ACHILLES TENDINITIS

prevention & treatment

A SPECIAL REPORT FROM

PEAK PERFORMANCE

The research newsletter on stamina, strength and fitness

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From the publisher

Many athletes may not know precisely what the Achilles tendon is, apart from being a stretchy bit of tissue between the ankle and the heel, but they will certainly be aware of the agonies of Achilles tendinitis. It is a condition that can wreck your training and utterly destroy your performance results. The purpose of this special report is to explain what the Achilles actually does, describe how it works and how it can be injured, and prescribe exercises and treatments that can prevent it being hurt and quickly bring it back to normal.

The report has been prepared by the *Peak Performance* team of experts, physiologists, fitness specialists and sports doctors, and is designed to tell you everything you need to know about the care and feeding of the Achilles tendon. It contains, among its abundance of practical advice, a number of strange and unexpected facts such as, for instance, that the length of your Achilles tendons may be a crucial factor and by stretching them you may actually improve your performance!

Strong ankles are one of the key factors in preventing Achilles tendinitis, and this special report has a definitive article on how to strengthen them and also prevent that bane of an athlete's life, ankle sprains. Finally, the report has an extra bonus: a guide to recovering from knee injuries.

I hope you enjoy this special report and find it useful.

Jonathan A Pye
Publisher

We look at the causes of Achilles tendinitis, and outline an exercise strategy that will make your Achilles as strong as spun steel

Achilles tendinitis is a very common injury, particularly in runners. Statistics show that it is one of the most common of all overuse running injuries, accounting for about one in 10 of all running injuries.

This article will review a definitive piece of research into the causes of Achilles tendinitis and then go on to discuss the biomechanics of running and the forces that the Achilles tendon has to cope with. The article will then prescribe exercises that will help prevent and/or rehabilitate the injury. These exercises will match the movements and forces involved in running in order to develop Achilles tendons that have the strength to cope without strain.

Was it excessive pronation?

A team of researchers, led by Jean McCrory at Wake Forest University, North Carolina in 2000, designed an experimental study to examine the causes of Achilles tendinitis. This study is important because it was one of the first to investigate the causes of Achilles tendinitis by analysing two groups of runners, one suffering from Achilles tendinitis and a control group with no problems. Previously, the causes of Achilles tendinitis had been surmised through survey questionnaires or from expert opinion.

Based on these studies and opinions, explanations of what causes Achilles tendinitis revolved around the concept of excessive pronation – ie, too much inward rotation of the rear foot during the stance phase of the running cycle. This pronation may bow or twist the tendon (more on this later). The hypothesis is that thousands of repeated foot strikes involving excess pronation can cause damage to the Achilles. The practical application of this theory has been to prescribe orthotics which are inserted into the running shoe to control the level of rear foot motion.

'The hypothesis is that thousands of repeated foot strikes involving excess pronation can cause damage to the Achilles'

...or repeated eccentric contractions?

Another theory about the cause of the injury is that the tendon is unable to cope with the repeated eccentric contractions which the calf muscles must perform as the foot makes contact with the ground. If the calf muscles did not contract eccentrically, ie, produce tension as the muscle lengthens, while the foot falls onto the ground and the knee rolls forwards, the ankle would collapse (again, more on this later.) Eccentric contractions produce forces which, when repeated, may cause excessive stress on the tendon. The practical application of this theory has been to prescribe calf muscle strengthening exercises, usually the toe-raise exercise.

McCrory's experiment

McCrory and her team's purpose was to investigate all possible biomechanical factors and activity patterns in runners with persistent Achilles problems and compare the results with a similar group of runners who had no injury problems. In this way, any differences in either biomechanics or activity between the groups can be considered a causal factor to the injury. For example, if the injured runners ran on grass most of the time and the non-injured runners ran on roads most of the time, then running on grass can be seen as a potential cause of the injury.

The runners who took part in the study had been in training for at least one year, averaging a minimum of 10 miles per week

of running training. 31 runners were diagnosed by a specialist as suffering Achilles tendinitis. These made up the Achilles tendinitis group (AT). 58 runners with no history of overuse injury which prevented them from running made up the control group (C).

All the runners completed a questionnaire which provided data on running history, training miles, training pace, years running, surfaces, shoes and stretching habits. The purpose of the questionnaire was to discover if training or behavioural factors had any effect on injury incidence.

Q angle and Arch Index

Next all the runners had their 'anthropometric' measurements recorded. These are measurements of body height, weight and details of leg anatomy that are relevant to running. The first measurement was Q angle, which is the angle between the line of the hip to the patella and the line of the shin to the patella. The greater the Q angle, the more inwardly the knee points in from the hip. A greater Q angle is related to internal rotation of the knee and pronation during running. Secondly, an 'Arch Index' was calculated as the ratio of the length of the medial arch compared to the length of the whole foot. Arch Index is also related to pronation during running. Finally, the flexibility of the ankle joint was evaluated by measuring the degree of motion either side of the neutral ankle position, which is when the ankle is at 90^{o}. Again, ankle flexibility has been related to pronation in running, specifically if the calf muscles are tight, ie there is not enough dorsiflexion, so the foot has to pronate more during running to compensate for this lack of motion.

Strength...

The runners were then tested for strength. This involved tests of maximum strength and strength endurance on a isokinetic dynamometer. Isokinetic testing machines measure the amount of force produced at a fixed speed throughout the range of motion. In this study, the runners performed tests for ankle plantar flexion and ankle dorsiflexion.

...rear foot motion...

The runners' rear foot motion during running was analysed using a video camera. To do this, the researchers placed markers on the back of the shoe and up the back of the calf. Subjects then ran at their normal training pace and the foot strike was recorded. The video image was digitised so that the researchers could determine various parameters, such as foot angle at contact, maximum pronation angle and time to maximum pronation.

...and the stance phase

The final analysis performed on the runners was a measurement of the forces involved during the stance phase of the running cycle. The researchers had the subjects running at their normal training pace down a runway which contained a force platform. The force platform measured the ground reaction forces (in three directions – vertical, horizontal and lateral) of the foot contact with the ground.

So what did McCrory and her team find out?

The whole purpose of this experiment was to identify differences between the AT group runners and C group runners. The following is a summary of the key differences found.

In terms of training behaviours, C group ran fewer kilometres per week (44.5 versus 54.1 km). C group also had run for fewer total years and was slightly younger (9.6 versus 11.9 years running and 34.5 versus 38.4 years old). The training pace of the AT group was faster than the C group (4.6 min/km versus 4.9 min/km).

C group stretched more frequently than AT group, but the majority of C group did not stretch regularly, so this difference is considered inconclusive. The surfaces runners trained on was similar, except C group did more on-road and AT group more on off-road track. This is probably a result of AT runners wanting to avoid roads, rather than the off-roads being a causal factor.

The Arch Index of the two groups of runners was significantly different (Group C = 0.25 and Group AT = 0.23). This means AT group had a slightly higher arch, but both groups had Arch Index within the normal range.

The major findings

The first major finding was that C group were stronger than AT group. C group had larger force levels of dorsiflexion peak torque at 600 per second, and higher force levels of plantar flexion at 1800 per second. There were no differences in strength between the injured and non-injured legs in the AT group.

The second set of major findings were the differences in rear foot motion between the groups of runners. First, at initial contact the AT group rear foot is supinated more than the C group. The maximum degree of pronation is also greater for the AT group, as is the velocity of pronation. This means the AT group's rear foot goes through a greater range of motion – from a supinated position to a pronated position – and faster than the C group.

There were no differences in the forces between the two groups of runners when the foot was in contact with the ground.

'If a runner completes more miles per week, has been running for a longer period of time and runs at a faster average pace, then obviously the risk of suffering an overuse injury such as Achilles tendinitis will be increased'

What do these findings mean?

McCrory and her colleagues identified some differences in training behaviours between AT and C groups; number of years of running, training pace and weekly mileage were all greater for the injured running group compared to the non-injured group. Logically this stands to reason. Achilles tendinitis is an 'overuse' injury which is defined as stress caused by an accumulation of forces. If a runner completes more miles per week, has been running for a longer period of time and runs at a faster average pace, then obviously the risk of suffering an overuse injury such as Achilles tendinitis will be increased. This research supports the idea that 'older' runners (in running years not necessarily age) are more likely to suffer.

One could argue that novice runners could also be at greater

risk of suffering injuries such as Achilles tendinitis because they are not used to the forces involved in running and need to build up gradually to develop the strength necessary to cope with regular training.

The conclusion from this is that a moderately experienced runner who avoids excessive mileage will be the least likely to suffer from Achilles tendinitis. This conclusion agrees with the majority of previous research into running injuries.

