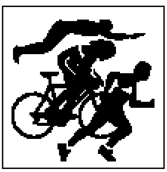


Training for

SPEED, POWER & STRENGTH

A SPECIAL REPORT FROM

PEAK PERFORMANCE

The research newsletter on stamina, strength and fitness

Training for

SPEED, POWER & STRENGTH

Training for

SPEED, POWER & STRENGTH

A CIP catalogue record for this book is available from the British Library.

Printed by: Baskerville Press Ltd
6-8 Newton Road, Salisbury, Wiltshire SP2 7QB

Published by Peak Performance Publishing

Peak Performance Publishing is a trading name of Electric Word plc
Registered office: 67-71 Goswell Road, London, EC1V 7EP
Tel: 0845 450 6404
Registered number: 3934419

ISBN: 1-905096-08-9

Publisher Jonathan A. Pye
Editor Isabel Walker
Designer The Flying Fish Studios Ltd

OTHER TITLES IN THE PEAK PERFORMANCE SPECIAL REPORT SERIES

ACHILLES TENDINITIS –
PREVENTION AND TREATMENT

CARBO LOADING –
FOR THAT EXTRA EDGE

COACHING YOUNG ATHLETES

CREATINE –
CUTTING THROUGH THE MYTHS

DYNAMIC STRENGTH TRAINING FOR SWIMMERS

TRAINING FOR MASTER ATHLETES

FEMALE ATHLETES –
TRAINING FOR SUCCESS

SHOULDER INJURIES –
PREVENTION AND TREATMENT

MARATHON TRAINING –
FOR YOUR PERSONAL BEST

NUTRITIONAL SUPPLEMENTS –
BOOSTING YOUR PERFORMANCE

SPORTS PSYCHOLOGY –
THE WILL TO WIN

The above reports are available at a cost of £29.99 each from Peak Performance (S/R), 67-71 Goswell Road, London, EC1V 7EP. Cheques should be made payable to Peak Performance.

CONTENTS

Page 11 – **Strength training:** Fish out of water: the land-lubbers' strength programme for swim competition
Raphael Brandon

Page 19 – **Power training:** Add power to your punch with plyometric exercise
John Shepherd

Page 27 – **Weight training:** For sporting success make your weights programme specific to your chosen activity
John Shepherd

Page 35 – **Power v strength training:** Strength or power – which matters most for peak athletic performance?
Raphael Brandon

Page 45 – **Ageing and speed:** The bad news is that speed declines with age; the good news is that you can arrest, even reverse, this degenerative process
John Shepherd

Page 53 – **Rotational power training:** All you need to know about getting in shape to perform zippy turns on the hoof
John Shepherd

Page 61 – **Muscle training:** Twitch and you're gone – all you need to know about developing fast-twitch muscle fibre for speed, power and strength
John Shepherd

Page 71 – **Agility training:** Float like a butterfly, sting like a bee – sport specific drills for boosting agility
John Shepherd

Page 79 – **Speed development:** Tried and tested ways to fast-forward your sporting performance
John Shepherd

Page 87 – **What the scientists say:** Eccentric moves recruit most fast-twitch fibres

Page 88 – **What the scientists say:** ATP is no creatine

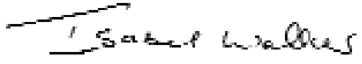
From the editor

Anyone who has ever considered Peak Performance biased towards endurance sports and events can bask happily in the almost entirely explosive emphasis of this special report. It will not help you to work out/run/swim/cycle for longer (although there are other reports in the series that do just that) but it will give you the knowledge and the tools you need to enhance your speed, increase your power and boost your strength.

Prepared for you by PP's expert conditioning duo, John Shepherd and Raphael Brandon, the report covers a wide range of interests, from strength training for swimmers (gym exercises designed to replicate water action as closely as possible) to rotational power training (very useful for all sports involving sudden turns); from speed development (drills to help you run like the wind) to battling the ageing process (sadly speed declines much faster than endurance with the passing years); and from weight training (impossible for any athlete to ignore these days) to agility training (much more than optimum sports technique).

In all these articles you will find not just a distillation and critique of the latest scientific research but a variety of carefully selected, highly-targeted practical drills, techniques and exercises which will help you to enhance your own abilities, whatever your chosen sport or activity. You will not just want to read it once but keep it by your side to refer to again and again, and use it to track your inevitable progress.

Have a great time reading – and living – this special report.



Isabel Walker
Editor

Fish out of water: the land-lubbers' strength programme for swim competition

To optimise strength and power, competitive swimmers need to supplement their pool training with land training in the gym. For best effect, swimmers need to follow a programme of exercises that replicate their actions in the water as closely as possible.

Strength and conditioning experts around the world all agree that, for time spent in the gym to have a positive impact on your sports performance, you must ensure the exercises you perform – and the way you perform them – are related to your sporting movements in competition. For example, Barbell Squats involve ankle, knee and hip extensions in a vertical plane that are directly related to the mechanics of a vertical jump; thus the squat is a useful exercise for developing jump performance.

If we perform a basic analysis of the mechanics of the front crawl stroke, the main actions that produce forward propulsion through the water are:

- the 'arm pull down' through the water, which propels the swimmer forward and
- the 'leg kick', which alternates hip flexion and extension of the legs.

In addition, competitive swimming involves:

- the 'dive start and push off turn', which involves dynamic ankle, knee and hip extension.

When designing your strength programme, you should focus mainly on exercises related to these movements. Other exercises may use the same muscles as those involved in swimming, but only exercises that use right muscles in a related mechanical movement will provide optimum training benefit.

A limitation of land training with weights for swimming is that the type of resistance you encounter when moving in the water is different from the resistance occurring when you move a weight through the air. In the water, the faster you pull or kick the greater the resistance applied back by the water; on land, a given weight requires a constant force to move it, regardless of the speed of movement.

Hydraulic-type resistance equipment that mimics aquatic resistance is expensive and not widely available. The best compromise when using regular equipment is to try to mimic the speed and nature of the swimming stroke. To this end, you should aim to perform the strength exercises with a smooth and constant force, and select weights that allow the movement to be performed at a swimming-related speed. For example, the leg-kicking motion during front crawl is quite fast, so hip flexion and extension exercises that can be performed at a good speed would be best.

The following exercises are related to the mechanics of the front crawl stroke. For each component, the relevant exercises are described and their mechanical relationship to the stroke explained.

Arm pull down exercises

1. Cable rotational front and back pulls

Front pull This is the mechanical equivalent to the pulling-through-the-water action in front crawl, as the hand comes diagonally across the body as it pulls down. For this exercise you need a high pulley machine with a simple handle grip.

Kneel down on one knee to the side of the machine. Take the hand nearest the pulley and grasp the handle with the hand high and slightly out to your side. Before you start the exercise make sure your back is straight, your shoulders are wide and your chin is tucked in. Pull the handle down and lower your arm across your body in a rotational movement until your hand is next to the opposite hip. Smoothly return the bar to the start position and continue, performing sets of 5-8 reps for maximum strength or 12-15 for strength endurance.

Try to keep your posture solid throughout the movement. Maintain a slight bend in the elbow as you pull, but focus your effort on the shoulder muscles only.

Rear pull This exercise involves the opposite movement to the front pull and is useful for promoting a balanced strength about the shoulder joint. Specifically, the front pull trains the internal rotator cuff muscles and the rear pull trains the external muscles. To avoid shoulder injuries, a balanced rotator cuff strength is important. For this exercise you need a low pulley machine with the simple handle grip.

Stand to the side of the machine and grasp the handle with the opposite hand. Make sure your back is straight, your shoulders wide and your chin tucked in. Start with your hand by the inside hip and fix a slight bend in the elbow. Pull the handle up and away from your body, rotating the arm up and out. Finish with the handle high and out to the side, with the palm of the hand facing forwards. Smoothly return the handle back and across to the opposite hip, and continue. Again go for sets of 5-8 reps for maximum strength or 12-15 for strength endurance.

Keeping your posture solid during this exercise is quite difficult, as it is tempting to use your trunk muscles to help the rotation movement. However, you can train your core stability skills by keeping your navel pulled into your spine and relaxing your upper body so there are no additional movements apart from the arm raise and rotation.

In combination, the front and rear diagonal pull train almost every muscle in the shoulder joint and shoulder girdle. This makes them very useful exercises for any sport.

‘In combination, the front and rear diagonal pull train almost every muscle in the shoulder joint and girdle’

2. Medicine ball single arm overhead throw

This exercise develops the power of the latissimus and pectoral muscles in a functional manner for swimmers, involving a movement similar to the front crawl stroke. The aim of the throw is to improve the rate of force development in the

‘Closed kinetic chain movements are thought to be particularly functional for sports performance’

shoulder by accelerating the arm hard to throw the ball. For this exercise you need a partner and 2-4kg ball. Small rubber balls are best as they can be held in one hand.

Because the ball is quite heavy for one hand, you will not be able to throw it far or move the arm very fast. This makes it ideal for swimming as the pull stroke is not that fast.The training effect comes from your attempts to accelerate the arm movement as fast as you can, thereby improving the power of the pull.

Lie on your back on the floor, with knees bent slightly so your lower back is comfortable. Grasp the ball in one hand with your arm up and behind your head, slightly bent at the elbow. Vigorously pull the arm up and down across your body, throwing the ball over the opposite knee. Get your partner to return the ball, and perform sets of 8-12 repetitions with each arm in turn.

Do not lift your head or pull up from the stomach as you throw. Focus on producing the power from the shoulder and pulling across the body as you do in front crawl.

3. Swiss ball body pulls

This is a ‘closed kinetic chain’ movement, where the moving limbs remain in contact with a fixed object – in this case the hands with the floor. Such movements are thought to be particularly functional for sports performance, so offering greater training benefits.

This exercise is performed in a horizontal prone position, with the arms pulling down under the body, matching the position and action of a swimmer in the pool.

Position yourself face down, with your lower legs on the Swiss ball and your hands on the floor supporting your weight, body parallel to the floor. This is the equivalent of a press-up position with your feet up. Slowly roll the ball up your legs while your arms extend out in front of you until you achieve a stretched position, with a straight line through your arms, shoulders, back, hips and legs. At this point your body will make a shallow angle with the floor and the ball will be positioned on your thighs. Then, keeping this perfect alignment of your body, push down through your hands into the floor and pull yourself back to the press-up position. The ball should roll back down your legs as you do this. Perform sets of 8-12 repetitions.

