five-metre time) concentric muscle strength and power variables<sup>(2)</sup>. Thirty male athletes performed six 10m sprints from a standing start. Sprint times were recorded, as were the force-time characteristics of the first ground contact (using a recessed force plate).

Three to six days later the subjects completed three loaded concentric jump squats, using a traditional and split-squat

## **Plyometric training and acceleration**

A team of researchers from New South Wales (Australia) examined the effect of heavy versus light-load 'jump squats' (the plyometric exercise) over an eight-week training programme on **electromyography (EMG)** and various other physical performance measures<sup>(3)</sup>.

Twenty six athletic men with varying levels of resistance training experience performed sessions of jump squats with either 30% of 1RM (the JS30 group – nine members), or 80% 1RM (the JS80 group – 10 members), or controls (the C group – seven members). All the subjects performed an agility test, 20m sprint and jump squats at 30%, 55% and 80% of their 1RMs before and after training. Peak velocity, peak power, maximum jump height (JH), and average EMG activity for the concentric phase were calculated for the jumps.

The researchers discovered that there were significant increases in peak power and velocity in the 30%, 55%, and 80% jump squat performances of the JS30 group. This group also significantly improved their 1RM scores and crucially, showed improvements in their 20m sprint times. In contrast, while the JS80 jump squat group significantly increased both peak power and velocity in the 55% and 80% 1RM jump squat and significantly increased their 1RMs, their 20m times were much slower. This investigation indicates that training with light-load plyometric jump squats resulted in increased movement velocity capabilities. In contrast, the heavier load did not benefit sprint acceleration, which could be as a consequence of the slower ground contacts and reactive forces that lifting such a load requires.

technique, with a range of external loads from 30-70% of one repetition maximum (1RM). These exercises require the performer to bend their legs to jump, pause and then jump. In doing this they invoke an almost purely concentric muscular contraction, rather than a plyometric one.

The results showed that athletes who were better at moving the weights during the squat jumps were the best 10m accelerators. This led the researchers to conclude that concentric (not plyometric) force development was critical to sprint start performance and accordingly that maximal concentric jump power was related to sprint acceleration.

To further clarify; the first step from a stationary start (or near stationary position for a field/racket sport player) requires a concentric muscular action. This contrasts to the subsequent

sprinting strides that profit from the increased plyometric power opportunities provided, which occurs when the eccentric priming of the subsequent concentric contraction increases power potential, in the muscles of the calves, thighs and hips. Think of it like stretching out a spring to its full extent (the eccentric contraction) and then letting it go. A lot more power is released in the split second the spring recoils (the concentric contraction).

### **Acceleration and leg stiffness**

Most sprint coaches recommend a programme of plyometric exercises, such as hopping and bounding to develop explosive ability (including acceleration) and enhance leg stiffness. Basically the stiffer a sprinter's (or field/racket sport player's) legs are, the better able they will be at generating power from the running/playing surface. To provide an analogy, carbon fibre legs will be much stiffer and therefore propulsive than pipe-cleaner legs!

However, a team of French researchers discovered that leg stiffness as measured via a hopping test was not directly proportional to accelerative ability, although it was to flat out speed<sup>(4)</sup>. The acceleration and maximal running velocity developed by eleven subjects over a 40-metre sprint was measured by radar. Leg power was measured by a treadmill test and a hopping test. Each subject performed maximal sprint accelerations on a treadmill equipped with force and speed transducers, which were used to calculate forward power. The hopping test was performed on a force platform. Leg stiffness was calculated using the flight and contact times of the hopping test – *ie* the greater the hop height and the quicker the ground contact, the stiffer the performer's legs.

What did the researchers find? Treadmill forward leg power was correlated to both the initial acceleration and maximal running velocity during track sprinting. However, leg stiffness calculated from hopping was significantly correlated with maximal velocity but not with acceleration. These findings were corroborated by another French team whose very similar

research is particularly interesting in that it involved 19 regional to national level 100m sprinters – rather than non-elite performers<sup>(5)</sup>. These athletes had best times ranging from 10.72 to 12.87 seconds. The 100m sprint was divided into a 0-30m acceleration phase, a 30-60m secondary acceleration to maximum speed phase and a 60-100m speed maintenance phase. This team discovered that their hopping test was the best predictor of the last two phases of the 100m race and that sprinters who had the greatest leg stiffness produced the highest acceleration between the first and the second phases - not the first.

So why is leg stiffness less important for acceleration? The answer is as indicated previously more than likely a response to the fact that concentric muscular strength expression is a key acceleration determinant, while plyometric power – which is enhanced by greater leg stiffness – becomes more relevant to the sprint athlete when they can use a fast eccentric pre-stretching muscular contraction to enhance the power output of the subsequent concentric contraction.

### **Weighted sleds and acceleration**

Athletes from numerous sports tow weighted sleds (or car tyres) loaded with weights over distances from 5-40m in an attempt to improve their acceleration. Variations in standing starts are used, for example, three-point and sprint starts. Achieving a low driving position is particularly important when towing if the athlete is to get in the best position to overcome inertia. The added load will force the athlete to drive hard through their legs and pump vigorously with their arms.

A team of Greek researchers looked specifically at the validity of towing methods as a way of improving both acceleration and sprint speed<sup>(6)</sup>. Eleven students trained using 5kg weighted sleds (the RS group) and 11 without (the US group). Both followed sprint-training programmes, which consisted of 4 x 20m and 4 x 50m maximal effort runs. These were performed three times a week for eight weeks. Before and after the training programmes the subjects performed a 50-

metre sprint test. The students' running velocity was measured over 0-20m, 20-40m, 20-50m and 40-50m. In addition stride length and stride frequency were evaluated at the third stride in acceleration and between 42-47m during the maximum speed phase.