Ankle muscle strength is important

As already noted, one of the major differences found between the groups of runners was in strength. Both dorsiflexion and plantar flexion peak force were lower in the AT group. This means the calf muscles (plantar flexors) and anterior tibialis (dorsiflexor) were weaker. Interestingly, both injured and non-injured legs had similar peak force in the AT group. This suggests that it is not the injury that caused the weakness but the reduced strength present before the injury occurred. This would appear to be very convincing evidence that ankle muscle strength is important for reducing Achilles tendinitis injury risks.

Last, but not least, pronation

Finally, the AT group of runners had a greater range of pronation of the rear foot during the foot-strike with the ground. Specifically, the foot had a greater supination angle as the foot made impact and then turned over and inwards to a greater maximum pronation position. The velocity of this pronation was also greater for the AT group.

The consequence of this greater range and speed of the pronation movement is that the Achilles tendon itself incurs a greater force as the foot contacts the ground. As the rear foot turns inwards – pronates – the Achilles will bow. The greater this bowing force, due to the increased pronation angle and pronation velocity, the greater the strain on the Achilles, increasing the risk of stress and injury.

In summary, McCrory's research found that after looking at

a whole host of factors, *a greater degree of rear-foot pronation* and *reduced ankle-muscle strength* were strongly associated with Achilles tendinitis. This supports previous research and expert opinion. The practical application of these findings is that runners need to develop sufficient strength in the ankle muscles and use specific conditioning and running technique exercises to control excessive pronation of the rear foot.

The best exercises to follow

If runners need to develop their ankle strength and improve their running action (to control excess pronation to prevent or rehabilitate Achilles tendinitis), then what are the best exercises to do this? Many experts and practitioners dealing with injuries will have different opinions on this. I have put together a variety of exercises that I believe will be beneficial. The aim of this selection of exercises is to develop sufficient and specific strength in the ankle muscles that are immediately related to Achilles tendinitis, and also the rest of the leg and the pelvis, to promote a good efficient running style.

Before I describe the exercises, it would be useful to analyse the biomechanics of running. This will show exactly how and when the muscles work during running. The purpose of the exercises is to strengthen the leg muscles in a similar manner to the way they work during running. In the usual *Peak Performance* style, I will advocate 'Functional' or 'Specific' exercises for optimum benefits.

First, a sideways glance at biomechanics

Running biomechanics involve each leg following an alternate stance – swing cycle. Let's first look at this from the side view point, which sports scientists call the 'sagital plane'. At the beginning of the stance phase, when the foot first makes ground contact, let's call it 'foot-down', the knee and hip are slightly flexed. The knee is usually flexed about 10° and the hip is usually flexed about 25°. At foot-down, the ankle is usually at its neutral position, which is 90°. The part of the foot that actually contacts the ground first can vary among runners

between heel and fore foot.

The stance phase can be split into distinct parts, the cushioning phase and the push-off phase. During the cushioning phase, the joints are flexing and most leg muscles are working to absorb the impact with the ground and stabilise the body position. During the push-off phase the joints become rigid or extend and certain muscles contract to propel the body forward.

At the beginning of the cushioning phase the knee joint flexes rapidly, from 10˚at foot down to a maximum of around 40˚of flexion. The ankle joint plantar flexes a little at foot down, but as the knee flexes and the tibia moves forward over the foot the ankle quickly dorsiflexes. The amount of dorsiflexion is about 20˚, making a minimum ankle angle of 70˚at the end of the cushioning phase.

On to 'toe off'

Once the maximum flexion of the knee and ankle has occurred, the push-off phase begins and the ankle, knee and hip all begin to extend. This extension should occur in a coordinated pattern. Thus at the end of the push-off phase, let's call this 'toe-off', the knee has re-extended to a flexion angle of 10˚, the hip extends behind the body line into 30˚of extension. The ankle also extends with the knee and hip and goes back through the neutral 90˚ankle position to 20˚of plantar flexion at toe-off.

During swing, the knee flexes again and then the knee swings through as the hip flexes forward. After toe-off, the ankle returns to its neutral 90˚angle as it swings through, ready for the following foot strike.

It is important, as you will discover below, to consider as well the lateral and rotational movements of hip, knee and ankle that occur during running. These are intrinsically related to the extension and flexion movements of the ankle, knee and hip described above.

Now the rear view

Let's look at the rear view of the running biomechanics. At foot

down the foot is inverted, which means the top of the foot is facing outwards. This is known as a supinated position. Through the cushioning phase, as the ankle and knee flex, the foot pronates. This pronation movement is an essential part of the shock-absorption process, with the foot being flexible as it rolls in to attenuate the impact with the ground. It is important to understand that a normal degree of pronation of the foot is not bad, but is in fact part of the running mechanic. As the ankle, knee and hip extend, in the push-off phase, the foot viewed from the rear starts to invert once more, and should become rigid to allow for a strong toe-off propulsion.

'This pronation movement is an essential part of the shock-absorption process, with the foot being flexible as it rolls in to attenuate the impact with the ground'

The body is supported on one leg

At foot-down the hip, when looking from the rear, is level or the swing-leg-side hip is slightly higher. During the cushioning phase, as the knee and ankle flex, the swing side hip will drop slightly, around 10°. This drop is a result of the impact with the ground and the weight of the body being supported on one leg. During the push-off phase the hips become level again.

The knee at foot-down, when looking from the front, is rotated outwards slightly. This rotation comes from the hip. As the knee and ankle flex, the swing-leg-hip drops slightly and the rear foot pronates during the cushioning phase, and the knee will also rotate inwards. This inward rotation of the knee is strongly associated with foot pronation movement. During the push-off phase, as the ankle, knee and hip extend, the rear foot inverts and returns to a supinated position, hips become level, and the knee will rotate outwards again.

A weak link in the chain?

What you should understand from this description is that the running mechanic involves a coordinated set of joint movements. These joints work together, cushion the impact and then propel the body forward during the stance phase. If this chain of coordinated joint movements has a weak link, then other parts of the chain have to compensate and excess stress can occur. This is how inefficient biomechanics can cause injury.

Let's look at the muscle activity that occurs during the running mechanic to discover how and when the muscles are working to produce this complex chain of joint movements.

The exact opposite

What is fascinating about the nature of leg muscle activity during running is that what occurs is quite the opposite of what you might expect to happen. For example, you may think that the quadriceps – as the most powerful muscles in the leg – will contract to extend the knee in the push-off phase. Actually, the quadriceps are not active during the push-off phase. This is also true of the gluteus maximus and the gastrocnemius and soleus muscles. During running, the muscles that extend the hip, knee and ankle are not active during the push-off phase. You may be forgiven for thinking this is a little strange. So what exactly *is* going on?

In the last part of the swing phase, just before foot-down, the gastrocnemius, soleus, anterior tibialis, quadriceps, hamstrings, gluteus maximus, hip abductors and adductors are all active. The fact that all these muscles are switched on at this time is to prepare the body for impact with the ground. The muscles act to provide a stiffness to the joints in order to control the landing.

Why the knee and ankle don't collapse

During the cushioning phase the quadriceps, gastrocnemius and soleus are all active. In fact, this is when the peak activity of these muscles occurs. At this time the quads, gastroc and soleus are contracting eccentrically. As the knee flexes and ankle dorsiflexes, these muscles produce tension to control this flexion while they are lengthening.

If these muscles were not eccentrically contracting, then the knee and ankle would collapse at foot-down, instead of the controlled cushioning phase that occurs. The gluteus maximus and hip abductors are also active during the cushioning phase. They also act eccentrically, to control the movement of the hip. The gluteus maximus helps the body to maintain an upright posture and the abductors prevent

the swing-leg-side of the hip from dropping laterally, as we discussed above. The hamstrings and anterior tibialis are also active during the cushioning phase. The hamstrings assist the quads with a co-contraction to maintain a joint stiffness in the knee. The anterior tibialis also contracts eccentrically to control the pronation movement of the rear foot. As with the ankle and knee joints, if the anterior tibialis did not contract, then the rear foot would collapse inwards at foot-down.

The main function of the leg muscles during the cushioning phase is to control the impact with the ground and to absorb forces, allowing the knee and ankle to flex, the rear foot to pronate and maintain a stable hip. At this time the leg muscles contract eccentrically.

What happens in the push-off phase

During the push-off phase, the activity of most of the leg muscles reduces and even switches off completely. Only the hamstrings and adductors are active at this time. This means that the hamstrings and adductors are providing a hip extension forward propulsion force, but the other muscles are inactive. The extension of the knee, ankle and inversion of the rear foot during the push-off phase occur as a result of the elastic component in the muscles and tendons.

The energy stored when the muscles contract eccentrically, as they lengthen when the joints flex, is returned through the elastic properties of the muscles and tendons. This energy is returned for free! By that I mean it does not require a contraction of the quadriceps or calf muscles to extend the knee or ankle. In terms of the ankle extension during the push-off phase, it is the Achilles tendon that will provide this energy return.