The difficult part of the exercise is the pull back up. At this point you must use your stomach muscles to support your spine and focus on using a strong pull of the shoulder muscles to raise your body back to the parallel position. This exercise is not easy, but it is very beneficial for many sports, helping to develop core and shoulder strength.

Leg kick exercises

Hip extension and flexion kick

These exercises mimic the upward and downward phases of the swimmer's kick action, where the glutes and hamstrings extend and the hip flexors flex the leg at the hip. For these exercises you need a low pulley machine with an ankle strap attachment. Each leg is worked independently to increase the specificity for swimming, and the weights used should be relatively light so you can kick with good speed, as in the pool.

Hip extension Stand facing the low pulley machine, with the ankle strap attached to one leg. Lift this leg off the floor, taking up the slack of the cable, and place your balance solidly on the other leg. Hold onto the machine's frame with your hands to stabilise your upper body and check that your back is straight, with shoulders relaxed.

Pull the cable back dynamically by extending the leg backwards until you feel you need to lean forwards, then bring it back in a controlled manner to the start position, retaining good posture. Continue pulling the leg back, focusing on the gluteals and hamstrings to kick back powerfully.

Hip flexion Stand with your back to the low pulley machine, with the ankle strap attached to one leg. Lift this leg off the floor, taking up the slack of the cable, and place your balance solidly on the other leg. Use a stick to support yourself, and check that your back is straight with your shoulders relaxed. Pull the cable dynamically by kicking the leg forwards. Pull the weight, using your hip flexor muscles at the top and front of the thigh, until your leg reaches an angle of about 30° or you start to lean back. Smoothly return your leg to the start position, retaining good posture, and continue.

Perform sets of 10 reps at a fast speed and build up to sets of 20 or 30 for power endurance of this movement.

‘Dive start and push-off turn’ exercise

Barbell squat jumps

This exercise involves dynamic extension of the ankle, knee and hip joints and trains the calf, quadriceps and gluteal muscles to improve vertical jump performance. The vertical jump is mechanically related to the dive start and push-off turns involved in swimming: with the dive or turn, the ankle, knee and hip extension propels you forwards in the horizontal plane, while with the jump the leg extension propels you upwards in the vertical plane. Essentially, it’s the same movement rotated by 90°!

The point of using a barbell to add weight to the squat is to help you to generate peak power. If you perform the jump squat with body weight only, the jump will be very fast and high. With the addition of a moderate weight (about 30-40% of the 1 repetition max weight for the squat exercise), the jump will not be as high or fast, but the muscular power required to leave the ground will be maximal. This is based on the knowledge that peak power is achieved when the force used is about one third of the maximum force for that movement.

Again, your goal is to attempt to achieve the fastest extension of the legs to maximise power production and training benefit. If you use 30-40% of 1RM weight, I recommend 3-5 sets of 5 repetitions.

Stand with the barbell across the back of your shoulders. Squat down, bending at the hips and knee, making sure the weight goes down through the back half of your foot. When you reach the half squat position, drive up dynamically, rapidly extending your legs so that you leave the floor briefly. Absorb the landing with soft knees, then go smoothly into the squat again. Continue for 5 repetitions.

The bottom line

In summary:

Strength and power training is essential for élite swimming performance.

To optimise the benefit of land-based training, you must select exercises with mechanical relevance to the swimming action, particularly those movements which propel the swimmer through the water, such as the arm pull and leg kick.

As the resistance in the water is different from the resistance provided by weight equipment on land, unless you have special hydraulic equipment you must also focus on mimicking the speed and smooth movement of the swimming stroke when performing land-based exercises.

Various exercises for the arm pull, leg kick, dive and turn movements are suggested, all with a good functional relationship to the swimming action. While this is not a definitive or exhaustive selection of exercises, especially as it focuses solely on front crawl, it involves highly specific swimming movements in terms of mechanics, positions and speed. When you design strength programmes for swimming performance or any other sport, be sure to think about each exercise in terms of its relevance to performance.

Raphael Brandon

Add power to your punch with plyometric exercise

Do you ever look in awe at top sprinters when you realise just how fast they are running? Dwain Chambers would get a speeding ticket in built-up areas! And what about the slam-dunk in basketball? How on earth do players like Kobe Bryant leave planet earth and attain such height? And what of Matthew Pinsent and James Cracknell? Unbridled, these rowers would seem to be able to tear their boat apart!

Wherever you look in the world of top-class sport, power counts; and one of the best ways of developing this most precious commodity is through plyometric training.

Plyometric exercises are based on the understanding that a concentric (shortening) muscular contraction is much stronger if it immediately follows an eccentric (lengthening) contraction of the same muscle. It's a bit like stretching out a coiled spring to its fullest extent and then letting it go: immense levels of energy are released in a split second as the spring recoils. Plyometric exercises develop this recoil or, more technically, the stretch/reflex capacity in a muscle. With regular exposure to this training stimulus, muscle fibre should be able to store more elastic energy and transfer more quickly and powerfully from the eccentric to the concentric phase.

Unlike traditional weight training, plyometric drills can closely mimic both the movement pattern and the speed of execution of actual sports performance. While a sprinter's foot may be in contact with the ground for just 0.084 seconds, and even running at a moderate pace can result in a foot strike time of 0.2 seconds, most standard weight-training lifts, performed at their quickest, take 0.5-0.7 seconds to complete. A plyometric drill will match runners' ground contact times, while at the same time generating a significant amount of force.

One piece of Soviet research showed that under, certain conditions, athletes could display brief (in the range of 0.037-0.067 seconds) plyometrically-induced muscular tensions equivalent to 1,500-3,500kg, although it should be noted that this example was probably based on eccentric exercises (drop and hold depth jumps from a great height) rather than the more familiar types of plyometric drills, of which more later. So you can see why weight training for sport can be limiting when it comes to specific training transference, and why plyometrics are a great way to address power needs.

To get the best out of plyometrics you need adequate pre-conditioning. Some authorities recommend that an athlete should be able to half squat at least 1.5 times their body weight before embarking on a plyometric programme, but this may be an excessive requirement, particularly if an athlete is planning to embark on a progressive plyometric-conditioning programme, beginning with low-intensity drills before progressing to the more intense exercises *(see table opposite)*. As with all 'new' training experiences, progress should be incremental.

‘To get the best out of plyometrics you need adequate pre-conditioning’

Despite my seemingly dismissive comments about weight training, it should not be discounted as means of generating specific sports-related power. Weight training still has a vital role to play in terms of laying the foundations for greater power and pre-conditioning an athlete for plyometrics. A larger and stronger muscle (built up by weight training) will be able to generate greater force plyometrically, and strengthened tendons and muscles will be less prone to strains and pulls. It is also possible to combine weight training with plyometrics for a heightened fast twitch muscle fibre response *(see PP114 Feb 1999)*.

When it comes to selecting the right plyometric moves, the coach or athlete needs to consider the specifics of their sport, the athlete's maturity, his level of pre-conditioning and his ability to pick up what can be a complex skill. Single leg moves are often more complex and stressful than double leg moves.

Plyometric drills ranked by intensity		
Type of plyometric move	**Examples**	**Intensity**
Standing-based jumps performed on the spot	● Tuck-jumps ● Split-jumps ● Squat-jumps	Low
Jumps from standing	● Standing long jump ● Standing hop ● Standing jump for height	Low-medium
Multiple jumps from standing	● 5 consecutive bounds ● 2 x 6 bunny jumps ● Double-footed jumps over 4 hurdles ● Double-footed jumps up steps	Medium
Multiple jumps with run-up	● 3 x 2 hops and jump into sand pit with 11 stride approach ● 2 x 10 bounds with a 7 stride run-up	High
Depth Jumping (Recommended drop height 40-100cm the greater the height the greater strength component, the lower the height the greater the speed.	● 2 x 6 jumps – down and up ● Run to hop off low box onto one leg landing followed by three subsequent hops ● Bounding uphill	High Very high Very high
Eccentric drop and hold drills	● Hop and hold 5 times ● Bound/hop/bound/hop and hold over 30m (To perform the above two examples the athlete literally stops on each landing before springing into the next move where required.) ● Drop and hold from height above 1m	High High Very high

Compare squat jumps to alternate leg bounding over 20m, with either a single or double arm shift and a 15m run-on. The complexity and speed component of the latter is significantly greater than the former. And it is likely that a beginner – or even a moderately conditioned individual – would not be able to perform even the first bound without collapsing, let alone a series over 20m, whereas he or she would probably be able to perform five consecutive squat jumps.

Always err on the side of caution when selecting your moves. The table above ranks various plyometric lower limb drills in order of intensity. Those new to this type of training should be sure to start with the low-intensity moves when introducing plyometrics into their training programme. You should wear well-cushioned trainers and perform the drills on a yielding surface, such as a running track or sprung floor.

Eccentric drop and hold jumps

These drills, although utilised in training and research from the 1960s onwards, have not been as prevalent in training programmes as the other drills referred to in the table. Eccentric drills focus on the plant and absorption phase of a dynamic movement and forsake the concentric phase in the stretch/reflex sequence. They are advocated because of their huge force absorption potential, and as a further conditioner of the stretch/reflex.

Poor interpretation of the work done by Yuri Verhoshansky (the former Soviet sports scientist, known as the 'father' of plyometric research) sometimes resulted in subjects being asked to perform depth jumps (*ie* rebound on landing) from very considerable heights (*eg* in excess of 3m) with obvious potential for injury. (I myself was once asked to perform this form of eccentric training from a similar height but refused on the grounds of sanity. The height itself is a major fear factor, let alone the landing!)

However, if implemented sensibly and from lower heights, or in the form of 'bound/hop and hold' drills, eccentric power training can be an effective way of further developing power. It's yet another way to overload muscles and thus avoid stagnation and maintain training progression in seasoned athletes. Both coach and athlete need to be aware that eccentric training is likely to cause muscular soreness even in the well-conditioned; but, as with other forms of eccentric training, such as downhill running, one session may be all that is needed to 'inoculate' the body against further soreness.

As with weight or endurance training, you can periodise your plyometric training. Obviously the specific requirements of your sport and your competitive aims for the forthcoming season need to be considered, but there are some general guidelines for progression. The following recommendations are based on the requirements of a power athlete with a single main competition period, but occasional reference is made to the needs of endurance athletes.

Pre-season/early conditioning phase

Plyometric moves such as split squats, jump squats and straight leg jumps can all be incorporated into a circuit. Normal circuit training protocols should be used – *ie* high reps, short recoveries. At this stage of general conditioning they will develop low-level power and general sport specific movement pattern conditioning, as well as specific endurance. If you are an endurance athlete you could continue this type of training beyond your pre-condition phase and integrate it into your non-track/rowing/cycling sessions. Runners could also incorporate plyometric drills into fartlek-type workouts.