The researchers discovered that the RS group improved their running velocity over the 0-20m phase *ie* their acceleration improved. However, this acceleration improvement had no effect on their flat out speed. This contrasted with the US group who improved their running velocity over the 20-40m, 40-50m, and 20-50m run sections. This led the researchers to draw the obvious conclusions that, 'Sprint training with a 5kg sled for eight weeks improved acceleration, but un-resisted sprint training improved performance in the maximum speed phase of non-elite athletes. It appears that each phase of sprint run demands a specific training approach.'

However, if sleds are used as a means of improving acceleration, what is the optimum load to tow for maximum training adaptation? Australian researchers from Sydney considered just this<sup>(7)</sup>. Twenty male field sports players completed a series of sprints without resistance and with loads equating to 12.6 and 32.2% of body mass. The team discovered that stride length was significantly reduced by approximately 10 and 24% for each load respectively. Stride frequency also decreased, but not to the same extent as stride length. In addition sled towing increased ground contact time, trunk lean, and hip flexion. Upper body results showed an increase in shoulder range of motion with added resistance. Crucially it was discovered that the heavier load generally resulted in a greater disruption to normal acceleration kinematics (sprinting technique) compared with the lighter load. In short, towing heavier weight sleds is unlikely to specifically benefit acceleration.

*‘The heavier load generally resulted in a greater disruption to normal acceleration kinematics’*

## Summary

Increased acceleration requires a structured approach and the use of specific drills, practices and conditioning. Developing powerful concentric leg strength is crucial, as is using weighted

sleds with a relatively light load (5kg). However, plyometric drills (and increased leg stiffness) are increasingly important as strides get longer, and ground contact times reduce as top speeds are approached. Acceleration and top speed running practices and conditioning methods need to be blended into a coherent training plan if an athlete is going to reach their full speed potential. Over-speed methods do not seem to offer real benefit, nor do heavy weight squat jumps or heavy load weighted sleds.

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## Short and sweet – why all athletes should consider 40m sprinting!

### Introduction

Many team sports athletes will go through a battery of fitness tests throughout their career. One of the most widely used is the 40m sprint (the 40-yard dash in the USA), which is used to test speed. James Marshall explains how you can benefit from 40m sprint training

While it's true that there are other speed tests that are relatively easy to administer and which provide immediate feedback to coaches and athletes, the 40m test is so prevalent in sporting circles that athletes may benefit from training plans that improve their 40m sprinting, as well as their linear speed, to assist their sporting performance. Indeed, in the USA, whole training programmes, websites and camps are devoted to 'improving your 40'.

This data is relevant to sports such as field hockey, football and rugby, where players are not only required to run bursts of similar distances during the game, but also need to have high top speeds and good acceleration, *eg* being first to a ball or racing back to get into defensive position; 40m sprinting can also be relevant in sports such as ice hockey (which has no running in it) as a measure of power and leg speed<sup>(1)</sup>. One study showed a high correlation between ice hockey players' 40yd times and their shooting performance within matches<sup>(2)</sup>.

### Running, jumping or squatting?

In order to improve running speed over 40m shouldn't you just practise running 40m? Inevitably, practising any skill that is

## **The NFL Combine**

The National Football League holds a scouting combine in Indianapolis each year in which the top 300 college players are invited to perform a battery of physical and skill related tests. This six-day event is an opportunity for the 32 professional teams to assess the capabilities of players at each position. The college draft takes place two months later in which teams select players by rounds. The earlier a player is selected, the more money he will make. The 40yd dash (36.9m) is one of the physical tests, alongside vertical jump, how many times a player can bench press 100kg and others.

Players across all positions have to perform the same tests, so 159kg offensive linemen and 81kg defensive backs all do the 40yd dash, but are compared by position. The results of all these tests provide a high correlation with draft position only for running backs, wide receivers and defensive backs – strangely enough, exactly the positions that frequently have to cover 40yds in the game at top speed<sup>(11)</sup>!

The 40yd dash times receive immense coverage in the US media, mainly because it is an easy to understand figure; every fan wants to know what their favourite player can 'do the 40 in'. The fastest time at this year's combine was by 79.5kg Yamon Figurs who ran the 40yds in 4.30 seconds. Figurs was drafted by the Baltimore Ravens in the third round and was the 74th player taken overall, coming from a small college, with limited prospects. His position was definitely augmented by his 40yd time.

going to be tested will result in improvements in untrained subjects as a learning effect takes place. However, developing strength through weight training exercises such as the squat, or power through exercises such as plyometrics or jump squats has also been advocated as an alternative to just running.

As usual, research is not 100% clear on the answer, mainly due to the design of the studies and the use of 'recreationally trained' or 'untrained' subjects (such as university students) who are usually male, instead of well trained athletes. The training effect demonstrated in these studies may therefore not be

especially relevant for those who are better trained or are female.

What is clear, however, is that running the 40m requires acceleration over the first 15m, which is improved by forward body lean and short but quick strides with minimal ground contact time and with a large force<sup>(3)</sup>. From 15m to 40m, stride length increases, with the fully extended rear leg pushing off the track with the toes and the leg driving forward with a high knee action. Squatting and jumping exercises that reproduce either a quick ground contact time or allow the triple extension of the hip, knee and ankle are most commonly used. These include jump squats, cleans and bounding drills.

Decreasing the ground contact time without enhancing the ability to increase force proportionately will result in slower linear speed because the acceleration produced will be less. Developing power with resistance training is usually achieved by either using heavy weights (70-90% 1RM) and low velocity or lighter weights (30-50% 1RM) and high-velocity movements. Both have been found to be effective when using squat, hip extension and hip flexion movements in improving 20m acceleration time<sup>(4)</sup>.

Improving maximal leg strength may prove to be crucial in improving speed in untrained subjects, but less so in experienced athletes. This is due to the fact that a large increase is needed in leg strength before a corresponding increase in speed is seen. A large strength increase is easier to achieve in untrained subjects than those who have been training for 10 or more years.