Contrary to what you may have thought about running muscles, the energy from the push comes from the tendons and not from active contractions of the muscles. The muscles mostly act with eccentric contractions during the cushioning phase to control the impact with the ground.

How biomechanical problems can affect the Achillles

I have described the biomechanics of running in terms of the coordination of the joints and the type and timings of muscle activity. So what can go wrong and cause an injury such as Achilles tendinitis? Why is it that McCrory and her team found that reduced ankle muscle strength and excess pronation are strongly associated with the injury?

We have seen how the coordination of the chain of joint movements is crucial to the running mechanic. The timing of the cushioning phase movements must be in sync as must the timing of the push-off phase. One of the problems caused by excess pronation is that the rear foot can move too far into a pronated position. This can be exacerbated by the fact that the foot structure is too cushioning and is unable to become rigid and return to the supinated position for toe off. If this happens, then during the push-off phase, the knee is extending and rotating outwards, which imparts an external rotation force on the tibia, but the rear foot remains pronated keeping the foot inwards and imparting an internal rotation force on the tibia. The net result is a twisting in the lower leg and the Achilles tendon. This twisting force can cause stress on the Achilles, resulting in injury.

Excessive whipping of the Achilles

Insufficient strength of the gastrocnemius, soleus and anterior tibialis, and specifically insufficient eccentric strength, will result in poor control of the dorsiflexion and pronation during the foot-down and cushioning phases of running. If these movements are not controlled, particularly the velocity of pronation, then this can cause an excessive whipping of the Achilles tendon as the foot strikes the ground and the knee rolls forward over the foot, which may result in injury. McCrory found both that the velocity of pronation was greater in the AT group of runners and that they also had reduced dorsi and plantar flexion strength. The two factors are most likely related.

Even the hip comes into it

The hip may also cause problems for the lower leg and Achilles tendon. If the gluteus maximus and hip abductors do not control the hip sufficiently during the cushioning phase, then the hip may drop laterally on the swing-leg-side, or the pelvis could tilt backwards. Either of these would result in a greater inward rotation force on the knee which would have the knock-on effect of causing a greater inward rotation of the tibia, which in turn inwardly rotates the ankle, thus increasing the degree or velocity of pronation. This is a perfect example of how the whole leg chain is dependent on all the links working correctly. If one area, such as the hip, does not perform its correct function, then other areas are adversely affected.

Beneficial exercises for the Achilles

McCrory's research shows that weak ankle strength is related to Achilles tendinitis (and there is more on strengthening the ankle later in this special report). The above discussion of the mechanics of running shows that eccentric strength of the gastrocnemius, soleus and anterior tibialis are also important. The following exercises target the eccentric strength of these muscles in a manner that is functionally related to running.

'If one area, such as the hip, does not perform its correct function, then other areas are adversely affected'

Ankle to toe walks

Stand up with good posture. Walk with straight knees, using the ankle only. Start by pulling the toes up as far as you can (dorsiflex the ankle). Softly place the heel on the floor and then actively control the foot as it rolls onto the floor. Use the anterior tibialis – the muscles at the front of the shin – to achieve this. If you have trouble controlling this movement, then it is a sign your anterior tibilias is not strong enough.

Then, as your weight rolls forward, actively push up onto your toes and lift your foot. Repeat on the other side and continue walking for 20 steps each foot.
Repeat for 3 sets.

Heel walks

Stand up with good posture. Walk with straight knees on your heels only. Pull your toes up, using your anterior tibialis, and keep them pulled up as far as you can while you walk.
Do 3 sets of 20 steps each leg.

Heel drop and calf raise

Stand on two legs with good posture. Bend your knees slightly, so they are the same angle as at foot down during running. Stand up on your toes. You may hold on to something for balance if you wish. Start by allowing your weight to drop down, letting your heel fall quickly to the floor. Then, just before your heels touch down, control the movement and immediately push back up on to your toes.

This exercise may take a little getting used to, but it is the perfect non-impact way of developing the eccentric control of the calf muscles. Hopping exercises can be too stressful for the injured runner, and so this exercise is a safe and effective alternative.

The important technical point is to let your heels drop and then very rapidly control the movement. This exercise should be performed fast. Just like the foot strike in running.

One-leg knee bends

Stand on one leg, with good posture. It is important that you actively use your gluteals to ensure the pelvis is level and the lower back stable. This will help train the hip muscles to stabilise during the stance phase of running.

In a controlled manner, allow the knee to bend, rolling it forwards over the foot. Use the quadriceps and calf muscles to slowly perform this movement. Let your knee extend and stand straight. Then repeat the movement but this time allow the knee to rotate inwards as it bends and the foot will pronate. Again ensure this movement is controlled. Both movements count as one repetition.

In this way you are stretching the Achilles tendon and working the calves and quads in a similar fashion to the way they

work during running.
Perform 3 sets of 10 repetitions on each leg.

Dynamic one-leg knee bends

Exactly the same as above, but this time perform the exercise as quickly as you can. Once you can control the above movement perfectly, start to speed up the exercise to stress the eccentric strength of the calf more. You will need to make this progression to allow your Achilles tendon to cope with the higher forces involved in running.

The faster movement also challenges your balance and the stability of your hip muscles further, which is an advantage.
Again, perform 3 sets of 10 reps.

Dynamic ankle jogging

Do not perform this exercise until your Achilles injury is healed as it may aggravate a weak Achilles.

This exercise involves jogging with straight knees using the ankles only. This means you must actively and vigorously pull the toes up when the foot is off the ground and rapidly extend the ankle, pushing into the ground during contact. Keeping the knees straight focuses all the effort on to your ankle muscles and really works the Achilles tendon. The more you pull the toes up prior to foot-down, the more you will dynamically stretch and strengthen the Achilles with this exercise. Aim for a ball-of-the-foot contact with this exercise. You know you are doing it well when you see a big movement of the ankle and you hear a positive sound when the foot hits the ground.

Raphael Brandon

Here's a further look at Achilles tendinitis, this time from a surgeon's point of view

'Achilles tendinitis' is a loose term which in the clinical setting is used to describe the pain, swelling and tenderness usually experienced in the relatively hypovascular area (an area with poor blood supply) 2cm to 6cm above the insertion of the tendon into the calcaneus (heel bone).

The terminology in Achilles tendon injuries can be confusing and perhaps all overuse injuries arising in tendons should be termed 'tendinopathies' rather than 'tendinitis' which suggests that the fundamental problem is inflammatory.

It is believed that two-thirds of Achilles tendon injuries in competitive athletes are incidents of paratenonitis (inflammation of the paratenon only) and one-fifth are insertional complaints (bursitis and insertional tendinitis). The remaining afflictions consist of pain syndromes of the myotendinous junction and tendinopathies[1].

When the term 'tendinitis' is used in a clinical context, it does not refer to a specific histopathological entity but rather to a group of conditions that are truly 'tendinoses' (tendon degeneration without associated inflammation). This may lead athletes and their coaches to underestimate the chronic nature of the condition[2].

Aetiology

The aetiology remains unclear. Excessive repetitive overload of the Achilles tendon is regarded as the primary stimulus which

results in tendinopathy. In one study, however, 31% of 58 patients with tendinopathies did not participate in vigorous physical exercise[3].

'It is most commonly seen in male recreational runners aged between 35 and 45 and although believed to be due to overuse, is again also seen in patients with sedentary lifestyles'

Believed causes of acute Achilles tendinitis include:
(a) inflexibility of the Achilles tendon
(b) insufficient gastrosoleus strength or flexibility
(c) functional over-pronation, producing a whipping action on the Achilles tendon as the heel goes from varus on heel strike to valgus in midstance[4]
(d) number of years running, training pace, stretching habits[5]
(e) recent change in shoe wear and poor running shoes
(f) recent increase in training, especially if it includes hill running
(g) eccentric loading of a fatigued muscle-tendon unit from overtraining or running on uneven terrain

Chronic Achilles tendinosis is a condition of unknown aetiology. It is most commonly seen in male recreational runners aged between 35 and 45 and although believed to be due to overuse, is again also seen in patients with sedentary lifestyles. Pain is often, but not always, experienced when the Achilles tendon is loaded [6].

Features

The patient may admit to a history of a change in training habits, and complain of localised pain and tenderness over the distal Achilles tendon. The pain is most acute during the push-off phase of running or jumping. Runners experience pain at the beginning and at the end of a training session with a period of diminished discomfort in between [7].

On examination, there may be localised swelling, a tight Achilles tendon, and heel alignment may be abnormal.

The preferred investigations to confirm and evaluate Achilles tendinopathy are MRI and ultrasound. There is a significant overlap of MRI findings in symptomatic and asymptomatic Achilles tendons[8]. However, ultrasound –

undertaken by a specialist musculoskeletal radiologist – has been recently shown to provide information that accurately diagnoses clinical Achilles tendinopathy and may help to determine the biomechanical processes involved in the injury [9].