Main power conditioning phase

Athletes who are sufficiently skilled should use drills from the medium-intensity categories in the table during this phase of training. Runners should progress to single leg variants, as these will have the greatest relevance to their sport. Do not neglect lower leg drills such as straight leg jumps – where the athlete literally 'pogoes' up and down on the spot. These will improve specific calf and achilles tendon power, leading to optimum foot-strike and force return when running.

Middle- and long-distance runners could incorporate bounding and hopping into the warm-up stages of their track sessions; they could also carry out hill training to develop running-specific power as well as maintaining plyometric drills within their circuit training.

'In power sports the activity itself will act as the prime conditioner: nothing beats a competitive situation for optimum power expression'

Pre-competition phase

During this period athletes should concentrate on quality plyometric drills that replicate the speed and movement patterns of their chosen sport. Select drills from the high-intensity examples in the table, but ensure quality and do not allow fatigue to impair performance.

Competition phase

In power sports the activity itself will act as the prime conditioner: nothing beats a competitive situation for optimum power expression. But in training athletes should perform high-quality plyometric drills in low numbers, well away (7-10 days) from important competitions. Endurance athletes could continue with medium/high-quality drills as part of their warm ups or low-intensity workouts.

Volume and intensity guidelines

The recommended volume of specific jumps in any one session will vary with intensity and progression goals. For jumps on the spot or from standing, measure the volume in terms of foot contacts. As a guide, a beginner in a single pre-season workout could perform 60-100 foot contacts of low-intensity exercises.

The intermediate plyometrics exponent might be able to do 100-150 foot contacts of low-intensity exercises in one workout and 100 of moderate-intensity exercises in another, while an advanced exerciser might be capable of 150-200 foot contacts of low-to-moderate intensity exercises in a single session.

Intensity is the key: the more dynamic the move and the greater the power generated, the fewer foot contacts are required. As training phases progress, maintaining quality is crucial and the number of foot contacts should be reduced, as optimum power and speed need to govern performance. Bounding and hops are best measured in terms of sets and reps, distance covered and whether they are performed from a standing start or with a run-on. Verhoshansky recommended incorporating a maximum of 5-10 bounds per set into a session, with no more than 50-75 ground contacts. If a run-on is used, the number of reps should be reduced.

For optimum sport specific training effect performers should not allow themselves to become fatigued. Rest between sets should be in the region of 1-2 minutes; successive depth jumps or drop jumps should be separated by intervals of at least 15-30 seconds – or even longer if very intense multiple hops and jumps routines are being performed. Such recovery intervals will allow the stretch reflex mechanism to return to optimum capability.

In terms of number of sessions, 2-3 per week should suffice – but they should not be performed on consecutive days or 7-10 days before important competitions. Those new to this form of training may experience an initial decline in their performance until they become accustomed to the training method.

John Shepherd

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

These days, hardly any sports performers can afford to neglect weight training. Get this training right and you could find your place on the medal rostrum; get it wrong and you could end up at the back of the field.

Weight training for endurance

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

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

1. The exercises selected must be relevant to rowing;
2. They must be performed ultimately at a pace equivalent to the actual stroke;

3. They must create conditions that mirror the heart rate levels sustained during a 2k race and
4. They must reflect the time it takes to complete the race distance.

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

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

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

The sport specific transference from this microcycle appears considerable. By targeting primarily type I muscle fibres and

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

the cardiovascular system, an intense physiological response would be elicited – similar to that achieved during a high-intensity interval-style rowing workout.

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

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

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

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

Charles Van Commenee is UK Athletics' multi-events and jumps coach and it was he who coached Denise Lewis to Sydney Gold. He believes that to develop power you initially need a good strength base, and advocates the use of exercises that train the whole body. Intensity is set at 90% of one rep maximum (1RM) and his athletes perform 5-15 sets, but only using 1-2 reps and interspersed by long recovery periods of 3-4 minutes.

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

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

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

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

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

Weight training and open sports skills

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

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

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

Mike Antoniades, a specialist speed, power and weight training coach, who has worked with many top sportsmen and women using the Frappier Acceleration system *(see article on page 79)*, provides a third reason why the open skills performer should not neglect weight training. He notes that footballers can lose up to 35% of their strength during a season – and more if they are unlucky enough to sustain an injury. The open sports skill performer therefore needs a weight training programme that maintains specific strength across a season.

Sport specific weight training exercises

The table below includes highly specific weight training exercises. Some, like the first, even contain an element of open sports skill performance because the performer has not just to perform the move but also to balance and be spatially aware. This is similar to the requirements of a striker having to take a shot at goal while off-balance. Note that these are advanced moves and should be attempted only by well-conditioned athletes with a suitable level of prior-conditioning.

Six top weight training tips for enhancing performance

1. Do some 'muscle re-education' work after lifting. If you are a cyclist, for example, you could do three minutes on a spin cycle after weight training. You will have stressed the muscles through weight training and the sport specific task that follows will help to re-coordinate the firing patterns of your muscles. A runner or games player could

achieve the same by performing some light strides after a weights workout.

2. Devise a progressive weight training programme to accompany the demands of your sport, but never lose sight of the sport itself. Weight training is largely peripheral unless it is adequately channelled into performance.
3. Select exercises, particularly during key training phases, that replicate the movement and have a similar speed element to the sport in question.
4. Take your level of maturity as well as your sport into account when devising your programme of weight training.
5. Don't turn into a gym narcissist, marvelling at your great new physique: it could turn into a burdensome suit of armour for you to haul around.
6. The more experienced the performer the more the coach will have to work at exploring new avenues for enhancing sports performance. Revisiting a weights programme could be crucial: look closely at the transition to competitive season phases and check out whether previous strength gains really are improving sports performance.

John Shepherd

Strength or power: which matters most for peak athletic performance?

Do you strength train for your chosen sport? And do you believe it makes you faster as well as stronger? If so, you could be barking up the wrong tree and might be better advised to work on your power.

Let me explain why. The figure below represents the theoretical relationship between concentric muscular force and muscle contraction velocity, or speed. Maximum force is generated by a maximal voluntary isometric contraction (MVIC), which has zero velocity. In theoretical terms, strength is defined as the maximum force of a certain movement. In practice, it is defined by the 1 repetition maximum (RM) load of an exercise in the gym.

The 1RM of a movement will produce slightly less force than the MVIC, as the 1RM is dynamic rather than static. To illustrate this by example, an athlete's maximum squat may be 200kg, this being the weight he can lift, just once, with a maximum effort. At 201kg, the athlete would not be able to move the bar; however, if he applied max effort the MVIC force would be slightly greater than the force produced during the successful 1RM lift. Nevertheless, for the purposes of most coaches and athletes, it is fair to assume that 1RM is highly correlated with maximum isometric force.

In many cases, the aim of a strength programme is simply to increase maximum strength. Athletes typically train with weights between 75% and 95% of 1RM, and after a few weeks their 1RM scores go up, which is great because it means they are stronger. Or is it so great? Look at the force-velocity curve again and note that at the high force end of the curve the velocity of movement is at its slowest. Now think about how an athlete lifts very heavy weights – slowly. This is because it takes time – more than 400msec – to develop maximal force within the muscle: it cannot be switched on like a light.

Most athletic movements do not involve slow contractions at near maximum force, but are characterised by mid-to-high velocity. For example, the contact time of the foot during sprinting is about 100msec – not long enough to produce half of maximum force. This leads you to think about the benefits of strength training in relation to athletic performance a little more critically. What, you might ask, is the point of being stronger at slow speeds when most athletic movements involve high velocities?

Power – how to generate rapid force

A separate quality, quite distinct from strength, which can be developed with training, is power. In simple terms, power is the ability to generate force quickly; it is defined mathematically as force x velocity. If you look at the force-velocity curve once again, you will see that high levels of power will occur in the mid-range of either force or velocity. If an athlete develops greater power, this, in turn, enhances his ability to generate both force (strength) and velocity (speed). This amalgam of speed and strength may be more useful for athletic performance than strength alone.

The above explanations of the force-velocity curve and the difference between strength and power raise two important questions:

1. Would an athlete benefit more from developing maximum strength or power?
2. What are the key differences between max strength training and power training?

For athletes who are inexperienced in strength training, any increase in maximum strength will tend to increase force across the whole velocity range of the force-velocity curve [1]. This means that increases in maximum strength (greater

1RMs in the gym) will also lead to increases in power and the ability to generate more force at fast speeds. Indeed, research shows that maximum strength is strongly correlated with power, especially in less experienced athletes[2]. This endorses traditional heavy weight training (75-95% of 1RM) as a way to improve athletic performance.

But research also shows that max strength development becomes limited beyond a certain point. Once an athlete has reached a high level of strength, any further increases will lead to improvement only at the high force/slow velocity end of the curve. This means no increases in power or force at fast speeds, which, as mentioned, is not necessarily desirable for most athletic movements. In a nutshell, as the athlete becomes more advanced and experienced in strength training, the effects of maximum strength training become increasingly specific to slow muscle contractions.

‘Research shows that max strength development becomes limited beyond a certain point’

By contrast, power or ‘ballistic’ training has been shown to increase power and rate of force production and is more highly correlated with athletic performance than strength training. Power training methods can vary in terms of force and velocity characteristics, since the description embraces a number of different approaches. Plyometric jumping or throwing exercises tend to use higher velocity and lower force, whereas Olympic lifting exercises – *eg* power cleans – use higher force and lower velocity. Between these two extremes lie ballistic weight exercises, such as barbell squat jump and bench press throw, which employ moderate forces and velocity.

The benefits of each method differ slightly. To summarise simply:

- plyometric exercises promote high movement speed, fast twitch fibre recruitment and elastic tendon energy release;
- Olympic lifts involve very high power outputs, high rates of force production and increases in muscular co-ordination of whole-body movements, such as combined ankle, knee and hip extension;
- ballistic weight exercises are very useful for developing

high power in specific areas of the body – *eg* arm extension power with bench press throws – and will result in high rates of force production and muscle activity in the specific muscle groups involved.

There is a good logical argument for training with exercises at specific loads that produce the maximum amount of power for that particular movement. Power has been shown by research to be highly correlated with level of performance, and training which develops the maximum power output will increase force levels at the mid-to-high velocity end of the force-velocity curve.