In trained subjects, squatting immediately before sprinting may produce an acute effect over 40m due to postactivation potentiation (PAP)<sup>(5)</sup>. One set of three heavy squats at 90% 1RM were effective in reducing 40m sprint time in college American football players compared with three squat jumps with a 30% 1RM load. A four-minute rest period was enforced between the exercise and the sprint. However, this is not recommended for untrained subjects as the squats would have an unduly fatiguing effect and reduce the ability to produce power.

## **The recovery phase**

Most studies have looked at training the drive phase of the sprint action; however, training the recovery phase could be just as important. One study using untrained subjects improved 40yd times over eight weeks by using elastic bands to improve hip flexor strength for the recovery phase<sup>(6)</sup>. The subjects tied the elastic band around their ankles and then reproduced the high knee lift against the resistance of the band. The subjects improved hip flexor strength by 12% and decreased their 40yd time by 9%.

The idea of reproducing this action under load is sound, but it is unlikely to work in trained subjects due to the limitations of using elastic bands. Unlike using free weights or cables, which require a large initial force to overcome inertia, bands have little inertia at the beginning of the movement, but resistance increases towards the end of range. This results in early deceleration, which is counterproductive in most athletic movements.

## **Sprint training protocols**

As the 40m is a very specific running test, and most training time is limited, the running drills need to be very effective. Running a series of 40m sprints, with 'walk back recovery,' which is common in team environments, may not produce the best results. Instead, carefully managed rest times that allow recovery of the phosphocreatine energy system should be used. This will then help the athlete run at their top speed for each sprint in the training session. Rather than run the same set of drills in each session, it may be best to include some over-speed and uphill sessions as well as normal sessions.

Incline or running with resistance is designed to increase ground contact time and reduce stride length, which may be useful in the initial 15m of acceleration. Downhill running or overspeed training is designed to increase stride length and reduce ground contact time, important in the 15-40m phase of the sprint. When using inclines, declines, resisted or overspeed training methods, it is important to observe running mechanics. Too much incline or resistance will result in severely altered

## Testing ‘the 40’

While testing the 40 is theoretically quick and easy to administer, experience shows that it can’t always be done. One major problem is the weather. Indoor facilities that have a 50m space in a straight line (you have to allow at least 10m for safe deceleration at the end) are rare. Outdoors, the surface has to be dry to allow foot purchase and should be consistent between tests to establish reliability. Athletic tracks that have surface water on them become very slippery and injuries could occur.

Wind is also a factor, with tail, head or cross winds all affecting the times. If you are just conducting one test to establish who is quickest on your team, then wind is not a problem because the conditions are the same for everyone. But, if you are using the data to monitor progress over time or comparing with players from other parts of the country, then conditions become important.

Equipment used could be handheld stopwatches or electronic light gates. If using handheld times, then up to three testers should be used and an average between the three scores recorded<sup>(12)</sup>. If using electronic gates, make sure you have spare batteries, as they can become depleted quite quickly. Mark out the distance with an accurate tape measure and ensure you get metres and yards correct – I have seen the two confused and some very fast scores recorded!

Allow athletes sufficient time to warm up, providing a general and then specific warm up with speed drills. Then allow each athlete three attempts to run their quickest score, with rest time between each attempt. The starting position is important, from a two-point or three-point stationary start; on the line or 75cm behind the first electronic gate. The times recorded will be different for each protocol, but the consistency between tests is crucial – everyone must follow the same protocol. There’s no evidence that athletes competing against each other over 40yds run faster than when running against the clock (or vice versa), so whichever method is easier for you to administer should be used<sup>(12)</sup>.

running styles and poor posture, which then has a detrimental effect when the resistance is removed. The same is true for decline or overspeed training (being towed).

Two recent studies had different views on this. The first used a protocol of towing (over-speed sprints), pushing (resisted sprints) and normal sprints and compared the three groups over 22m<sup>(7)</sup>. The subjects were untrained college students and the

sprint sessions were conducted three times a week for six weeks and consisted of sprinting 22m five times.

All three groups improved their times at their own protocol (*ie* the resisted group got better at running against resistance) but the transference to flat speed was greatest in the normal sprint group and then by the overspeed group. The short-term nature of this study indicates that the adaptations to the training were neuromuscular in nature; the subjects became more efficient at their drills. This may not have transference to sport specificity, but if you are trying to get good at a one-off 40m test, then training at that speed for six weeks may help. However, in the longer term, you are unlikely to get better results by just doing that.

The second study combined uphill, flat and downhill running into the same session to provide resisted, tempo and overspeed stimulation to the subjects and compared that to just uphill, flat or downhill sessions (without resistance or towing)<sup>(8)</sup>.

The researchers designed and built a wooden platform that had a 20m flat portion, a 20m incline at 3 degrees, a 10m flat portion at the top, a 20m decline at 3 degrees and then a flat 10m at the end. The combined uphill/downhill group ran this 80m total six times with 10 minutes' rest between sprints, three times a week for six weeks. The other groups ran the same total distance, but in shorter bursts using the same platform, so they ran 12 sets of 40m combining the flat and either the down or the up portion of the platform.

At the end of the six weeks training, the subjects were tested over 35m and the combined uphill/ downhill group showed a 3.4% increase in top speed with the downhill group showing a smaller 1.1% increase. The flat and uphill training groups made no significant changes to running speed after six weeks of training.

The key factor distinguishing between the downhill only group and the combined uphill/downhill group is that the latter had their neuromuscular system overloaded, then unloaded and then assisted. This loading and unloading in the same session could be the difference and is worth trying in training.

## Sample 40m sprint training programme for football

Concentrating on four areas: technique, strength, sprinting, plyometric training (energy system conditioning is assumed to be done as part of the team training sessions thought the use of small-sided games).

### A – Off-season

Technical drills to be done for 10 minutes as part of football team training warm-ups.