Treatment: non operative

In the acute phase the following non-operative measures are employed:

(a) relative rest (avoiding painful aggravating activities)
(b) ice
(c) non-steroidal anti-inflammatory analgesia (local gels and tablets)
(d) customised orthoses and heel lifts (12mm to 15mm) to alleviate overpronation caused by tibia varum or subtalar or fore-foot varus. Heel lifts are commonly used, especially in runners, with success in up to 75% (10) of cases
(e) stretching by pulling, holding and releasing the gastrocnemius-soleus complex using a wall, stair, or 20^{o} inclined board [11]
(f) cross-training
(g) cryotherapy for its analgesic effect
(h) therapeutic ultrasound may reduce swelling in the acute inflammatory phase

If symptoms are severe and unresponsive to the conservative measures above, a short period (to a maximum three weeks) of cast immobilisation may be necessary.

Patients with chronic problems are initially treated as for acute injuries although some researchers suggest that this may be time-consuming and unsatisfactory [12].

Treatment: operative

It has been generally accepted that if a patient has symptoms persisting for at least six months that interfere with work or athletics, and if he/she has been engaged in a defined physical therapy programme, then surgery may be offered.

The Achilles tendon should be explored, partial tears surgically debrided and remaining tissue repaired. Thickened paratenon should be incised or excised [13]. Any bony calcaneal prominence should be excised. Satisfactory results have been reported in approximately two-thirds of patients [14,15]. However, a recent study has critically reviewed the outcome of surgery for chronic Achilles tendinopathy stated in 26 publications [16]. It suggests that the study methods employed in these publications influenced the reported surgical outcome. The true result of surgery for Achilles tendinopathy is therefore unknown. Surgery must only be contemplated when the surgeon is satisfied that there is an absolute indication for it, and that all the appropriate non-operative measures have been attempted by the correct personnel.

It is not known whether open surgery induces revascularisation, denervation, or both, resulting in reduction of pain. Multiple percutaneous longitudinal tenotomies (keyhole partial cuts in the tendon in order to allow it to lengthen) can be performed instead of open procedures with comparable outcome [17]. This relatively simple procedure should be reserved for patients who have isolated tendinopathies less than 2.5cm long that have been confirmed by ultrasound and where the paratenon is not involved. Such tenotomies have recently been shown to increase the blood supply to the degenerated area in a rabbit model [18].

Rehabilitation post-surgery may be prolonged. It has been reported that six months of post-operative rehabilitation for chronic Achilles tendinitis is not enough to recover concentric and eccentric plantar flexion muscle strength compared with the non-injured side [19]. Furthermore, progressive calcaneal bone loss has been shown on the operated side one year after surgery [6].

Corticosteroid injections

The use of local corticosteroid injections for the treatment of Achilles tendinitis is controversial as many case reports have implicated them as the cause of subsequent Achilles tendon

rupture. The theory is that corticosteroid decreases the metabolic rate of chondrocytes and fibrocytes resulting in a weakening of the structural integrity of the tendon and articular cartilage. There are no published rigorous studies that evaluate the risk of rupture with or without corticosteroid injection, and the data published is insufficient to determine the comparative risks and benefits [10]. Taking all this information into account however, it is best to avoid the use of corticosteroid injections in the treatment of Achilles tendinitis.

The future

Promising short-term results from a prospective multi-centre study have been recently published[20]. Chronic Achilles tendinosis was shown to respond well to heavy load eccentric calf muscle training (significantly better than to concentric training), with 82% of patients satisfied and returning to their pre-injury activity level. Long-term results are needed to evaluate whether this will reduce the need for surgical intervention for tendinoses located in the mid-portion of the Achilles tendon.

'Although many of the molecular factors promoting tendon healing have been identified, delivering them to the damaged tendon is proving difficult'

The future may lie in molecular biology. Although many of the molecular factors promoting tendon healing have been identified, delivering them to the damaged tendon is proving difficult. The answer to this problem may lie in gene therapy whereby the transfer of growth factor genes into tenocytes may allow the continuous release of growth factors at the healing site. This has been successfully done in animal studies![21].

Alex Watson and Fares Haddad

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Achilles tendinitis is the curse of the running classes. If you suffer from it, these exercises should help prevent it happening again

Achilles tendinitis is a common injury for all athletes and fitness participants, especially those who run seriously as a sport or main fitness activity. The injury involves damage to the fibres on the Achilles tendon unit, often at the narrow point of the tendon just above the heel. This area is most at risk because it has a smaller blood supply than the rest of the tendon, and so is unable to repair itself as easily. The symptoms involve pain in the Achilles with motion (which will increase if exercise continues), tenderness to touch and often warmth and swelling in the area. Sufferers can also complain of stiffness and pain when getting up in the morning.

Achilles tendinitis is a chronic stress injury. Excessive forces cause damage to the tendon, where lots of little stresses accumulate to overload the Achilles. This is in contrast to an acute stress or accident-type injury, where a single large stress causes the damage, eg, an ankle ligament sprain.

Bad shoes can be a factor

There are a variety of reasons for repetitive excess stress. Incorrect shoes are a common cause, where the training shoe provides either insufficient support or insufficient cushioning. If an athlete suddenly develops tendinitis and he/she has been using the same shoes for a long time (over six months) or has

run many miles in those shoes (over 500), then it is quite likely that the training shoes have simply worn out. Replacing the shoes will probably solve the problem. It is also possible that if the onset of tendinitis symptoms coincides with a change in training shoes, then the new shoes are probably not suitable.

Training surfaces are also related to tendinitis injuries. Running on hard surfaces, such as roads, creates greater impact forces that will stress the tendon more. Alternatively, uneven surfaces will place greater shear forces on the tendon. Shear forces are applied sideways and tendons are less strong in this direction (which can also cause overloading). This is why treadmills are often very useful for athletes with injury problems, since they are smooth but have more give than roads.

'Running on hard surfaces, such as roads, creates greater impact forces that will stress the tendon more. Alternatively, uneven surfaces will place greater shear forces on the tendon'

Imitate the action of the tortoise

The amount of mileage an athlete completes each week is also strongly related to their risks of Achilles tendinitis. Quite simply, the more miles you run, the more stress is placed on the tendon. For example, an athlete may never be injured completing a moderate 20-30 miles a week schedule, but will suffer problems if attempting 40-50 miles a week. One of the most important training principles to avoid injury is 'gradual progression'. This means any increase in mileage or intensity of training must be slow and steady, otherwise injury risks are greatly heightened. A guideline of a 5-10% increase in mileage per week is a good rule of thumb. Adopting this measured approach allows the muscles and tendons time to increase their strength to cope with the extra stress. Many injuries are caused by athletes increasing volume or intensity too rapidly.

Pronation and weak calves

Individual biomechanical factors also affect the forces acting on the Achilles. For example, excessive pronation can contribute to tendinitis. Pronation is the inward movement of the rear-foot as you contact the ground during walking or running and is necessary to absorb the impact forces. However, too much pronation, or too fast a rate, can internally rotate the

lower leg excessively, which means the rearfoot does not achieve the optimum position during the pushing-off phase. To compensate for this less-efficient mechanical position, the muscles and tendons of the lower leg must work harder, and thus excessive stress can occur. For this reason, orthotics worn inside the running shoes to control the rear-foot motion can often help athletes who over-pronate.

Two other individual factors causing tendinitis can be lack of flexibility and lack of strength in the calf muscles. Tightness in the calf will lead to extra tension being placed on the Achilles tendon, during running and walking, especially up hills. Lack of strength may mean that the tendon will not be able to cope with the forces applied during movements. During running, the calf muscles are most active during the first half of the contact phase, when the muscles are absorbing the impact with the ground. At this point the calf muscles are working 'eccentrically' to control the forward motion of the lower leg. When a muscle works eccentrically, it is lengthening as it contracts. The faster this contraction, the greater the forces applied.

With this in mind, a strengthening programme for the calf muscles should focus on developing eccentric strength, using progressively faster speeds of movement to increase the forces that the calf can handle. This type of programme is 'functional', which means that it involves the same type of contraction of the calf muscles that occurs during running, and so should have greater benefits for injury prevention and rehabilitation.

Here's an exercise plan...

Harvey Wallmann (2000), an assistant professor of physical therapy at the University of Nevada, presents the following exercise plan to help athletes recover from Achilles tendinitis. It is based on the factors discussed above, specifically, development of flexibility and eccentric strength in the calf muscles in order to increase the tendon's ability to cope with forces. The stretching component of the programme is doubly important for athletes recovering from injury because, during the healing process, the direction of the collagen fibres that are

regenerated is dependent on the forces applied to the tendon. Gentle stress in the form of stretching will ensure the fibres are laid down in the correct alignment. Without this force during the healing process, the fibres are laid down randomly, which means that the tendon will not be as strong and the likelihood of the injury recurring is increased.