Exercises of this type that I recommend frequently to athletes include power snatch, power clean, barbell squat jump, bench press throw and heavy bag rotation throw. These are all functional movements that involve moving moderately heavy loads as fast as possible. To generate maximum muscular power, a reasonable amount of load is required, and so these exercises involve greater power output than plyometric jumps, which use no additional load, or medicine ball throws, which are relatively light. Max power training is a distinct discipline and should be performed in addition to plyometric training, not instead of it.

Research has shown that the maximum power produced on a bench press throw or squat jump occurs with loads of around 50-60% of 1RM for the bench press or squat exercises. To develop max power levels in the legs and upper body, you can use 1RM test scores to determine the power training loads. For example, an athlete with 1RM scores of 200kg squat and 120kg bench press would produce max power on the squat jump exercise with a 100-120kg barbell and on the bench press throw with a 60-70kg barbell. Women may produce max power at slightly lower levels.

The importance of quality training

When performing a max power workout, 3-5 sets of 3-5 repetitions for each exercise would be effective. Power training must be high quality, as the aim is to recruit fast twitch fibres. For this reason, it is important to take at least three minutes rest between sets and to focus on moving the bar as quickly as possible. Max power training performed at less than max power simply does not work; coaches must encourage their athletes to hit each lift with max effort, while athletes must learn to focus on high-quality execution of the exercises. Power training is not like endurance training, where it is enough just to complete the session: it is how well you train for power that makes the difference.

'Max power training performed at less than max power simply does not work'

With the Olympic lifts, such as power snatch and power clean, I have found that, for most athletes, maximum power occurs at slightly less than the maximum load. For example, if an athlete has a 1RM power clean of 100kg, then maximum power will be produced around 85kg. This is probably because most athletes do not have the time to develop the perfect technique and timing of elite weightlifters, and tend to produce a better speed of movement and coordination at less than maximum load. However, as technique improves the difference is likely to diminish.

There are great transferable benefits for athletes using loads for the Olympic lifts that produce maximum power for that lift. The athletes learn to feel the effort required for max power and speed of the lift and take this increased power into the sporting movement. This is my personal experience of the neural and coordination effects of max power training. Again 2-4 sets of 2-5 reps with long rests are recommended.

Many athletic movements, particularly throwing and kicking, involve trunk rotation. Rotational movements are not possible with barbell or weight machines, but standing rotation throws of a heavy bag (15-30kg depending on the strength of the athlete) are very effective at producing maximum rotation power, as they involve greater muscular force than medicine ball exercises. The same sets, reps and rest as above are recommended for effective training.

To summarise: the main difference between traditional heavy weight training and power training lies in the load and speed of the exercises. Loads of 75-95% of 1RM will result in increased maximum strength, while loads of 50-60% of 1RM, performed ballistically, will result in increased maximum power. Once an athlete has reached high strength levels, maximum power training may be more conducive to peak athletic performance than further increases in max strength.

Elite strength levels

How strong does an athlete need to be before the benefits of further strength training become limited? This depends on the individual athlete and his or her chosen event. For example, the shot put is significantly heavier than the javelin and may require higher max strength levels for success. As a guideline, elite levels of strength for a male athlete are 1RM squat of 2.5-3 x body weight and 1RM bench press of 1.5-2 x bodyweight, while those for a female are 2 and 1.25 x body weight respectively.

Once these levels have been reached, any athlete would probably benefit more from maximum power training than strength training. Having said that, there seems to be considerable benefit in combining the two methods within a periodised programme. A phase of maximum strength training followed by, or combined with, a phase of maximum power training is an approach supported by the literature.

‘The quality of performance of the exercise is fundamental to the training benefit’

Some researchers support the continued use of maximum strength training for power development. For example, Ditmar Schmidtbleicher, a German biochemist who has worked with Olympic athletes, advocates using high-intensity weight training for increased rate of force development, and claims that the results are transferable across the whole range of the force velocity curve, as they are for novice athletes (3).

However, the quality of performance of the exercise is fundamental to the training benefit. When using near maximal loads for rate of force development training, athletes must attempt to move the bar as quickly as possible, even though the actual lift will be quite slow. That’s because it is the voluntary effort of attempting to ‘hit the bar hard’ with each repetition that produces the neuromuscular benefit of increased rate of force development, even at high loads that are normally associated with slow speeds.

This argument is supported by recent research suggesting there is no difference between the sprint performance benefits derived from strength training slowly with heavy loads or fast with moderate loads [4].

Further research suggests that for 'stretch shorten cycle' movements, where an eccentric contraction precedes a concentric contraction, maximum strength is highly correlated with initial rate of force production in the concentric phase. By contrast, for concentric-only movements maximum strength is not significantly correlated with initial rate of force production [5]. Given that many sporting movements are stretch shorten cycle in nature *(see PP186, September 2003, p1)*, it would appear that maximum strength is important.

The purpose of strength training

In writing this article, my aim has not been to diminish the importance of maximum strength training for athletic performance, but to make athletes and coaches think about a more complete approach to strength and power training in order to optimise performance. Remember that the purpose of strength training for athletes is not to increase 1RMs but to run faster, jump higher or tackle harder.

Improved performance is the ultimate goal, and power is highly correlated with performance – possibly more so than strength. It is logical to assume that training with exercises that produce maximum power outputs must produce improvements in rate of force production, muscle activation and functional coordination that are transferable to athletic performance.

Having said that, however, maximum strength is a precursor to power and needs to be developed to a sufficient level to maximise power production, particularly in stretch shorten cycle movements.

Athletes who wish to continue to benefit from training programmes must vary their training. By incorporating both max strength and max power training into a training cycle, or periodisation, athletes can present their neuromuscular systems with a variety of different stimuli, so enhancing the adaptations.

The table below sets out an example workout for an elite jumper, used during the summer competition phase. The split squats were used to maintain max leg strength levels, while the cleans and squat jumps were used to develop max power. After following this programme of developing power and maintaining maximum strength for 10 weeks, the athlete increased power output on the power clean by as much as 10% (from 2600W to 2900W at 90 kg).

Finally, the quality of exercise performance has a crucial benefit on the benefits gained. Athletes must learn to make maximum efforts, recruiting as many muscle fibres as possible. It is also important for athletes to ensure sufficient recovery between workouts and to plan max power training sessions for times when they are fresh and capable of high-quality lifting.

Table 1: competition-phase workout for an élite jumper

Cleans	4 x 3	80% of 1RM	3 minutes rest
Squat jumps	4 x 4	50% of 1RM squat	3 minutes rest
Split squats	4 x 5	80% of 1RM	2 minutes rest

Raphael Brandon

References

1. *Strength and Conditioning Journal, 22(3), 65-76*
2. *Journal of Strength and Conditioning Research, 15(2) 198-209*
3. *Schmidtbleicher 1992. Training for Power Events. In 'Strength and Power Training for Sports'. Komi et al*
4. *Journal of Sports Sciences, 20(12), 981-990*
5. *Medicine and Science in Sports and Exercise, 32(10), 1763-1769*

The bad news is that speed declines with age; the good news is that you can arrest, even reverse, this degenerative process

Of all the physiological variables, speed seems to get written off most quickly as we age. Football pundits make jokes about outfield players being 'a few yards slower' and goalkeepers diving in 'instalments' as soon as the former hit 30 and the latter become David Seaman.

But England's Rugby World Cup winning pack averaged well over 30 and, despite being called 'Dad's Army', still fathered a victory; the likes of Neil Back and Martin Johnson were certainly very speedy around the field. In track, Carl Lewis, Frankie Fredericks, Linford Christie and Merlene Ottey are – or were – still winning titles well into their thirties and, in the case of Ottey, beyond. But can veteran athletes still put in speedy sprinting performances in their forties, fifties, sixties – and beyond?

First, let's take a look at why we slow with age. One significant factor is a decline in muscle mass and muscle fibre (sarcopenia). We will all experience a 10% decline in muscle mass between the ages of 25 and 50 and a further 45% shrinkage by our eighth decade – if we do nothing about it. To illustrate this decline by example, the biceps muscle of a newborn baby has around 500,000 fibres while that of an 80-year-old has a mere 300,000. As we age, we also produce less growth hormone, which leads to reduced levels of protein synthesis and, again, muscle atrophy. This is not the kind of acceleration needed by the veteran athlete in search of speed, as decreased muscle equates to reduced strength and power and less ‘oomph’ for sprinting.

‘Speedsters are not as blessed as endurance athletes in the ageing-and-performance stakes’

Unfortunately, the bad news keeps on coming! Fast-twitch muscle fibre, that most precious of commodities for speed and power, displays a much more marked decline than slow-twitch fibre as we age. Speedsters, it appears, are not as blessed as endurance athletes in the ageing-and-performance stakes. The latter can expect to maintain their slow twitch fibres and even increase them – by as much as 20% with the right training – as they ripen. They can also hold on to nearly all their aerobic capacity until late into their fifth decade at least. If only it were so for their sprinting counterparts, whose fast-twitch fibre can decline by as much as 30% between the ages of 20 and 80.

To add another blow, creatine phosphate, that premium ingredient for short-term activity, also declines with age. With less quick-release energy in our muscles, we’re theoretically less able to tackle high-intensity sprint-type workouts.

Flexibility, another important physiological variable for sprinting, also declines with age as our soft tissue hardens and our joints stiffen.

What are the known effects on performance of these various reductions in capacity? It gets worse! Numerous studies have indicated that stride length declines considerably with age. Korhonen analysed the performances of 70 finalists (males 40-88, females 35-87) in the 100m event at the European Veterans Athletics Championships in Jyväskylä, Finland in 2000, using high-speed cameras with a panning video technique to measure velocity, stride length, stride rate, ground contact time and flight time [1].

Unsurprisingly, his research team discovered a general decline in sprint performance with age, which was particularly marked for those aged 65-70. Velocity during the different phases of the run declined, on average, between 5 and 6% per decade in men and 5-7% in women. Key to this decline was an accelerating reduction in stride length and an increase in contact time, with stride rate remaining largely unaffected until the oldest age groups in both genders.

Hamilton compared 35-39-year-old runners with 90-year-olds and found that stride length declined by as much as 40%, from 4.72 metres per stride (2.36m per step) to 2.84m per stride (just 1.42m per step). The implication is that the oldest veteran sprinters may need to take almost twice as many steps in the 100m as their younger counterparts. More positively, though, this research group also found that stride frequency did not decline significantly with age (2).

If you take a look at Table 1, below, you'll find some much better news. Take note of the phenomenal times recorded by master 100m sprinters; these indicate that it is possible to maintain a significant amount of speed with age. So now let's take a look at what we have to do to achieve that goal.