#### *Strength (two sessions per week)*

Squats 4 sets of 3 reps @ 90% 1RM 2 mins rest between sets

Jump squats 4 sets of 5 reps @ 30% 1RM 2 mins rest between sets

Cable leg drive 4 sets of 5 reps @ 30% 1RM 2 mins rest between sets

#### *Plyometrics (two sessions per week)*

Double-leg bounds 10m; progress to 20m

Tuck jumps continuous 2 sets of 10 reps

Single-leg bounds for distance 10m; progress to 20m

Single-leg bounds for speed 10m; progress to 20m

#### *Sprints (two sessions per week)*

Session 1 Alternate each week between resisted sprints towing a 10kg weight or an uphill run of 40m at 3 degrees. 4 resisted/uphill sprints, 3 mins rest between reps. 4 flat 40m sprints at full speed, 5 mins rest between reps.

Session 2 4 downhill sprints for 40m at 3-degree decline, 3 mins rest between reps. 4 flat 40m sprints at full speed, 5 mins rest between reps.

*Sample week for a player who does two team sessions in the off season; player does two sprint sessions, two plyometric sessions and two strength sessions each week*

	Sun	Mon	Tues	Wed	Thurs	Friday	Sat
<b>Session1</b>	Rest	Sprint1	Plyo1	Rest	Plyo2	Rest	Strength2
<b>Session2</b>	Rest	Rest	Team	Strength1	Team	Sprint2	Rest

### B – In-season

*Sample week for in-season training; only one strength, plyometric and sprint session per week in order to avoid fatigue (because of the high number of matches being played)*

	Sun	Mon	Tues	Wed	Thurs	Friday	Sat
<b>Session1</b>	Rest	Sprint	Rest	Match	Rest	Plyo	Match
<b>Session2</b>		Strength	Team		Team	Rest	

## **Other benefits of practising ‘the 40’**

Regular sprint training can lead to better sprint times, but could it also be used as a training tool in itself leading to other physiological improvements. Plyometrics are often used as an effective training method to help reduce ground contact time for sprinters and jumpers. A Croatian study compared a sprint training protocol with a plyometric protocol over 10 weeks and looked at the effects on drop jumps, countermovement jumps, squat jumps and squat strength as well as 20m sprint time and 20yd shuttle runs<sup>(9)</sup>.

Both groups improved their jumps but the sprint group also improved their isometric squat strength and their speed and agility scores. This study showed that sprinting could be used as a training tool that has similar or better effects than plyometrics. The same researchers also analysed anthropometric characteristics of the two groups and found that the only significant change was a 6.1% reduction in body fat in the sprint group<sup>(10)</sup>.

## **Summary**

Assumptions may have to be made in designing training protocols for well trained athletes due to the paucity of research using trained subjects. However, it does appear that once a well developed strength base is in place with sound sprint mechanics, the use of different sprint speeds and drills followed by normal mechanics at top speed is more effective than running just flat speed drills.

In untrained subjects the most effective way to improve 40m speed over the short term (circa six weeks) is to practise the test and coach the running style well. This will be effective once, but for those athletes who are tested regularly, a solid strength base needs to be developed in combination with power exercises either in the gym or using plyometrics.

It's worth commenting on the use of time spent on sprint drills. Most coaches who have limited access to their players will not allow players to spend even 10 minutes doing nothing in

their training session; taking up a whole evening doing six maximal sprints over 40m with 10 minutes' recovery will not therefore go down well. Try doing that on a rainy night in January and your players won't like it much either! Doing 20 sets of 40m sprints with 'walk back recovery' may look busier and the players will be tired, but it won't help their 40m speed either!

Working on lower body strength and power in the gym, however, will have the two-fold effect of improving both sprint speed and overall conditioning, which will help in contact and collision sports.

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## Lower limb training to help increase your speed and avoid injury

### Introduction

Think about the physical requirements of a sprinter in full flow, and it's the powerful thigh muscles that invariably come to mind. However as explained in this chapter, neglecting lower limb training not only increases the risk of injury, but also limits an athlete's potential to maximise athletic speed and avoid injury.

The main muscles below the knee are the two calf muscles, the larger gastrocnemius and the smaller soleus. Both contribute to ankle extension. Gastrocnemius is the larger of the two and resides on the outer portion of the lower leg, while soleus is smaller and is positioned to the inside.

The calf muscles interact with the ankle joint through a myriad of smaller muscles that stabilise and control the movement of this joint and the foot. Crucial in this lower limb soft tissue movement chain is the Achilles tendon. This band of soft tissue connects the heel bone to the calf muscles. It acts as a kind of cable that 'pulls' on the heel, through the action of the calf muscles, to create ankle movement. It also has a crucial shock absorption role, which can significantly contribute toward the development of the type of athletic power needed for sprinting movements (*expanded upon later*).

To the front of the lower legs, running over and around the shin, is further soft tissue that also stabilises and controls ankle and foot movement. This includes the muscle peroneus longus and tendons, such as the extensor hallucis longus. The foot structure contains over 100 muscles, ligaments and tendons and

24 bones. As we'll see later, it too can contribute significantly to speed, balance and stability.