The rehabilitation process should take place after one or two weeks of rest, during which time the athlete is inactive, apart from some gentle calf stretching. After this rest period the tendon should have 'healed' and any pain and inflammation should have gone. This is the time to begin strengthening the tendon.

Follow this workout

The workout comprises the following, and should be performed every day:

1. warm-up
2. stretching
3. eccentric programme
4. stretching

The warm-up should involve 5-10 minutes of gentle CV exercise. Ideally, this should be non-weight-bearing, eg, cycling. The purpose of this is to warm up the muscles to prepare them for the stretching and strengthening exercise that follows.

The stretching involves static stretches for both the gastrocnemius and soleus muscles. To stretch the gastrocnemius, lean forward against a wall with one leg behind you. Keep the leg completely straight, the heel on the floor and the toes pointing forward. To stretch the soleus, lean against the wall with one leg behind you but slightly closer than before. Bend the knee slightly and place your weight on the front foot, keeping your heel on the floor and toes pointing forwards. Perform three lots of 30-second stretches on each side, holding a moderate stretch each time. These stretches must not be painful.

The eccentric programme involves the simple calf-raise exercise using only body weight. The progression comes from

increasing the load and speed of the eccentric phase of the movement, which is the heel-lowering phase. Each athlete must progress at his/her own speed, depending on the pain response to the workout. The last set of repetitions should feel hard but not painful. If the next day the workout feels the same or easier, then increase the difficulty the following day. Progress in this manner until you can reach the highest level outlined below, which may take from a few weeks to months, especially if you have suffered from Achilles tendinitis for a long time.

Level one

Perform a straight-legged heel raise with the uninjured leg. Place the ball of the injured leg down and lower slowly with both legs until heels reach the floor. The drop should last for four counts.

Repeat 10 times. Perform three sets with 30 seconds rest between sets.

Progress by increasing the lowering speed to a count of two, and then progress to a fast drop of one count. Once this is achieved, move on to performing a bent-legged heel raise, which will place an extra load on the soleus muscle. The knee should be bent 20-30 degrees. Again, start with a slow lowering phase and gradually speed up.

Level two

Perform a heel raise with both legs for lowering and raising phases. Perform three sets of 10 reps with 30 seconds rest. Progress by increasing speed and on to the bent-legged position as in level one.

Level three

Perform the heel raise with only the uninjured leg during the raising phase and then only with the injured leg during the lowering phase, thereby focusing the eccentric load on the injured side. Perform three sets of 10 reps with 30 seconds rest. Progress the speed of lowering and the bent-legged position as level one.

Level four

Perform the heel raise with both legs during the raising phase with with only the injured leg during the lowering phase. Perform three sets of 10 reps with 30 seconds rest. Progress as level one.

Level five

Perform the heel raise lowering and raising with only the injured side. Perform three sets of 10 reps with 30 seconds rest. Progress as level one.

'This five-level progressive eccentric workout is a suitable way to strengthen the calf muscle and the Achilles tendon after an injury'

This five-level progressive eccentric workout is a suitable way to strengthen the calf muscle and the Achilles tendon after an injury. In combination with the stretching exercises, the workout will improve the function of the calf muscles and help the athlete back to full fitness. Wallmann claims that both research and clinical experience support the use of the programme which I can back up anecdotally by the fact that one of my clients, who has suffered from Achilles tendinitis for years, is currently following the programme and making good progress.

Raphael Brandon

Weak ankles are a key factor in causing Achilles tendinitis. Here's a guide to making them strong and proof against sprains as well

Take any sport you choose – rugby, football, cricket, sprinting, whatever – and a sprained ankle will be the most common injury. Few athletes have escaped suffering from one at some time or other in their career.

Sprained ankles are 'double trouble': they can be extremely painful, and they often curtail training or competing at key times of the year. Worst of all, even after you've 'recovered' from an ankle sprain, your ankle is temporarily weaker than normal, and thus you're at a higher risk of sustaining another sprain – or even a more serious ankle injury. What should you do to re-build your ankle after a sprain?

Surprisingly enough, the answer is to use a balance board. Balance-board work can improve your overall coordination and thus take excessive strain off your ankles and help you move more efficiently. A balance board can also increase the active strength of the muscles in your ankles, as well as your feet and legs, dramatically lowering your risk of injury. In addition, balance-board routines can upgrade the mobility and flexibility of your ankles (as well as your feet, shins, and calves), further decreasing injury risk and leading to more powerful push-offs and longer strides whenever you move vigorously during your sporting activity. While you strengthen your ankles, you'll also give your performance a boost.

Not just ankle sprains

Best of all, balance-board routines are good for other injuries, too. Although balance boards are not especially popular among athletes, balance-board training has been used for decades by sports-medicine specialists to rehabilitate and treat a wide range of injuries to the foot, ankle, shin, calf, knee, hip and trunk. These injuries include (in addition to ankle sprains) Achilles tendinitis, Achilles-tendon ruptures (post-surgery), shin splints, calf strains, ACL tears and ruptures, hamstring maladies, and lower-back problems. Boards are also utilised frequently by patients who have undergone hip-replacement surgery, as well as by individuals who have gone under the knife to repair a troublesome back.

'Balance-board training has been used for decades by sports-medicine specialists to rehabilitate and treat a wide range of injuries to the foot, ankle, shin, calf, knee, hip and trunk'

Even though balance boards have historically been used primarily in a therapeutic setting, they have recently become more popular with serious athletes as a training tool. As balance boards have squeezed their way into the training arena, the line between balance-board rehabilitation therapy and balance-board training has become increasingly fuzzy, as therapists and coaches have begun to borrow techniques and methods from each other. Among athletes who use boards, the current thinking is: 'If they are good for rehabilitation from injury, they are probably good for prevention of injury, too, and thus might help me train more consistently'. Among physiotherapists and other sports-medicine specialists, the thought is: 'If athletes are using balance boards in certain ways, those techniques should also be good for patients who need to restore functional strength'.

For individuals who engage in a sport that requires a fair amount of running, a primary area of concern – from both an injury-prevention and training standpoint – would be the structures of the foot, ankle, and lower part of the leg (including the muscles, tendons, ligaments, bones, and cartilage in those areas). These structures are under constant stress during running and undergo considerable (and repeated) loading, even during short runs, with a force equal to two-and-a-half-to-three times one's body weight passing through the body parts

with each step. Athletes have become increasingly aware that they need to shore up the strength of the lower parts of their legs, and they are also beginning to realise that if they can strengthen and more effectively coordinate the actions of their feet, ankles, shins and calves, they will be able to develop more explosive and powerful push-offs and thus longer strides, leading to potential gains in performance.

Exercises with a balance board are especially effective at improving the strength, mobility, flexibility, and elasticity of the muscles, tendons and ligaments which run between the knees and toes. These structures include the intrinsic muscles of the feet, the plantar fasciae, the plantar and dorsiflexors of the ankle, and the Achilles tendons. All of these anatomical components help to stabilise and control the foot and lower part of the leg during the foot-strike portion of the gait cycle and, in particular, govern and coordinate 'pronation', the natural inward movement and rotation that occurs at the ankle immediately after the foot hits the ground. Balance-board exercises mimic what happens to the muscles, tendons, and ligaments of the feet, ankles, and lower legs during running – and thus fortify them for the stresses they must endure.

What kind of balance board is best?

Balance boards are made in two general configurations. The first type – the 'rocker board' – has a platform on which you stand and a rectangular strip of wood on the bottom of the platform. The strip on the bottom runs the entire length of the platform (12-16 inches) and is typically half to one inch wide and half an inch high. Instability – and thus an increased demand for coordinating force production by the muscles of the feet, ankles and legs – is created by placing this strip on the ground and standing on top of the platform. Obviously, the direction of instability can be varied from front-to-back or side-to-side, depending on how you position your foot relative to the wooden strip, but that is all you can do with a rocker board, and thus instability can really be created in just one plane of motion.

Rocker boards are most useful for beginning and

intermediate-level balance-board trainers. For best results, they should allow for 10 to 15º of motion (ie, incline/decline of the platform surface).

The second type of board – the 'wobble board' – has a wooden (or plastic) half-sphere on the bottom of the platform and thus provides instability in multiple planes of motion. Since the true motion of the ankle joint during the act of running can never be described as a simple flop forward or backward or a simple roll to the inside or outside (the only motions permitted by rocker boards), it's clear that wobble boards provide much more specific training for runners (ie, they mimic joint movements much more effectively) and are considerably more beneficial than rocker boards.

The half-sphere beneath a wobble-board platform can vary in size from a-half to two inches high. For two-footed wobble-board exercises, the feet are placed on opposite sides of the platform with the half-sphere in the middle. For exercises on one foot, the weight-bearing foot is placed in the centre of the platform, directly over the half-sphere. Wobble boards are most useful for intermediate and advanced balance-board trainers and should allow for 15 to 20º of motion (incline/decline of the platform surface) in all planes for best results.