Table 1: Masters world age records

Age group	Time (secs)	Athlete	Age when record set	Country
40	10.84	Erik Oostweegel	40	NED
45	10.96	Neville Hodge	45	US
50	10.95	William Collins	50	US
55	11.57	Ron Taylor	57	GB
60	11.70	Ron Taylor	61	GB
65	12.62	Malcom Pirie	65	AUS
70	12.91	Patton Jordan	74	US
75	13.40	Patton Jordan	75	US
80	14.35	Patton Jordan	80	US
85	16.16	Suda Giichi	85	JPN
90	18.08	Kozo Haraguchi	90	JPN
95	24.01	Erwin Jaskulski	96	AUT
100	43.00	Everett Hosak	100	US

Source: World Masters Athletics Association as at 24/09/02

Hill training for stride length

As we've seen, two crucial factors affecting speed decline in the older sprinter are a reduction in stride length and an increase in ground contact time. Hill sprinting can reverse these negatives; the gradient will emphasis dorsiflexion (a greater toe-up foot position) on foot strike, which will, in turn, generate more work for the calf muscles on push off, enhancing stride length and reducing contact time on the level. Lower limb and ankle strength and power are crucial for sprinters of all ages, although they can be overlooked by coaches and athletes in favour of conditioning the quadriceps and glutes.

One of the key factors contributing to the age-related decline in stride length is the action of the free leg as it leaves the running surface and the foot travels a curvilinear path beneath the body to a forward position in preparation for the subsequent foot strike. An older runner's 'return phase' is much less dynamic than that of his or her younger counterparts. For optimising speed transference into the next running stride, the lower leg needs to 'fold up' towards the butt and be pulled through quickly and powerfully as a short lever. This action relies on hip, glute and hamstring strength.

Returning to Hamilton's work, she and her co-workers discovered that range of motion at the knees during running decreased by 33% – from 123° to just 95° – between ages 35 and 90. For the oldest runners in the study, this meant that the lower part of the leg attained a right angle with the thigh at the point of maximum flexion, dramatically slowing free leg transition into the next stride.

Hill sprints can play a key role in combating this lower leg lethargy; by creating a greater leg drive, they can increase the speed of the free leg through reaction to the ground and condition a much more effective and speedy biomechanical sprinting action.

Weights for fast-twitch maintenance

Weight training is crucial for mature sprinters determined to hang on to as much zip as possible, particularly after 50 when muscle mass begins to decline more steeply. Training with weights set around 75% of one rep maximum will offset fast-twitch fibre shrinkage quite significantly. Unfortunately, though, it has no impact on muscle fibre reduction, which is governed by an age-related decline in motor cells in the spinal cord.

Weight training, by strengthening soft tissue, will also go some way towards protecting older speed merchants from injury.

Plyometrics for stretch/reflex

Plyometric exercises condition the stretch/reflex in our muscles and, as well as boosting speed and power, can stimulate the fast-twitch fibres of older sprinters into further action. As mentioned above, stride length declines significantly with age, and plyometrics, like hill training, offers another significant training option for offsetting this decline. Bounding and hopping are two very effective exercises for enhancing stride length.

Intense exercise for GH release

Exercise is known to stimulate growth hormone (GH) release, which is crucial for speed maintenance in later life [3]. Growth hormone helps us hold on to more lean muscle mass, retain more energy and offset some of the general effects of ageing. The positive release of GH begins almost immediately after we start to exercise, and it seem that the higher the intensity of the exercise, the more GH will be released.

Stokes and co-workers compared the effects of maximal and less intense cycle ergometer sprinting in a group of 10 male cyclists, who completed 2 x 30s sprints separated by one hour's passive recovery on two occasions [4]. The first effort was completed against a resistance equal to 7.5% of body mass and the second to 10% of body mass. Blood samples were taken at rest, between the two sprints and one hour post exercise. Analysis of blood samples showed that the first effort elicited a much more significant serum GH response than the second. Note that, although both sprints generated the same peak and mean power outputs, the first allowed the cyclists to generate higher RPM scores – *ie* to pedal faster.

'Weight training, by strengthening soft tissue, will go some way towards protecting older speed merchants from injury'

Despite the apparent attenuation of GH release in the second effort, since speed is maintained and enhanced by regular anaerobic training silver sprinters should benefit from regular and above-normal GH release.

Creatine for muscle power

Intense speed and power training can also combat the normal age-related decline in creatine phosphate. Research has shown that anaerobic (and aerobic) training increases the production of creatine phosphate. Research by Moller and co-workers showed that six weeks of cycle ergometer training increased the creatine phosphate levels of 61-80 year olds to levels similar to those of younger adults [5]. The regular anaerobic workouts of sprint training will maintain and increase the ability of our muscles to replenish high-energy phosphates, regardless of age.

But since there's nothing wrong with giving Mother Nature a legal helping hand, the older sprinter should take supplementary creatine. Numerous studies have shown that creatine supplementation can increase muscle power and power maintenance over a series of anaerobic repetitions and will contribute to the maintenance of lean muscle mass.

One interesting piece of research that specifically addressed sprinting threw up some encouraging – and other slightly less encouraging – information for veteran sprinters supplementing with creatine. Schedel *et al* looked at whether the improvement in maximal sprinting speed after creatine supplementation could be attributed

to an increase in stride frequency, stride length, or both[6].

Seven sprinters completed four consecutive sprints after one week of placebo or creatine supplementation. By comparison with the placebo condition, creatine-fed sprinters increased their running speed (+1.4%) and stride frequency (+1.5%), but not their stride length.

This research also substantiated the use of creatine for sustaining power output, as decline in performance of subsequent sprints was partially prevented after supplementation with creatine. The researchers concluded that their findings could be related to the recent discovery that creatine supplementation can produce a shortening in muscular relaxation time, thus promoting increased sprint times.

Train smart for all-round benefits

Finally, the older sprinter needs to make use of the wiser head on his or her shoulders. Training needs to be intense to minimise the age-related decline in sprint speed, but it also needs to take account of the fact that older bodies may be less able to sustain daily, flat-out power-oriented work. Rest, proper nutrition, supplementation and a commonsense approach that involves 'listening to the body' need to be key features of the training routine of any veteran sprinter intent on maintaining speed.

John Shepherd

References

1. *Med Sci Sports Exerc 2003; 35(8):1419-28*

2. *Journal of Applied Biomechanics, vol 9, 15-26, 1993*

3. *Sports Medicine 2003;33(8): 599-613*

4. *Journal of Applied Physiology 92:60-608 2002*

5. *Clinical Psychology 2 (4): 307-314, 1982*

6. *J Physiology. 2000 Apr;50(2):273-276.*

All you need to know about getting in shape to perform zippy turns on the hoof

Such was the ferocity of Pete Sampras' serves that they were in danger of singeing the net; Irish and British Lions rugby centre Brian O'Driscoll swerves around opponents flat out, like a Formula One racing car taking a bend; discus and hammer throwers, and some shot putters, spin with the grace of ballet dancers before releasing their implements with the power of a nuclear strike.

Developing these explosive rotational sports skills relies not just on innate ability and technique, but also on specialist conditioning drills and methods. In this article, I will consider such skills as turning, turning to sprint, turning and throwing, and turning to hit/kick a ball or opponent, from both stationary and moving positions.

Although all-over body power is needed to perform these activities, the core (abdominal and back muscles) is fundamental for their optimum performance. This area must be strong enough to maximise the transference of power through the limbs into a sports skill, such as a golf drive or a tennis forehand; it must be able to withstand – and reduce the risk of – injury in training and competition; finally (and crucially), it must be able to generate specific sports power itself. Agility is also fundamental to zippy turns *(see article on page 71)*.

It is often assumed that athletes who are fast when travelling in a straight line will be fast in any direction. However, research suggests that this assumption may be erroneous. Young and associates researched the impact of straight-line speed training on rotational/change of direction speed, and vice versa [1].

Thirty-six males were tested on a 30m straight sprint and were given six change of direction tests, the latter involving 2-5 tangent runs at various angles. These tests took place before and after a six-week training period, in which one group focused on 20-40m straight-line sprints and the other on 20-40m, 100° angle change-of-direction sprints.

What did the researchers discover about the impact of this training on performance? Not surprisingly, the straight-line sprinting training improved straight-line sprinting performance. However, this increased zip did not translate into speedier turns. In fact, the researchers discovered that the more complex the change of direction/turning task, the less transference there was from straight-line speed training. Similarly, the turning/change-of-direction training gave a major boost to turning/change of direction performance, but had no impact on straight-line speed.

These findings have important implications for athletes and coaches in sports like football and tennis, where players have to constantly rotate in order to make up the ground to perform their various sport specific skills. It seems that the ability to rotate the body at speed is a highly specific skill, requiring specialist conditioning, and that being fast in a straight line is just not enough. Some of the exercises at the end of this article can be used to condition such players' 'rotational muscles'. They will also benefit from specific agility training.

Rotational sport specific strength

Developing greater strength through resistance training is a fundamental aspect of all performers' conditioning routines. Coaches and athletes alike hope that the strength developed thereby will translate into improved sports performance. However, this can be a very challenging conditioning requirement for those in search of rotational power and speed.

Let's begin by considering weight training: most popular sports conditioning weights exercises, like the squat, power clean and snatch, are performed in a linear fashion and do not reflect the way power is generated in a rotational sports movement, like the discus throw. Although these exercises are relevant in terms of establishing a power base, athletes and coaches need to develop a repertoire of more specialist weights exercises, such as the Russian twist and the wood-chop *(see below)*, which are better suited to channelling strength and power into rotational sports skills.

However, the direct relevance of even specialist weights moves to sports performance is open to question. Welch and associates looked at the forces generated in a baseball hit and found that the batter's hip segment rotates to a maximum speed of 714° per second, followed by a shoulder segment rotation of up to 937° per second [2]. The product of this kinetic link is a maximum linear bat velocity of 31m/sec. The golf swing, to give another example, can be completed in a mere 250 milliseconds.

'The direct relevance of even specialist weights moves to sports performance is open to question'

Developing the 'wind-up-and-rotate' velocity for these sports through weight training alone would be virtually impossible. This poses fundamental conditioning questions, such as: how can weights (and other resistance training methods) be best employed to enhance specific sports performance skill? And how important is speed of performance? Cronin *et al* went in search of the answers and reached the following conclusions [3]:

- Developing qualities like strength, power and rate of force would appear of greater importance than training at the actual movement velocity of a task. It may be that (irrespective of load and limb velocity) the repeated intent to overcome a resistance as rapidly as possible is an important stimulus for functional high velocity adaptation;
- Workouts should ideally combine sport specific training with a heavy or varied training load in order to develop the muscular and neuromuscular coordination that will improve functional performance;
- The ability of the nervous system to activate and coordinate all the muscles involved in performing a movement is essential.