## **The action of lower legs in walking, running and sprinting**

### **Walking**

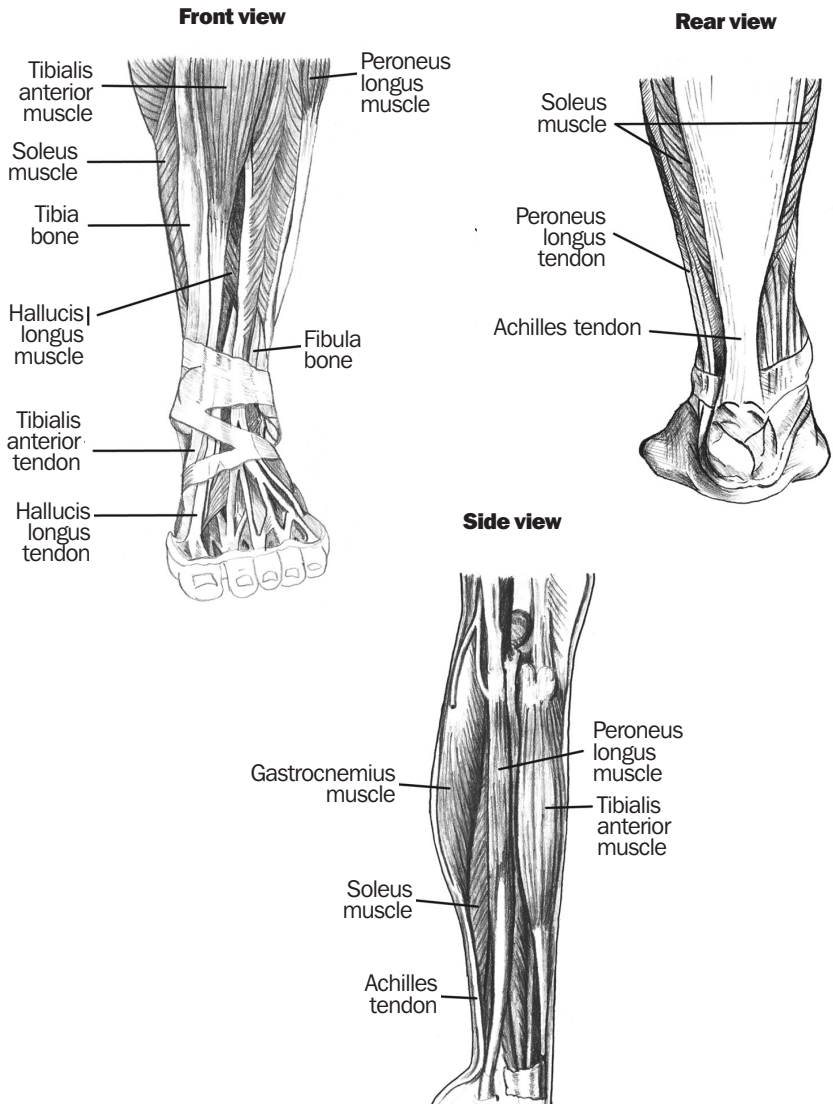
Researchers from California have spent some time analysing the role of the main lower leg muscles involved in walking<sup>(1)</sup>. The team examined the individual contributions of the gastrocnemius and soleus muscles at a walking speed of 1.5 metres per second. At any instant in the gait cycle (the walking or running action), the work required by these muscles to support the body and move it forward was defined by its contribution to the trunk's vertical and horizontal velocity, and its contribution to moving the legs forward during the swing phase of the gait cycle.

The stance phase occurs when one foot is on the ground and the other is swinging forward (the swing phase) in preparation for the next foot strike (ground contact) and ensuing stance phase. During the stance phase the body is normally held in an upright position.

For lower leg muscles, the researchers found that the gastrocnemius and soleus provided trunk support during the single-leg stance and pre-swing phases of the walking action. As the body moves forward into early single-leg stance, the muscles accelerate the trunk vertically but decelerate forward progression of the trunk. In mid-single-leg stance, the gastrocnemius delivers energy to the leg, while the soleus decelerates it.

However, these functions are reversed in the action on the trunk. In the late single-leg stance, just prior to the foot leaving the ground, both major calf muscles perform a concentric muscular contraction as they accelerate the trunk forward while decelerating the downward motion of the trunk (basically they act to prevent the ankle collapsing back to the floor). However, the soleus acts to accelerate the trunk forward, while the gastrocnemius delivers almost all its energy to accelerate the leg to initiate its swing.

## Major lower leg and foot structures



### Running/sprinting

The action of the lower leg muscles is very similar during running/sprinting, although the hip muscles play a far greater role in generating speed in terms of the upper legs<sup>(2)</sup>. Sprinting also involves far greater impact forces than walking (up to three times body weight) even though the foot may only be in contact with the ground for around 0.8 seconds for an elite sprinter. During the foot strike, pre- and mid-stance phases, the calf muscles have to absorb this force, before contributing to pushing the athlete forward into the next stride, whilst stabilising the trunk. This is akin to walking, but with a far greater shock absorbency requirement.

The calf muscles work with the Achilles tendon to absorb and return this force. This is achieved by lengthening as they contract (eccentric muscular contraction). Sports scientists refer to this muscular action during sprinting as requiring considerable 'joint stiffness'. Reduced stiffness is seen to impair speed generation. Think of it like a pogo stick made of jelly, rather than one made from very resilient rubber; the latter will of course return much more energy than the former. In fact, sports scientists argue that, during sprinting, the prime role of the ankle (and knee) is to

### **Even toes matter!**

As indicated earlier, the foot, and even toes, can influence running power. A team from Canada studied the energy contribution of the big toe or metatarsophalangeal (MP) joint when running and sprinting<sup>(5)</sup>. The team wanted to discover what the contribution of the MP joint was to the total mechanical energy involved in running and sprinting. Data was collected from ten trained male athletes (five runners and five sprinters).

The team discovered that during the stance phase, the joint absorbed large amounts of energy during running and sprinting. In terms of biomechanics this led them to conclude that lack of plantar flexion (toe-down position) of the MP joint resulted in a lack of energy generation during take-off; energy was absorbed at the joint and dissipated in the shoe and foot structures and was not returned to propel the athlete forward. Although it would be physically difficult to specifically train the big toe to contribute more to the sprint and running action, concentrating on a more active push off from the forefoot through the toes could allow the MP joint to generate more propulsive force.

create high joint stiffness before and during the contact phase, while the hip flexors (muscles at the tops of the thighs) function as the prime forward movers of the body<sup>(3)</sup>.