'The prescribed exercises develop shin-muscle strength and resiliency – as well as overall ankle coordination'

Balance-board exercises

The exercises described below are great for improving your strength, coordination, and flexibility, but they are by no means the only exertions that can be carried out with a balance board. Ultimately, you can use your own creativity to design and implement additional practical and exciting exercises with the balance board.

Beginning Exercises (carried out on a wooden floor or very firm, carpeted surface using a square rocker board):

1. The two-leg stand and balance with instability from side to side

The rocker strip should run from front to back, parallel to the

direction of your feet, with one foot on each side of the strip. Simply hold your position for 30 seconds without letting the edges of the board touch the ground.

2. The two-leg stand and balance with instability from front to back

This time, the rocker strip runs from side to side, perpendicular to the direction of your feet. Complete the exercise by simply holding a balance position for 30 seconds, without touching the edges of the board to the ground.

Both of these exercises develop balance and coordination of the entire body – the feet, ankles, legs, hips, trunk, neck and head. They also enhance the so-called 'grip strength' of the feet and toes, which will allow for progression into more difficult balance-board exercises.

3. Side-to-side edge taps

Position the rocker board so that the rocker strip is running from front to back, parallel to your feet, which creates side-to-side instability. Then, slowly and deliberately touch or 'tap' the lateral edges of the platform to the ground (left edge, then right edge, left, right, etc) for about one minute. This range-of-motion and strength exercise should be done under full control, without rapid swings of the board from side to side.

4. Front-to-back edge taps

Position the rocker board so that the rocker strip underneath the platform is running from side to side, perpendicular to your feet, and then slowly and deliberately touch or 'tap' the front and back edges of the platform to the ground (front edge, then back edge, front, back, etc.) for approximately one minute. Once again, perform this exercise with smooth, rhythmic movements, without sudden jerks of the platform.

Both tapping exercises develop gripping strength in the feet and toes and augment the mobility and flexibility of the ankles and feet. Compared to the first two exercises, these tapping routines have a much more pronounced strengthening and

mobilising effect on both the plantar fasciae and Achilles tendons due to their dynamic (as opposed to static) nature.

Intermediate exercises

Using a square rocker board placed on a wooden floor or firm carpet, carry out the four exercises described above, but this time on only one foot at a time (first the left foot, then the right). Working on one foot at a time effectively doubles the work load of your muscles, magnifying strength development, and also makes the exercises much more specific to running.

'Working on one foot at a time effectively doubles the work load of your muscles, magnifying strength development, and also makes the exercises much more specific to running'

If these intermediate, one-footed exercises are initially too difficult for you to perform without losing your balance, simply place the toe of your opposite (non-weight bearing) foot on the ground six to 10 inches behind the balance board. This should allow you to perform the exercises more effectively as you make the transition to one-footed exertions.

Advanced exercises

For these routines, use a round wobble board on a wooden floor or firm, carpeted surface.

1. Side-to-side edge taps

Place one foot directly in the middle of the platform, and note that your board is unstable in all directions (planes). Slowly and deliberately touch or 'tap' the lateral edges of the platform to the ground (left edge, right edge, left, right, etc.) for about one minute. Maintain full control at all times, avoiding hasty motions of the balance board. If the exercise is too difficult at first, place the toes of your other foot on the ground behind the wobble board for better balance. Once the minute is up, repeat the exercise on the opposite foot.

2. Front-to-back edge taps

These are just like the side-to-side exercise, except that you are touching the front edge of the balance board to the floor, then the back edge, etc. Do it for a minute on your left foot and then for a minute on your right.

3. Edge circles

Place your left foot in the centre of the wobble board, and then slowly and deliberately touch the edge of the platform to the floor, rotating this 'edge touch' in a clockwise fashion so that an edge of the platform is in contact with the floor at all times. The actual motion must be very slow and controlled to gain full benefit from the exercise and should be performed for one minute without stopping. As before, place the opposite foot on the ground behind you, if a full one-leg balance proves too challenging. Once you have rotated for one minute on one foot, change to the other.

4. Counter-clockwise edge circles

These are the same as the edge circles, except that you are now rolling the edge along in a counter-clockwise direction.

These advanced balance-board exercises develop coordination, balance, strength, and mobility in the muscles of the feet, ankles, legs, hips, and trunk. They are part of a progression which began with the simple, single-plane exercises (the beginning and intermediate ones) and serve to specifically increase the functional strength and elasticity of the key muscles used during running. The advanced exercises require a high degree of body awareness, and as a result, they must be practised on a regular basis. Fortunately, they don't take so long to carry out; the advanced exercises, for example, can be completed in five minutes or less. Since the motor skills needed to do them will require repeated exposure for optimal development, it's best to do them at least four to five times a week.

Very advanced balance-board exercises

5. The one-leg squat with balance board

This unique exercise strongly develops the quadriceps and gluteals, with a complimentary boost to the hamstrings, as it upgrades strength and improves coordination in your feet,

ankles, shins, and calves. To complete one-leg squats in the correct way with a balance board, stand with your left foot forward, on the centre of the board, and your right leg and foot extended straight back, with your feet about one shin-length apart. To see if you have the right distance, try squatting down by flexing your left knee and lowering your trunk; as you do so, your right knee should be not far from your left heel. Your feet should be hip-width apart from side to side. Place the toes of the right foot on a block, aerobics platform, or small step which is approximately six inches high. Almost all your weight should be directed through the heel of the left foot, the one which is perched on the balance board. 'Bend' your left leg (ie, flex your left hip and left knee) and lower your body until your left knee reaches an angle of about 90^{o} between the thigh and lower leg. Return to the starting position, maintaining upright posture with the trunk and holding your hands at your sides. Complete about eight reps, and then shift over to the other leg. After a brief rest, complete eight more reps with each leg. As your coordination and strength improve over time, you may increase the number of reps and sets.

6. 'Running' on the balance board

Stand upright with your left foot in the centre of the balance board and your right foot off the ground and balance board; your right leg should be flexed at the knee, as though your right leg were swinging forward during the 'swing' phase of the gait cycle. Then, perform a 'posterior pelvic tilt' by tightening your buttocks, contracting your abdominals, and curling your pelvis 'under'. The posterior pelvic tilt is sometimes referred to as 'tucking your tail'; you can think of it as moving the bottom of your pelvic girdle forward and the top slightly backwards. Your head and neck should be in a neutral position and aligned with your upper body. Your arms should be relaxed but flexed at the elbows, as they would be during running. Maintain this basic position throughout the exercise.

Simply move your arms forward in an alternating pattern (first right, then left), returning your right arm to your side as

your left swings forward, and vice-versa. Both arms should be in constant motion, without pause, and the overall arm and shoulder action should simulate what happens to your arms and shoulders when you run (as you get more coordinated, you may exaggerate the arm swings, taking your arms through a broader range of motion than would be characteristic of running). Repeat the exercise continuously for 30 seconds, and then shift over to your other foot. Over time, you may increase the speed of arm movement, but stay under control at all times. It's also appropriate to progress to three sets of this exercise, instead of just one.

As an extension of this exercise, you may hold dumbbells at your sides with your palms facing in towards your body, and then alternately 'curl' each arm until the dumbbell is in front of your shoulder. The curling action should be rhythmic, and your arms should be moving at all times (raise the right arm at the same time that you are lowering the left arm and vice-versa). Maintain a stable posture throughout the exercise. At first, the dumbbells should be very light, but you can progress to weights which produce significant fatigue after about 15 reps. Use a cadence of one arm curl (up and down) about every two seconds, and start with two sets of 15 to 20 repetitions (resting momentarily between sets), before progressing to three or four sets as your strength and coordination improve.

The worst is yet to come!

7. Balance-board core torture

Lie down, stretching out in a prone position (with face and belly downward), with full body weight supported only by your forearms and toes. The catch is that your forearms should be resting on either side of the centre of the balance board!

In this position, your elbows should be almost directly below your shoulders. Your forearms are resting on the board, pointed straight ahead (parallel to the line made by your body). Your toes (and feet) are about shoulder-width apart, and your toes are the only part of your lower body which are in contact the

ground (your toes are not on a balance board, at least not yet!). Your whole body is supported only by your forearms and toes.

'Tuck' your pelvis, as you did with the running-on-the-balance-board exertion. This basically means rotating your pelvic girdle by pushing the lower part of your pelvic area toward the ground while the upper part of the pelvis rotates away from the ground. Your hip area doesn't actually come any closer to the ground (your whole body should be in a fairly straight line from your toes up to your shoulders).