Former world javelin record holder Tom Petranoff advocates under-speed training when recommending medicine ball exercises – a great training tool for rotational power development. 'The key to any training is to train smart, to train slow and get the technique correct before you add more weight or resistance,' he advises [4].

This echoes the principle – often enshrined in former eastern bloc coaching methodology – of ensuring that a technique is properly mastered before more power is bolted on. This is particularly important in sports involving rotational movements, where controlled, smooth application of power is crucial as, indeed, is timing. A golfer could not swing his club speedily at the ball without these attributes, nor could a hammer thrower spin as fast as he was able: too much speed would result in loss of balance and control, with consequent underperformance.

'In sports involving rotational movements, controlled smooth application of power is crucial as, indeed, is timing'

Petranoff expands on this issue by emphasising the need for those performing rotational sports movements to develop an awareness of where their centre of gravity is – a requirement that could be compromised by constantly training at or beyond maximum performance velocities.

Throws athletes and their coaches are well aware of this requirement and spend hours performing various rotations, with or without resistance/throwing implements, in the pursuit of better spatial awareness, body positioning and footwork.

Below are some examples of dynamic conditioning drills in keeping with the theme of this article, some of them quite unusual. Although they are performed at various velocities, all develop the muscles used in rotational movements in a highly sport specific way.

Weights exercises

Russian twist

This exercise mimics the shoulder rotation movement employed in numerous hitting and throwing sports. Sit on the floor with your knees bent to about 90° and get a training partner to hold you down by the ankles. Holding a weights disc with both hands, lower your trunk to a 120° angle, then rotate left and right, stopping the weight at 10-15cm from the floor. If specialist equipment that supports the body off the ground is available to perform this exercise, you will be able to rotate even further.

Reverse trunk twist
Lie on a weights bench face down, having positioned a barbell across the back of your shoulders. Again you'll need a training partner to hold your ankles down. Rotate your torso left and right, while keeping your hips in contact with the bench. Again, some gyms may have specialist equipment designed for this exercise.

Cable chop
This exercise uses a high pulley machine and a triangular attachment to develop rotational power in the shoulders and trunk. Stand facing forward with feet slightly more than shoulder width apart. Hold the attachment with both hands over your right shoulder. Pull the cable across your body to just beyond your left hip. Complete your designated number of repetitions and repeat on the left side. This exercise can also be performed from a kneeling position.

Resistance/plyometric drills

Plyometric drills are a crucial weapon in the rotational sports power conditioning armoury. They lead to explosive power development, utilising the stretch/reflex mechanism in muscles to develop and release greater energy. A concentric (shortening) muscular contraction is much more powerful when it immediately follows an eccentric (lengthening) contraction of the same muscle, and this is the basis of plyometric training. During a plyometric drill, muscles operate a bit like elastic bands; if you stretch the band before releasing it, a great deal more energy is generated as it contracts, but when there is no pre-stretch the energy output is more 'flop' than 'pop'.

There are a number of plyometric exercises that can be used to boost the power capacity of the trunk (and other parts), some of them requiring specialist items of kit.

Throwing and catching/passing a medicine ball will develop plyometric power in the torso, legs and arms. Paul Chek one of the world's foremost authorities on sports conditioning, for golf in particular, recommends the following two exercises for developing rotational power [5]:

The twister
Place a small medicine ball between your legs. Holding your arms out straight at shoulder height, take small hops and rotate your knees to each side so that you land at an angle, first to the right and then to the left. The greater the degree of rotation, the greater the amount of work the obliques (the muscles of the outer abdominal area) will have to perform. These muscles play a key role in dynamic rotational sports skill performance.

The medicine ball toss
This is a more familiar plyometric trunk move, in which the performer stands side-on to a training partner (or a wall). The move develops the plyometric stretch/reflex in the obliques when the performer catches the ball with two hands and rotates first away from and then towards the partner/wall before throwing the ball back.

Tornado ball wall chop
This piece of kit – a polyurethane ball on a length of sailing rope – was specifically developed for generating rotational power. The 'wall chop' can be performed kneeling, sitting or standing, and with varying angles of 'chop'. For the standing version, position yourself about one metre away from a wall, with your back to it. Hold the tornado ball with two hands, then rotate and swing it, either to your left or right, so that it hits the wall. It will, of course, spring back towards you with great force. You need to be braced and ready to control this reaction so that you can swing back into another chop immediately. It is this rapid transference of power that evokes the plyometric response.

John Shepherd

References

1. *Sports Med 1997 Sep;24(3),147-156*
2. *J Orthop Sports Phys Therapy 1995 Nov;22(5),193-201*
3. *J Sports Med Phys Fitness 2002 Sep;42(8),267-273*
4. *Petranoff – Everything Track and Field www.everythingtrackandfield.com*
5. *Chek – Tornado Training part II www.paulchekseminars.com*

Twitch and you're gone – all you need to know about developing fast-twitch muscle fibre for speed, power and strength

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

‘Fast-twitch fibres contract 2-3 times faster than their slow-twitch counterparts’

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, below)*.

Fast-twitch fibres, also known as ‘white’ or ‘type II’ fibres, contract 2- 3 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 glycotic’ (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/glycotic 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 have a crucial effect on sports conditioning[1].

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!

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.

'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;

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

The table below 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!

Table 1: Fast-twitch muscle percentages compared

Subject	Fast-twitch muscle fibre (%)
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[1] and Williams (97)[2]

Ross *et al* studied motor unit changes in sprinters and concluded that positive adaptations of muscle to sprint training could be divided into:

- 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/glycotic energy system which is, in turn, gained from the creation and replenishment of high-energy phosphates [3]

Similar finding were made by Abernethy and his team, who compared sprint training methods with those used by endurance athletes [4] .

Table 2, opposite, 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.

Let's return to the sprint training research of Ross and his team [3]. 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 (goalkeeping), 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.

This can make the conditioning process very difficult. In the England cricket team, for example, batsmen are often encouraged to develop their aerobic fitness by running during down times in matches, and during pre-season. Although a general level of aerobic fitness is useful, it is possible that too much steady state work, particularly in-season, could blunt the batsmen's sharpness and dull their fast-twitch motor units.

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.

Table 2: The best training methods for motor units

Method	Comments
Lifting weights in excess of 60% 1RM	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
Performing a physical activity flat-out – *eg* sprinting, swimming, rowing or cycling as fast as possible	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 development is 75% of maximum
Training your muscles eccentrically	Research indicates that this form of training increases fast twitch motor unit recruitment.[6] An eccentric muscular contraction generates force when muscle fibres lengthen (*see plyometric training, below*)
Plyometric training	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.
Complex training	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 (*see PP 114, Feb 1999*). 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
Over-speed training	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
Good recovery	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
Sport specific warm-up	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
Mental preparation	Maximum fast-twitch motor unit recruitment can result from specific mental preparation before and during competition

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 [5].

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

References

1. *Dick F Sports Training Principles (4th edition) A&C Black 2002*
2. *J Comp Physiol [B] 1997 Nov;167(8):527-35*
3. *Sports Med 2001;31(15):1063-82*
4. *Sports Med 1990 Dec;10(6):365-89*
5. *Acta Physiologica Scandanavica, 151, 135-142*
6. *J of Strength and Conditioning Research vol 16 (1), 9-13*

Float like a butterfly, sting like a bee: sport specific drills for boosting agility

Muhammad Ali was the greatest – period. The champ had a superb athletic physique, awesome punching power and one of the fastest pairs of feet and hands ever to grace any athlete, let alone a boxer. He was so quick, he boasted, that he could flick off the light switch and then get into bed before the light went out! Maybe he was exaggerating his abilities here, but the champ was incredibly agile. So what can you do to develop equally ferocious agility?

In sport, agility is characterised by fast feet, body coordination during change of direction and sports skill performance, and reaction time/ability. It is an amalgam of balance, speed, strength, flexibility and coordination. Although a performer's agility relies heavily on the acquisition of optimum sports technique, it can also be enhanced by specific conditioning.

A variety of performance-enhancing agility drills, systems and items of equipment are available to the sportsmen of today and their coaches. The 'science' of agility (and speed and power) training has made rapid strides recently, especially in terms of its accessibility to the mainstream sporting world.

Dissecting a sports skill

Essentially, agility training dissects a sports skill: a skill like the fast-stepping ability required of a rugby player is broken down into its constituent parts, which are then specifically trained. It's all about patterning and conditioning a heightened physical, neural, sport specific response.

Let's consider in more detail the process involved in

‘Speed through a floor ladder can indicate much about a player’s quickness’

developing fast feet. One of the major tools available for this purpose is the floor-based rope ladder. This piece of kit is a key element of the Sports, Agility and Quickness system; (SAQ International is the world’s leading company for packaging and marketing sports-specific training and has been used by England’s Rugby World Cup winning squad).

A wide variety of running, hopping and jumping drills can be carried out in all directions, using the rungs of this ladder, which is laid flat on the ground. Such drills enhance foot speed and upper body agility, just like any other aspect of sports performance, by progressive overload. England rugby wing Ben Cohen has been specifically singled out as a player whose feet have been rendered especially fleet by means of extensive use of the rope ladder and other agility training methods.

Speed through a floor ladder can indicate much about a player’s quickness [1]. A time of less than 2.8 seconds (male) and 3.4 seconds (female) for running the length of a 20-rung ladder, one foot in each rung at a time, is regarded as ‘excellent’ for college athletes.

Agility training also utilises numerous other drills and items of specialist kit; these include balance drills, slaloming in and out of cones, and stepping over and around small hurdles. To make the transference of the agility skill even more sport specific, an actual sports skill can also be introduced. This could take the form of dribbling a football in and out of cones, or receiving a rugby pass while stepping through a foot-ladder. More of this below.

SAQ in female footballers

Obviously, companies like SAQ International claim their systems get results and improve players’ agility. But is their confidence justified? Polman and associates looked at the effects of SAQ techniques on female footballers over a 12-week period [2]. The players were divided into three groups, two performing SAQ training, while the third carried on with their normal conditioning programmes. The results were as follows:

- All three interventions reduced the participants' body mass index (-3.7%) and fat percentage (-1.7%), and increased flexibility (+14.7%) and VO_2max (+ 18.4%);
- However, the SAQ groups exhibited significantly greater benefits from their training programme than the other group on a sprint-to-fatigue test, a 25m sprint, and left and right side agility tests.