It's during the foot-strike phase of the sprinting/running action that calf muscles (and even more commonly) Achilles tendons, can be strained. Conditioning the lower limbs to accept greater eccentric strength can reduce injury potential and improve performance by increasing 'stiffness' (more of which later).

## **Reducing injury through lower limb strengthening**

There are a multitude of exercises that can be used to strengthen the lower limbs (examples of which are given below), but how effective are they?

A Norwegian study looked at how ankle and knee injuries could be reduced in teenage handball players during the 2002-03 season<sup>(4)</sup>; 1,837 players were split into an intervention group and a control group. The intervention group performed exercises designed to improve awareness and control of the ankles and knees during standing, running, cutting, jumping, and landing. The exercises included those with a ball, the use of wobble boards and covered warm-up, sport technique, balance and strength. The control group continued with their normal training methods. The main results were as follows:

- For the group as a whole, 262 players (14%) were injured at least once during the season;
- The intervention group had lower risks than the control group when it came to sustaining acute knee or ankle injuries;
- The incidence of moderate and major injuries (defined as absence from play for 8 to 21 days) was also lower for the intervention group for all injury types.

The researchers concluded that, 'the rate of acute knee and ankle injuries and all injuries to young handball players was reduced by half when players followed a structured programme designed to improve knee and ankle control during play.'

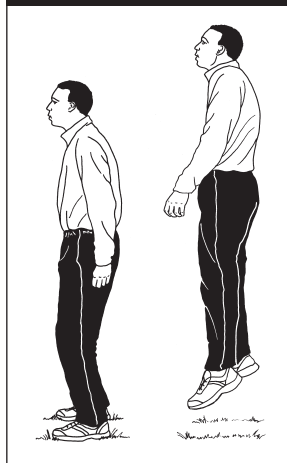
## Lower limb strengthening exercises

### Straight-leg jumps

Stand with your feet slightly beyond shoulder width apart. Swing your arms back behind your body and very slightly bend your knees. Swing your arms down, as they pass your hips jump into the air, using your calf muscles and ankles to provide most of the power. Land without undue yielding (in order to increase joint stiffness and improve eccentric force absorption) and spring immediately back into another jump.

*Suggested routine: 3x10 exercises with 1-minute recovery between sets.*

### Straight-leg jumps



### Eccentric calf raises

Eccentric calf raises have been identified as being as effective at combating and treating the majority of Achilles tendon injuries as other treatments, including surgery. When performing this exercise, concentrate on the lowering phase of the movement, lowering to a count of 4 and lifting to a count of 1. To gain familiarity, select a medium to heavy weight that creates fatigue after 8-10 repetitions, before progressing to heavier weights that create fatigue after 4-6 repetitions. Use a standard calf raise machine. After gaining familiarity and strength with this exercise, perform freestanding versions from a double- and then eventually from a single-leg stance, using similar loads and repetitions.

*NB. Standing calf raise exercises target the gastrocnemius, while seated calf exercises hit the soleus. To fully strengthen the main calf muscles combine both exercises in your training programme.*

## Foot and toe strengthening exercises

### Toe clawing

To perform this exercise stand barefoot on carpet. Scrunch the

toes of one foot and try to claw/pull yourself forward. Persevere, as you will be able to achieve some forward movement in time. Once mastered continue to pull yourself forward with your toes, using each foot in an alternate fashion.

### **Performing sprint drills/running barefoot**

Olympic medallists Roger Black (400m) and Jason Gardener (4x100m) both employed barefoot training to develop greater foot and ankle strength and flexibility. You can also strengthen your feet by performing sprint drills barefoot and even by running (although the latter should be carefully progressed to). If you run barefoot, do so only over moderate distances (40-60m) and on soft grass, making sure there are no sharp objects. Distances should be only gradually increased as your lower and upper limbs become used to the higher forces that running without shoes generates. This will reduce the chances of sustaining an injury and condition the feet, ankles and legs gradually. *NB. Running barefoot involves greater impact than barefoot sprint drills, hence the need for greater caution.*

### **Barefoot high knee lift with ankle extension**

Stand with your feet slightly apart. Lift the thigh of one leg to a position parallel to the ground, whilst at the same time pushing up onto the toes of the grounded foot. Claw forward with the suspended leg and then let the foot come down to the ground whilst lifting and pulling the previously grounded foot up toward your buttocks and through to perform the next stride simultaneously. You're basically performing a slow paced running action. Coordinate your arms with your legs (opposite arm to leg). You'll find that your feet and ankles have to work harder to control your movement and balance and are consequentially strengthened.

*Suggested routine: 4x20m with a slow walk back as recovery.*

### **Barefoot high knee lift with ankle extension**



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## Squats – new research on an old favourite to assist speed training

### Introduction

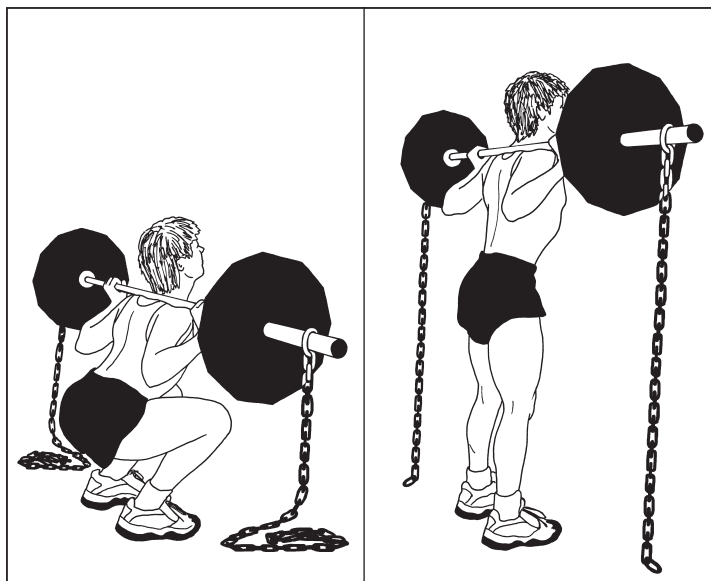
Squats are not only technically demanding, they're also one of the most exhausting strength exercises in the gym. However recent research suggests that squats and their variations have much to offer power athletes seeking a competitive edge.