A. Hold this basic position (body supported only on forearms and toes, pelvis tucked) for 15 seconds, and then lift your right leg off the ground and hold it there (roughly parallel with the ground) for 15 seconds (your body will now be supported by your two forearms on the balance board and the toes of your left foot, which are on the ground). Return to the starting position.

B. Next, lift your left leg in the air and hold it parallel with the ground for 15 seconds, before returning it to the starting position. Your body weight will be supported only by your forearms and the toes of your right foot.

C. Return to the basic starting position, hold it for 15 seconds, and take a one-minute break. Then, repeats steps A through C. However, once you've completed the second series, stay in the basic position, supported on forearms and toes only, for at least one more minute. Maintain an absolutely straight body posture for the entire period. Then, complete five to 10 'Chinese press-ups' (they're like regular press-ups, except instead of supporting your upper body with the palms of your hands, the support is provided by the forearms on the balance board). Try to keep your body fairly linear as you move your torso up and down, bringing your chest down close to the balance board and then back up to the basic position.

Now, flip over so that your back is facing the ground, and lift your body off the ground by supporting full body weight with

only the heels of your feet and your forearms on the balance board. Once again, try to keep your body in a fairly linear position, and remember to tuck your pelvis! Follow the same movement pattern outlined above (lifting first your left leg, and then the right), using roughly the same time periods. It's also fun to do more than just lift your appendages. For example, you can bring a knee toward your chest or swing your leg from side to side to increase the 'loading' and stress on your core muscles and shoulders.

The entire sequence outlined above can then be carried out with your toes on the balance board and your forearms on the floor. In this case, the toes of your feet would be positioned on either side of the centre of the board, and you would raise one arm at a time, rather than one leg. Obviously, the balance-board-core-torture activity does not mimic the posture or biomechanics of running, but it is devastatingly effective at improving your whole-body strength and coordination. You'll find it very challenging!

'Obviously, the balance-board-core-torture activity does not mimic the posture or biomechanics of running, but it is devastatingly effective at improving your whole-body strength and coordination. You'll find it very challenging!'

Final points

Here are six essential points about balance-board training:

(1) Before starting any of the balance-board routines, warm up for 10 minutes by performing light jogging, stretching, and range-of-motion activities for the trunk, low back, hips, quadriceps, hamstrings, calves, Achilles tendons, shins and feet. As you carry out the exercises, maintain an upright posture with your trunk at all times, and use smooth, controlled movements – not out-of-control jerks. Devote the first few weeks of your balance-board programme to developing coordination and technique; don't worry about racking up lots of reps. As your skill at carrying out the exercises improves over time, increase your movement speed, while maintaining balance and posture.

(2) Remember to perform all balance-board exercises when you are relatively free from fatigue. For optimal results, balance and coordination exercises require that the nervous system be fairly

well rested. Somewhat surprisingly, a fine time to do balance-board work is immediately prior to a speed workout, since the balance-board routines seem to 'wake up' the nervous system and prepare it for intense activity.

(3) Since the 'action position' for all athletic activities, including running, incorporates a certain amount of knee flexion, rather than straight legs, be sure to carry out all balance-board exercises with your knee(s) slightly flexed.

(4) At the very beginning of your balance-board training, if you are having trouble with coordination, you can stabilise yourself by placing the toes of the opposite (non-weight bearing) foot on the ground behind you during any single-leg exercises. However, do not use your hands for stabilisation, as this largely defeats the purpose of the balance-board activities.

(5) It's important to remember that you can increase the difficulty of any balance-board exercise by holding dumbbells in your hands – and by performing the exercises with your eyes closed. Closing your eyes removes visual cues and particularly enhances your kinaesthetic sense, ie, your ability to accurately judge the position of your body in space. This increased awareness can help you improve your coordination and efficiency of movement.

(6) Don't begin your balance-board routines until you have recovered from your sprained ankle (or other injury) and your doctor has given you his/her OK. Use the balance board frequently during training to lower the risk of future injury.

Walt Reynolds

Here's how to get an injured knee fully functional once more

The key to making a full recovery from any injury is not just correct treatment and healing but also re-strengthening and regaining coordination of the joint and all the movements it is involved with. Any injury requires a certain amount of time for treatment and healing, but, once this is complete, don't assume that you can start full training and competition immediately. If you are too hasty, the injury is more likely to reoccur.

To bridge the gap between the treatment bench and full competition, without risking another setback, you have to go through a planned and progressive rehabilitation training programme. The aims of this programme are:

(1) to strengthen the muscles involved in the injury to be just as strong as the unaffected side
(2) to regain full proprioception (joint position sense) in the injured joint
(3) to regain power and coordination of all sports-specific movements.

In terms of progression, the programme must start with low-intensity and low-volume work, gradually increasing so that you build up to the full intensity and volume required for full competition performance. This is quite difficult to do, since the training must be tough enough to have an effect but not so tough that the injury is aggravated. In addition, it is often difficult to remember that while the muscles respond quickly to strength loads, the tendons and ligaments take much longer

to gain in strength. This is why athletes must sometimes stick with training loads that feel easy so that the joint will be significantly tested.

In this article I will suggest a planned progressive rehabilitation programme for a knee-joint injury. I will assume that a successful healing period has already been completed, that most, if not all, mobility has been regained and that some basic strength work has been performed. This is the time that you may be tempted to go for it, but resist the temptation. Follow this programme instead and you'll find the results bear me out.

'In the first phase of rehab training, you must concentrate on functional strength exercises, balance training and regaining aerobic fitness'

Phase 1 (4-6 weeks)

In the first phase of rehab training, you must concentrate on functional strength exercises, balance training and regaining aerobic fitness.

The knee-strength exercises at this stage must be closed kinetic chain movements. A CKC exercise involves ankle, knee and hip joints, where all the muscles around the knee and involved in knee stabilisation are recruited, thereby ensuring the exercises are fully functional. It is generally agreed that much less benefit is gained from performing isolated quadriceps exercises since it is important that a hamstring and quadriceps co-contraction occurs during an exercise, so that the correct neuromuscular patterns are trained. For this reason, the squat exercise is chosen as the key knee-strength exercise because it seems to be one of the best knee exercises for hamstring/quadriceps co-contraction. In addition, the hamstrings are a priority for strength development because they play a crucial role in knee stabilisation, and the hip muscles must also be trained.

Strength training: two-to-three times a week with rest days between

Barbell squat. 2-3 x 8-10

The technique for this lift is: feet shoulder-width apart, barbell across back of the shoulders. Lower down until knee angle is at

90o. Keep your knees behind the toes. Start with a very light weight just to retrain the movement. Get someone to make sure that you weight each leg evenly. As the knee gets stronger, gradually increase the weight each week.

Terminal CKC knee extensions. 3 x 10

Take a strong piece of flexaband, make a loop and attach it around a table leg. Place the other side of the loop behind your injured knee (you may need some padding). Start with your support leg straight and your working leg slightly bent and up on the toe. Then pull back on the band, straightening your knee and flattening your heel down. You should feel the effort concentrated in the quads. Make sure your body is completely still. Re-flex your knee and ankle and continue.

Quarter one-legged squats. 3 x 10

This exercise is performed without any extra weight. Stand on one leg and bend the knee into a shallow squat position. Straighten up slowly and continue. This exercise is as much for balance as it is for strength. Keep the hips level and the knee behind the toes as you squat down. Use your stomach and glutes to ensure you maintain stability and balance. You may find the injured side is less coordinated at first; the aim is to ensure that both sides are performed evenly.

Leg curls. 3 x 10

The standard hamstring isolation exercise, but perform each leg at a time to make sure the injured side catches up.

Bum lifts. 3 x 10

Lie on the floor on your back, with your knees bent. Lift up your bum until there is a straight line from knee to shoulders; pause slightly and then lower down slowly. Surprisingly, this exercise works the hamstrings and gluteals quite hard. As you get stronger, bend the knees less and less until you can perform the movement with straight legs upon a small step. This is a functional hamstring exercise as it involves trunk extension.

Hip adduction, extension, adduction. 3 x 10

Use the total hip machine to ensure all the hip muscles get a good workout.

Trunk exercises

Include the usual exercises for stomach, obliques and low back to ensure good core stability and strength. Remember, all links in the kinetic chain are important for injury rehabilitation.

Aerobic training: three-to-five times a week

At this stage you probably haven't been able to complete much aerobic training and so may have lost fitness. Now that your knee is pain-free and mobile, you can use the stationary exercise bike with confidence. This would be my main choice for maintaining aerobic fitness. You may also consider running in the pool with a weighted belt. Research into the fitness benefits of pool running for injured athletes has shown that VO_2max can be maintained throughout an injury period with pool workouts, and practical experience suggests that the legs definitely get a good workout in the pool!

Balance and coordination training: every day

At this point, it is vital to include some balance and coordination training in your programme. This component is often the one that gets ignored, with a very detrimental effect in the long run.