Working to improve the agility of a dynamic sports performer (like a footballer or rugby player) by means of SAQ and similar techniques seems highly appropriate, relevant and valuable. But will the same principles apply to endurance athletes? After all, quick-as-a-flash agility is not a pre-requisite for triathlon or marathon running.

Alricsson and associates carried out a study to evaluate whether dance training had any effect on the joint mobility and muscle flexibility of the spine, hip and ankle and on the speed and agility of young cross-country skiers[3]. Cross-country skiing is a not a sport renowned for quick dynamic movement, but shaving seconds off on every turn and jump could add up to significant time savings. Dance training was selected for this task because of its potential contribution to agility and flexibility.

The study involved 20 elite cross-country skiers, aged 12-15, with half of them (five girls and five boys) receiving weekly dance training and the rest serving as non-dancing controls for a period of eight months. Joint mobility and muscle flexibility of the spine, hip and ankle were measured before the study period and at three and eight months. Two sport-related functional tests – a slalom test and a hurdle test – were carried out at the same times.

The researchers found that the dance group had increased their speed by a total of 0.3 seconds over the slalom test after eight months. They also improved their speed and agility on the hurdle test by 0.8 seconds after three months and by a further 0.6 seconds after eight months. Furthermore, they increased flexion-extension of the thoracic (upper) spine by 7.5° after three months and by a further 1.5° after eight months, while lateral flexion improved by 0.04mm and a further 0.03mm over the same periods. Meanwhile, the non-dancing controls did not show any improvements in any of the studied variables.

Effects of dance training

Alricsson concluded: 'Dance training has a positive effect on speed and agility and on joint mobility and muscle flexibility in flexion-extension and lateral flexion of the spine in young cross-country skiers'. Had his subjects made use of more sport specific agility training, the chances are that their gains would have been even greater.

Marathon runners do not have to dart sideways, backwards and forwards with lightning speed over the course of their 26-mile effort, so could they have anything to gain from agility training? To answer this question, we need to consider the interplay between agility and power training.

Research indicates that, despite prolonged running training, runners' leg muscles may not actually be that efficient at returning energy to the running surface. In fact, at certain speeds these muscles may be working at only 50% efficiency because of the 'natural' energy return effectiveness of the foot arch and Achilles tendon(4).

It's a bit like having an engine turbocharger that works in reverse. Your Achilles and foot arch are the turbo: they cut in automatically when your foot strikes the ground, producing a burst of power but leave the running muscles (quads, hamstrings and calf muscles – the engine) working at less than their full potential. Unless you target these running muscles with specific power conditioning drills, your ability to drive up running speed can be compromised.

Such exercises as hopping on and off of a low box and spring jogging (virtually straight leg movements, where the performer propels himself forwards primarily by means of feet and ankles) not only develop 'harder', and therefore more effective, running muscles through their plyometric effect, but also improve agility.

Plyometric exercises enable muscles to generate huge amounts of force in a split second, when a concentric (shortening) muscular contraction immediately follows an eccentric (lengthening) contraction of the same muscle. These agility and power moves can 'sharpen' foot/ground contact and result in a more economical and powerful running stride, regardless of running distance.

Backwards and sideways running can also 'pre-habilitate' against injury, providing a further reason why endurance runners (and those involved in running-based sports) should perform agility training.

'Backwards and sideways running can pre-habilitate against injury, providing a further reason why endurance runners should perform agility training'

As mentioned above, conditioning exercises, such as a plyometric drills, can develop both agility and power. However, these drills may not exactly match what is required in a playing situation. To ensure they do, it is essential for coaches to analyse in real detail the agility and movement patterns required for their sport and to use this information to construct the most relevant conditioning programme. In this respect foot positioning can be crucial.

Kovacs and associates looked at the relevance of foot positioning, particularly foot-landing positions, in athletes performing plyometric depth jumps drills involving stepping off a box then immediately springing upwards, sideways or forwards [5]. Specifically, the researchers were interested in comparing the force generated by flat-footed and forefoot ground contacts.

Ten male university students performed two types of depth jump from a 0.4m high box placed 1m from the centre of a force plate. They were instructed to land either on the balls of their feet, without the heels touching the ground, or on their heels. The researchers discovered that the two different jumping styles generated force in very different ways. Using specific measuring equipment, Kovacs' team demonstrated that a forefoot landing depth jump produced significantly more power at impact and at the transition into the jump than a flat-footed landing depth jump.

Depth jumps and power

Kovacs' findings have crucial implications for optimum agility and power conditioning. Even though a flat-footed-landing depth jump will develop power, this may not channel optimally into enhancing the agility and power of a player in a specific sport. For example, a sprinter would probably benefit more from forefoot-landing jumps, as the sprint action is performed from a similar foot-strike position, whereas a basketball or volleyball player is likely to develop greater vertical spring – a key requirement of the games – by using flat-footed landings. Muscle firing patterns are very specific, and conditioning drills must mirror sports skills for optimum results.

Finally here's an example of an even more specific agility/power conditioning drill, designed for a tennis player. The player should perform a depth jump with a forefoot – but non-aligned – landing position, which will enable him or her to rotate and sprint, in 3-5 strides, to a designated target to the left or right.

This drill mimics and conditions the typical agility (power and speed) required in a game situation – *eg* to reach a drop shot. And it can be made even more specific if the player holds a racket and 'ghosts' a shot on reaching the designated target.

In summary, if you or those you coach want to become faster, more elusive, more efficient and more dynamic in their movements, it is advisable to incorporate specific drills into regular training routines.

John Shepherd

References

1 www.brianmac. demon.co.uk/ qikfeet.htm

2 Journal of Sport Science 2004 Feb; 22 (2), 191-203

3 J Sports Med Phys Fitness 2002 Sep; 42 (3), 282-8

4 PP167, July 2002

5 Med Sci Sports Exerc, 1999 May; 31 (5), 708-16

Tried and tested ways to fast-forward your sporting performance

Billy the Whiz, the Flying Scotsman and the Kansas Cannonball all have something in common apart from great nicknames: they all have – or had – great speed. In their human incarnations, 'the Whiz' is Jason Robinson, the staccato-footed speed merchant who plays either wing or full back for England's rugby union side; Allan Wells is the Flying Scotsman, fast enough over 100m to win Olympic gold in just over 10 seconds back in 1980; and Maurice Greene (the Kansas Cannonball) is, of course, the former World 100m record-holder.

These athletes move, quite literally, in the blink of an eye. Like many of us in search of that most precious sporting commodity, speed, all have made use of a variety of techniques and equipment aids to sharpen them up. This article investigates some of these to help you gain some insight into how to fast-forward your sporting performance.

SAQ drills

SAQ (an acronym for 'speed, agility and quickness') is the title of a system patented by a company called 'SAQ International', which works in the UK with top football teams like West Ham United and the Rugby Football Union, and internationally with the likes of the Miami Dolphins American Football team and the New South Wales Waratahs rugby team in Australia.

Jason ('the Whiz') Robinson has two of the fleetest feet seen on a rugby player and, although blessed with innate ability to dance rings around his opponents, he has also honed his agility through the use of such SAQ drills as the 'foot ladder'. This type of rope ladder, a key component of SAQ training, is placed flat on the playing surface in order to develop foot speed and improved foot-ground contact.

There are numerous permutations of ways for athletes to step and run through the ladder, which can challenge the fast twitch fibres of even the fleetest athletes. 'One foot in, one foot out' (left, right, left into each rung) is not too difficult; 'two in, two out' (two feet one after the other into each gap) is more challenging; but backwards and sideways combinations definitely need to engage the brain as well as the feet. It's a bit like learning to waltz against the high-speed rhythm of Garage music!

These drills, like many of the speed-enhancing techniques mentioned in this article, are designed to optimise neuromuscular patterning and condition. Like any other physical attribute, speed can be trained and improved through repetition and overload. SAQ techniques never lose sight of this overall goal and the playing requirements of various sports. Depending on their emphasis, the drills are designed either to develop absolute speed and agility or to develop these attributes under the conditions of fatigue that players experience during a match.

Drills with a sport specific emphasis often shape up looking like an obstacle course, involving short swerves through cones, hopscotch, zig-zag runs, long swerves, two- footed jumps over low hurdles, backwards running and turns through 360 degrees. Players are often required to perform even more sport-specific tasks during the course of these workouts; for example, a rugby player might have to receive and pass the ball while running through the foot ladder.

For more information about SAQ International, go to www.saqinternational.com

The Frappier acceleration programme

The Frappier system is a more mechanised version of SAQ – think Terminator rather than Tarzan – which was described in detail in a recent issue of Peak Performance *(PP169 August 2002)*. It relies on high-tech kit like the 'Plyo-Press', the 'Multi-Hip', the 'Upper Body Implosion Unit' and the 'Super

Treadmill'. The system is the brain-child of American John Frappier, who began developing it in the 1980s. After gaining an MSc in sports science, Frappier spent a considerable time in Russia with the US junior gymnastics team and gained valuable insights into how the former Soviets trained for speed and power (a great deal of contemporary speed and power training theory is owed to the boffins behind the former Iron Curtain).

'The Frappier system applies the principles of controlled overload to speed development'

Back in the States, Frappier began working with top NFL (American Football) players and opened his first Acceleration Training Centre in 1986. Today there are more than 100 such centres, mostly in the United States.

The Frappier system applies the principles of controlled overload to speed development. All athletes, whatever their sport, are put through a six-week 'level one' programme, which identifies their individual strengths and weaknesses and introduces them to the programme's protocols, and particularly the use of the 'Super Treadmill'. Those in search of scintillating speed are progressed through a 12-level programme, while those seeking sustained speed endurance work through six levels. Both programmes use eight-week training cycles, with 3-4 sessions a week. Speed workouts use the treadmill, while conditioning routines involve other items of specialist kit as well as more 'everyday' sports and speed conditioning drills.

After the six-week introductory course, the Frappier system claims that you can expect, on average, a two-tenths-of-a-second improvement in 40 yards time and a 2-4 inch improvement in vertical jump ability.

The 28mph Super Treadmill is the key to the Frappier system, since it allows for the performance of flat and inclined running (up to 40%) under controlled conditions. The acceleration coach is able to stand alongside the athlete, offering verbal and uniquely physical support. A carefully-placed hand to the lower back can 'spot' or support the sprinting athlete, leading to the maintenance and development of biomechanically correct form.