Speed, acceleration and jumping ability are used in many track and field events, as well as field sports, gymnastics, weightlifting and martial arts to name just a few other activities. Developing lower-limb strength and then power helps improve speed and acceleration<sup>(1)</sup>. In particular, developing maximal strength in the lower body is an essential prerequisite of developing power.

Strength training develops the muscles' ability to exert force, for example pushing a heavy object. Power training develops the ability to exert this force in less time – *ie* to make the movement quicker, for example throwing a ball.

Sprinters can generate forces of up to three and half times their body weight when racing, so having sufficient leg strength to generate this force without injury is necessary<sup>(2)</sup>. This explains the commonly quoted guideline that a power athlete needs to be able to squat a weight equivalent to twice their body weight – *eg* an 80kg male rugby player should be able to squat 160kg.

The squat and squat jump are two exercises that have a major role in developing leg strength and power. This article will look at recent research on squat variations and the squat jump and give some guidelines on what loads should be lifted in order to gain the greatest benefit.



### **Strength before power**

The squat exercise uses most of the major muscle groups in the lower body, overlapping with those used in running and jumping, so it is very suited to most sports. The squat can increase the ability to produce power in the long term, but it has also been shown to improve power production in the shorter term through the post activation potentiation (PAP) effect in trained individuals<sup>(3,4)</sup>.

Post activation potentiation has not been fully explained yet, but the effects are the basis behind the theory of complex training, which combines strength and power exercises into small sets, where the muscles' ability to produce a more powerful contraction is improved by performing strength exercises shortly beforehand.

However, this does not appear to happen in untrained individuals, who are simply fatigued from the preceding strength exercises. The assumption, therefore, in the rest of this article is that the athlete has already established a strength base (the ability to squat a load equivalent to their own body weight).

## Chain squats

Although most squatting is performed using a simple barbell and weight arrangement, there are variations on this theme. A popular variation of the squat in the USA is to add chains to either end of the barbell.

The chain is attached to the top of the barbell, with some portion of it on the floor. As the squatter descends, more of the chain is on the floor, decreasing the overall load. As the squatter ascends, less of the chain is on the floor, increasing the overall load. This arrangement requires greater force production at the top end of the squat (because more of the chain is off the floor and thus suspended from the barbell) when the legs are in a more mechanically advantageous position to produce greater force. This mechanical advantage arises from the fact that the length of the quadriceps is shortened, allowing more opportunity for cross-bridge contractile activity.

At the bottom of the squat, when the quadriceps muscles are lengthened, there is less cross-bridge activation and the legs are at a mechanical disadvantage. So, although the external resistance is constant (the barbell), the force produced by the muscles isn't constant due to mechanical changes.

The theory behind the use of chains is that it overcomes mechanical changes and produces a constant force throughout the movement.

An alternative method is to use elastic bands or tubing, with one end fixed to the floor and the other to the barbell. Again, as the squatter descends less resistance is produced because the tension in the elastic is reduced, but more resistance is produced on the ascent due to the elastic lengthening and tensing.

How big a chain? Well, it depends on the strength of the athlete! Chains can normally be bought in inches (width) and feet (length), with half-inch chains being a good size for strong athletes when squatting. Smaller chains can be used for intermediate athletes and also for the bench press.

A half-inch chain weighs around 7.5kg per foot. If the barbell rests on a typical athlete's shoulder at 5ft off the ground, two half-inch chains would provide an additional 75kg of load.

*“Another proposed benefit is that the athlete does not have to slow down their movement near the top of the squat”*

Descending 2ft would reduce this load by 30kg (2ft length of chain that was previously suspended would now be on the floor at each end of the barbell). So an athlete with these chains could have a barbell weighing 60kg, and be squatting 135kg at the top of the movement but only 105kg at the bottom.

Another proposed benefit of chain squats is that the athlete does not have to slow down their movement near the top of the squat; instead they still have to keep trying to move quickly to overcome the added resistance. This type of training movement is probably more appropriate for sporting situations where contact is involved, and the player has to drive into the opponent with maximum extension of the legs, rather than slowing down just before impact.

### **Chain squat research**

Two studies have been conducted to test the efficacy of this training method. In the first, US researchers from Marquette University in Wisconsin looked at 11 college athletes and measured electromyographical activity during a squat with barbells, with barbells and chains, and with barbells and elastic bands<sup>(5)</sup>.

No difference was found in force production between the three conditions. However, the authors commented on the fact that all the athletes ‘felt’ the squats were different to perform. They also commented on the fact that part of the study design was to reduce the load of the barbell by 10% to accommodate either the chains or elastic bands. However, in normal training conditions, one of the advantages of using chains and bands is that additional loads can be lifted. This additional load may result in greater force production and therefore strength gains.

In the second study, researchers looked at 10 resistance trained adults and the effects of altering resistance at around 60% and 85% 1RM (maximum weight that can be lifted for one rep) of the squat<sup>(6)</sup>. They used bands to provide an extra 20% or 35% of the total resistance and compared this to a control group who were just doing the squat.



No differences were found in the rate of force development between the squat with bands and the squat without. However, both peak power and peak force were found to be greater when using bands. The difference was even more significant when performing the 85% 1RM, heavier load. The optimal condition appeared to be the heavier 1RM load, with 20% of the resistance coming from the bands. More research is warranted in this area, but the use of chains or bands in squats could be a worthwhile addition to athletes' strength training routines.

## **Squat jumps**

One method of developing power in the legs is through the use of weightlifting exercises such as the clean and the snatch. This is currently in vogue; with many national governing bodies (NGBs) issuing guidelines that all their funded athletes become proficient in these lifts.

However, the time and effort that it would be necessary to invest in developing the technical proficiency in these lifts to

allow the athlete to lift loads that develop power, may be better spent in performing other exercises that have similar benefits, but require less coaching – the squat jump being one such exercise.

How much load should be placed on the athlete? Well, the assumption made here is that they have already established a strength base (non-strength trained subjects respond differently to the squat jump than trained individuals, with loads as little as 5kg creating a decrease in peak instantaneous power)<sup>(7)</sup>.

## Description of exercises

A brief description of the squat and squat jump follows, but care should be taken when performing these exercises with load. Learning these exercises under qualified supervision is recommended.

**Squat** – The common form of this exercise is performed with a barbell placed across the back of the shoulders:

- Place the bar on the squat rack at a height that is 3-5 inches lower than your shoulders;
- Stand under the bar and position yourself so that it rests on the upper part of your shoulder blades (or traps). The bar should NOT be resting on the vertebrae of the neck area;
- Place your hands on the bar, palms facing forward, at a distance that is comfortably wider than shoulder width;
- Drawing your shoulders back and keeping the back straight, stand fully erect and step forward, lifting the bar clear of the supports;
- Standing with feet shoulder-width apart, toes pointing slightly out, inhale and contract the abdominals;
- Draw the shoulder blades backwards, squeeze and tighten your lower back muscles in order to 'lock' your spine into a straight position;
- Keeping the back straight, start the descent by leading with the hips rather than the knees. In practice, this means drawing the hips backwards before the lowering begins. Bending the knees before shifting the hips backwards tends to throw the knees forward and makes it harder for the powerful buttock muscles to contract;
- Ensure that the first few inches of the lowering movement are slow and controlled. Don't allow the bar to build up its own momentum;
- Continue to lower smoothly until your thighs are parallel with the floor. Don't let your thighs drop below parallel. Check that your torso is not angled too far forward – as you reach the bottom of the movement, the angles at the hip and knee joints should be roughly equal;
- Check that your heels remain flat on the ground during the entire lowering phase. Raising the

However, too heavy a load will slow the jump down. The velocity of the jump has to be enough to allow maximal power output to be achieved.

Fortunately, measuring power output, or looking at changes in performance such as 20-metre sprint times, can identify the optimal load for squat jumps. One study looked at using either 30% or 80% loads of the subjects' 1RM squat to perform squat jumps and then measure the changes in performance <sup>(8)</sup>.

The 26 subjects followed an eight-week, twice-weekly

heels increases the risk of injury to the knees by shifting the centre of gravity forward, in turn placing extra stress on the lower back;

- When the thighs are parallel with the floor, contract the thighs, buttocks and lower back, then begin the lift. Keep the upward movement smooth, but try and develop some 'drive' through the movement remembering to follow the same path as that through which you descended. The torso and back should remain erect and the hips remain under the bar throughout the ascent.

**Squat jumps** – This exercise is commonly performed with a barbell across the shoulders and with a much lighter weight than the squat.

- Stand with feet shoulder-width apart, descend until thighs are parallel to the floor as described above and then jump up with feet leaving the floor;
- Don't pause at the bottom part of the squat jump. Land on both feet and cushion the landing with a small bend of the knees, then return to standing position;
- Try not to make a noise when landing; this will help remind you to land with a cushioned knee, rather than a jolt.

**Safety precautions** – The squat is a very common exercise (every time you lower yourself into and raise yourself out of a chair without using your hands you are performing the squat action); however, care must be taken when loading the spine.

- If you have any lower back problems, or knee, hip or ankle joint problems, then you should get these treated before squatting unsupervised;
- If you cannot perform 10 squats with just your own body weight, then no load should be added across your shoulders;
- Squat jumps are more dynamic and can cause a jarring effect on the back and neck if not performed correctly. Do not perform loaded squat jumps if you cannot squat with a load equal to your body weight on the barbell.

training programme performing four sets of five jumps after warming up, with three minutes rest between sets. Both groups improved their 1RM and their peak power. The 30% group increased their peak velocity and decreased their 20m sprint times. The 80% group increased their 20m sprint times. So while both training modes were effective in increasing peak power and 1RM strength, the lighter loads had a much better impact on speed of movement.

This is obviously of importance to most coaches and athletes. However, it's worth adding that the training history of this group of subjects was quite varied, and so this may be partly why they benefited from the lighter loads.

Another study looked at rugby league players who were strength and power trained and found that squat jumps with loads varying between 47 and 63% of 1RM were effective in improving power output<sup>(9)</sup>. These players were strong athletes; the loads showing the highest power output were between 85 and 95kg, and one group of the players in the study had average 1RM for normal squats of 161kg.

The researchers found that using a load less than 47% 1RM did not result in enough resistance for peak power to be generated. But a load heavier than 63% 1RM resulted in too slow a movement. More generally, trained players may need higher loads to generate peak power because of their neural adaptations to strength and power training; they can simply recruit more of their muscle fibres to act in synchronisation quickly than non-trained individuals.

If you are intending to start using squat jumps, try sequencing them into your current strength-training programme. Having a minimum strength base of squatting 1RM equivalent to your own body weight is essential. A four-week, twice-weekly programme of four sets of five jumps at 30% of 1RM with three minutes rest between sets is a good start. As you become stronger you can alternate fortnightly between strength sessions and sessions incorporating squat jumps. When you can squat equivalent to twice your body weight for 1RM, then you can progress towards the jump squat load of 50%1RM.

**James Marshall MSc, CSCS, ACSM/HFI, runs Excelsior, a sports training company**

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## **Notes**



## **Notes**