The Plyo-Press is perhaps the most interesting of the other specialist pieces of speed-enhancing equipment employed by the Frappier system. It combines weight-based resistance training with plyometric training in one hit, allowing athletes to strengthen their muscles in a highly speed-specific way. You select the appropriate weight from the weights stack in the same way that you would on a piece of standard fixed weight equipment, then lie on your back with the machine's pads behind your shoulders within a sort of track. From this position, you are able to generate the power to push yourself towards a footplate that you then 'react' against through your lower and upper legs to launch yourself back up the track.

Conditioning this 'stretch/reflex' is perhaps the key to developing the power to move over a playing surface like a racehorse rather than a donkey. In sprinting, there are three stretch/reflex reactions, occurring at the ankle, knee and hip. If you can succeed in minimising the 'amortisation phase' (the gap between impact/stretch and power expression/contraction) you will be a faster, more powerful athlete. The Frappier system is designed to help you achieve this [1].

For further information on the Frappier system, go to www.sportdimensions.com

Uphill sprinting

The Frappier system, being true to its high-tech principles, tends to eschew nature's hills for mechanised ones. But uphill sprinting, wherever it takes place, is a great way to develop speed. For best results you need a 30% gradient, which will optimally overload the ankle dorsiflexors and plantarflexors, the knee flexors (during the swing phase), the knee extensors and the hip extensors and flexors [2]. This degree of incline also results in greater range of motion at the hip and ankle, faster joint motions during push-off and 2-3 times greater neuromuscular activity in the hip and knee extensors.

Downhill sprinting, elastic cord sprinting and the concept of 'over-speed'

If uphill sprinting provides such a great speed-enhancing opportunity, what about turning round and sprinting downhill?

This activity will result in what is known as 'over-speed' running. Greene is aptly nicknamed the Kansas Cannonball, and during his training it's more than likely that he will have used over-speed downhill running and other over-speed methods to reach speeds he would not normally be able to attain.

Other over-speed devices include towing methods, running 'with the wind' and elasticised harnesses. These devices are essentially giant rubber bands that are attached around the waist. Tension is built up by pulling them out (you need a coach or another athlete to do this); when the harness is released, the athlete is pulled down the track beyond his or her normal sprint speed.

All over-speed methods push or pull athletes to speeds they would not be able to achieve using their bodies alone. Whatever method is employed, it is crucial for athletes to 'fire' their muscles in order to achieve the super-fast sprinting speed rather than being dragged to fast speeds. It's the same difference as falling or running down a hill. If you fall down, you may get to the bottom more quickly, but you'll probably not remember how you did it. If you run down, on the other hand, you'll be conscious of all your steps. For all over-speed work you need to be conscious of your sprinting movements in order to maximise neuromuscular patterning.

'All over-speed methods push or pull athletes to speeds they would not be able to achieve using their bodies alone'

Having tried most over-speed methods myself, I have found that downhill running using a slight decline (10% or less) seemed to offer the greatest transference to my sprinting capability. Elasticised harnesses (read catapults), although great fun, were rather like roller-coaster rides: very exhilarating and scary at the time but easily forgotten, with only marginal consequent improvement to my sprinting speeds. Downhill sprinting, however, enabled me to fire my own muscles, and because of this there was greater transferability to my on-the-flat sprinting.

The old Eastern Bloc countries were quick to realise the benefits of sprinting on various gradients. A trip to their former training facilities – such as Potsdam in East Germany, where they had constructed incline/decline sprint tracks – makes this perfectly clear. To achieve optimum speed transference, Eastern Bloc trainers would get their athletes to sprint uphill one week, on the flat the next and downhill the next.

Specific speed conditioners

1. The Powerbag

This is a relatively new item of speed and power-enhancing kit, which is used by the England rugby team, among other elite performers, and has only very recently been launched to the wider fitness market. Powerbags are tubular padded sacks made from a rip-stop vinyl, with webbing handles at shoulder width, which enable them to be easily carried, lifted and thrown.

Powerbags, which come in various weights, specifically address core stability, balance and the recruitment of the body's stabilising muscles – all key elements of speed and sport specific conditioning. In terms of speed development, they come into their own when conditioning explosive upper body power.

No matter how powerfully you might perform a traditional upper body resistance exercise, like the shoulder press, it is very likely that you will 'hold back' as you come to the end point of the press, simply because you won't be able to follow through as you would when throwing or pushing an object. With a Powerbag, you can safely condition this explosive, speedy response because you can throw it. The bag can even be caught by a partner and thrown back to develop upper body plyometric power in another way.

For further information on the Powerbag, e-mail mail@performt.com or go to www.performt.com

2. Speedballs

Allan Wells was a great advocate of the 'boxer's' speedball, believing that it enhanced his upper body speed and power. There is no doubt that it would have conditioned such a response (Wells being no slouch) but the drawback was that the firing pattern of the muscles of the upper arms and chest were developed in an opposite direction to that required for the sprinting action. However, the speedball does have its merits

as a pre-conditioner and neuromuscular 'sharpener' – and it's great to work out with to the theme from Rocky!
Speedballs can be obtained from specific fitness retailers.

3. Foot-flexor devices
Foot-Flexor devices aim to secure the foot in a dorsiflexed position during sprint training and are attached around the sprint shoe to the ankle. The theory behind this form of sports bondage is that it encourages sprinters to run with their toes up rather than down, which contradicts the older coaching wisdom that sprinters should run high on their toes.

Proponents of dorsiflexed sprinting believe that it maximises force return from the running surface, thus enhancing forward locomotion. A toe-down position is seen to 'break' the sprinting motion because the lower limbs will yield as the feet strike the ground, no matter how strong the athlete's calf muscles.

The devices themselves may be somewhat overrated, but the dorsiflexed foot position is not; you really do get a feeling of greater power return from the track while running toes up, and the foot has to be 'coming back toward you' to optimise push off. However, concentrated toes-up sprinting needs to be gradually introduced into an athlete's training programme to avoid injury.
Foot-Flexor devices are available through SportDimensions (see above).

If speed is your goal why not try out some of the above-mentioned training methods and systems. You could even come to deserve your own great speed related nickname!

John Shepherd

References

1. *Ferley D, Getting up to Speed with Acceleration, unpublished paper on Frappier system, 1998*
2. *Swanson SC (1998) Master's Thesis: muscular coordination during decline sprint training, University of Massachusettes, USA*

WHAT THE SCIENTISTS SAY

Reports on recent conditioning-related studies by Isabel Walker and Raphael Brandon

Eccentric moves recruit most fast twitch fibres

A new piece of research has investigated the differences in activation patterns between concentric and eccentric quadriceps contractions. In particular, the researchers were concerned with measuring the amount of muscle activity as revealed by electromyography (EMG) and the mean frequency of the EMG signal.

As a rule, the larger the EMG signal recorded the more muscle fibres are being recruited, while the frequency of the signal is an indication of how fast they are being recruited. Research has shown that higher frequency EMG is consistent with greater fast twitch fibre recruitment.

Concentric contraction involves force created when the muscle fibres shorten, while eccentric contraction involves force created when they lengthen. For example, when you land on two feet from a jump and bend your knees, the quadriceps are lengthening but also creating a force to control the landing. As you spring back from the landing, extending your knees and jumping back up in the air, the quadriceps are shortening as they create force to push you off.

In this experiment, the subjects performed maximal concentric and eccentric contractions of the quadriceps, while the researchers measured the EMG activity and frequency of signals. They found that the total EMG signal was greater during the concentric phase – suggesting more muscle fibres are active at this time – while the mean frequency of the EMG signal was greater during the eccentric phase – suggesting more fast twitch fibres are being recruited at this time.

They concluded that during a maximal eccentric contraction there is less total muscle fibre recruitment, with fast twitch fibres recruited in preference to slow twitch ones, whereas during a maximal concentric contraction all the muscles fibres are used.

This finding is significant for power athletes: if you want to train your fast twitch fibres it would seem that eccentric contraction movements are more useful than concentric ones.

Plyometric exercises, which involve high-force eccentric movements, would be particularly useful for this purpose. A good example is the depth jump, which involves jumping off a box, bending at the knee and hip to control the landing softly, then jumping back up. The landing phase is the eccentric contraction – and the bigger the depth jump, the greater the eccentric forces.

Power athletes may also want to consider performing strength exercises using the eccentric phase only. By this means you may be able to target just the fast twitch fibres and perform less total work, potentially making the training more efficient. You will need a training partner or coach to assist you with each concentric phase, leaving you to complete the effort on each eccentric phase alone.

Journal of Sports Sciences, 20(2), p83-91

Raphael Brandon

ATP is no creatine

The search for the 'new creatine' continues – but ATP seems unlikely to fit the bill if the results of a new US study are anything to go by. ATP (adenosine 5-triphosphate), found in every human cell, is the body's universal energy donor. It also plays a key role in a number of other biological processes, including neurotransmission, muscle contraction, cardiac and circulatory function and liver glycogen metabolism.

So it is not too far-fetched to assume that supplementary ATP might offer some useful ergogenic benefits for athletes, particularly enhanced anaerobic capacity and muscular strength.

That was the theory these researchers set out to test with a study of 27 healthy men, randomly split into three equal groups receiving one of the following oral supplements for 14 days:

- Low-dose ATP (150mg);
- High-dose ATP (225mg);
- Placebo.

Because supplementary ATP is not easily absorbed by the body, the supplements were coated in a methylcellulose 'shell' designed to protect the molecule during its passage through the gut.

Anaerobic power (via the Wingate cycle ergometer test), muscle strength (via the bench press) and total blood ATP concentrations were measured under three conditions:

1. Baseline (before the supplementation regime began);
2. Acutely (seven days later, before and 75 minutes after ingestion of the first dose);
3. Post (after 14 days of daily ingestion).

Statistical analysis of all the data showed no significant effects of supplementation on blood ATP concentrations or anaerobic power either between or within groups. However, some improvements in measures of muscle strength were observed after treatment in the high-dose ATP group, although the researchers acknowledge that these effects were small and quite possibly spurious.

Interestingly, people in the high-dose group (who were, of course, blinded to which supplement they were receiving) reported feeling better during treatment. This improvement in sensation is physiologically plausible, the researchers point out, as 'ATP and associate nucleotides have been shown to affect brain levels and release of noradrenaline, glutamine and serotonin and hence modulate mood and other responses…'

Nevertheless, they question the practical usefulness of the small improvements they observed and conclude that further research is needed before ATP supplementation can be recommended as an ergogenic aid.

Med Sci Sports Exerc, vol 36, no 6, pp 983-990

Isabel Walker

Notes

Notes

Notes