I would recommend spending a few minutes two or three times a day on a wobble board (see also the previous article). You should learn to balance both two-legged and one-legged. Once you get good at the wobble board, you should be able to perfect exercises such as catching and throwing a ball while maintaining balance and mini-squats while maintaining balance.

Phase 2 (three weeks)

Use the following guidelines to help assess when you are ready to move into phase 2 training. (i) place even strength between

injured and uninjured sides in the hamstrings on the leg curl machine (ii) correct technique and balance during both the barbell and one-legged squats, combined with some strength improvement (iii) a good level of skill on the wobble board.

In this phase you will continue regaining strength as above, but now you can start running again and developing the coordination of sports-specific movements such as jumping, landing and cutting, starting with low-impact exercises.

Strength training

Continue with the phase 1 routine, increasing weight gradually with each exercise. With the one-legged squats, the range of movement can be increased with a deeper knee bend but only if the correct balance and technique can be maintained.

Aerobic training

Continue using the bike and the pool as before. However, now you can try jogging. Start with five minutes only. Take a day's rest and then try a seven-minute jog. If there is no adverse reaction, continue building up the distance jogged every other day until you can jog for 21 minutes. If there is a bad reaction, then drop down the time. Once 21 minutes has been established, continue at this distance but gradually increase the speed up to that of normal training.

Balance and coordination training

You need to retrain the neuromuscular coordination of the dynamic movements involved in sports, beginning with low-impact movements. The following is a sample programme.

Mini hops. 3 x 10 each leg building up to 3 x 50 each leg

These can be performed on the ground or on a trampette. Starting with just a little lift, hop on one leg on the spot. Make sure you flex the knee on landing and make contact with the ground with the ball of the foot. Use your abs and glutes to ensure good stability and posture.

Lateral double hops. 3 x 8 building up to 3 x 20
With both feet hop from side to side. Use a line or a small object such as a tennis ball to hop over. Again, make sure you flex the knee, make contact with the ground with the ball of the foot and maintain good posture and stability. As you improve, gradually build up the height of each hop. This drill begins to train the lateral side movement involved in most sports.

Landing drill. 2 x 8
Stand on a six-inch step. Drop off it and land on the balls of your feet, flexing your knees to absorb the impact. Step back on the step and continue. The aim of this exercise is to train the coordination of landing. You should be able to land accurately, maintain an upright upper-body stability and quickly absorb the impact with your knees. A good landing should finish with you stock still with knees slightly bent and body upright. With time, gradually increase the step height.

'All the elements in the training programme should come together so that you can complete a full training routine'

Mini-squat jumps. 3 x 8
Stand with feet shoulder width apart, squat down to the quarter position and then rapidly jump up, land correctly, squat down and jump again. Aim to perform eight squat jumps with good landings, smoothly linked together.

Slalom runs
Set up a little slalom course with 4-6 cones. Perform the slalom run at jogging pace 5-6 times with a brief rest period in between. In time, gradually increase the speed of the run but no faster than three-quarter speed at this point.

Phase 3 (two weeks)

This phase should finally bring you back to full fitness. All the elements in the training programme should come together so that you can complete a full training routine. You should be able to perform the barbell squat with correct technique at a full training weight. You should show complete equality between sides on exercises such as the leg curl, one-legged squats and

mini-hops. You should be well coordinated on the wobble board and at the landing, lateral hopping and jumping exercises. You should be able to run for at least 20 minutes pain-free, and have regained full aerobic fitness with the bike and pool workouts. These final two weeks of rehabilitation training should include a gradual re-introduction of all the normal training methods and match play practice.

Strength, coordination and aerobic training

Continue with the above schedules (half a week for each) as a maintenance training stimulus to ensure the knee remains strong and coordinated and that you are fully fit.

Plyometric, sprints and agility training

Having developed basic coordination with the low-impact drills of phase 2, you must now reintroduce the normal plyometric drills. For example, full-squat jumps, bounds, lateral bounds, and hurdle hops. In the first workout, you should perform just one set of each exercise. After a few days' rest, try two sets of each and then three. The plyometric exercises are very important as they develop the eccentric strength of the hamstrings and quadriceps and teach these muscles to contract fast and control the knee joint on impact. The co-contraction of the hamstrings and the quads that occurs during plyometric drills is a very beneficial training factor. Remember that, when reintroducing plyometric drills, it is the quality of technique that is paramount - the speed or distance can be achieved later.

In addition to this, you must start to reintroduce sprinting at full speed. For the first sprints workout, I recommend performing only six 30m runs with a rolling start at three-quarter speed. After a few rest days, try six 30m runs with a rolling start at full speed. If that is OK, progress to six 60m runs with a rolling start and then finally to 60m efforts from a standing start.

Agility drills should also be included at this stage. Lateral runs, shuffles, slaloms, cutting and side-stepping must all be performed. Again, start at jogging speed only and then progress gradually to full-out efforts.

Matchplay

You must also start to model the competition situation. If you're a games player, eg, tennis/rugby, you should begin with a small period of a non-contact game. If you're a track and field athlete, begin with a few throws or jumps or some below-distance race pace efforts. Again, gradually build things up in terms of time and intensity.

Although waiting this long after an injury before starting to play again may seem excessively cautious, it should also instill confidence from the fact that you should suffer no setbacks. By this stage in the rehab process, you should be fully strong and agile with a good level of aerobic fitness, and be feeling that you are not too far from being able to play again. Your patience will pay off, since having done all the correct rehab training you will have ensured that the injury is fully healed and won't recur. Over the whole rehab period, you will need psychological help from your physiotherapist, fitness trainer and coach. Goal-setting at each phase of the rehab process is a good idea so you are clear about what you need to achieve and why you are doing all this training instead of just getting out there and playing.

Raphael Brandon

WHAT THE PAPERS SAY

Having a short Achilles tendon may be an athlete's Achilles heel

Clever runners are always trying to improve their 'running economy' (the rate at which oxygen is used to run at a particular pace), because better economy (lower oxygen consumption) almost always translates into better race times and lower perceptions of effort during quality running.

For years, exercise physiologists have believed that the key ways to upgrade economy involve (1) doing intervals on the track at faster-than-race speeds, and (2) carrying out lots of hill training, which includes running up hills at about race pace with regular running form and also 'bounding' up steep inclines with exaggerated knee lifts. The theory is that the fast intervals and hill running boost leg-muscle power. Improved power then makes it possible to recruit fewer muscle fibres while running at quality speeds. The lower recruitment diminishes oxygen consumption (heightens economy). In addition, many physiologists speculate that the vigorous intervals and hill training also improve neuromuscular coordination during running, leading to fewer wasteful body movements and lower oxygen usage.

Runners who do a lot of work on hills and carry out frequent race-speed intervals do have better economy than runners who train differently, but researchers at the Laboratory for Functional Anatomy and Biomechanics at the University of Copenhagen in Denmark have recently identified two key *anatomical* factors which can account for differences in economy between runners, too. These two factors are Achilles-tendon length and Achilles-tendon area. Basically, the longer and slimmer the Achilles tendon, the more economical is the runner, say the Danish researchers.

It's the elastic energy return

The Danes had previously noticed that economy can be nearly doubled in humans just by improving the 'elastic energy return' of

the tendons in the legs. To understand elastic energy return, think about what happens to the Achilles tendons during running. As one of your feet swings forward prior to foot-strike, the Achilles tendon attached to that foot is stretched out greatly. As your foot hits the ground and you roll forward over the ball of your foot just prior to toe-off, your stretched Achilles tendon 'recoils' (shortens), just as an extended rubber band snaps back into a shorter configuration when it is released.

This recoil of your Achilles tendon is good, because it pulls up on your heel and helps you pitch forward onto your toe for toe-off. Best of all, it doesn't cost you anything – in terms of energy or oxygen. The energy comes from 'stored energy', put into the Achilles tendon when it was stretched prior to foot-strike. In other words, your poor, abused calf muscles don't have to use up glycogen or gobble up oxygen in order to get you into a powerful toe-off position. That makes you more economical! Because your Achilles tendons are good at 'returning' energy, you're a better, more efficient runner.

It follows that if your Achilles tendons get even better at returning energy, your economy should improve and your race times should slim down too. But what separates great Achilles tendons from shabby ones? To find out, the Danes studied a group of young athletes and found that if an athlete has Achilles tendons which are about 10% shorter than average, mechanical efficiency (economy) is hurt by about 6%. On the other hand, if the Achilles tendons are 1% longer than average, economy is enhanced by 8%!

Longer tendons can be stretched more

Why would this be true? Longer Achilles tendons can be stretched to a greater extent than short tendons. The greater the length of a stretched Achilles tendon, the greater the force it can apply to the foot when it 'snaps back'. The greater the force, the lower the reliance on glycogen and oxygen and the better the economy.

The Copenhagen researchers also noted that thick Achilles tendons were bad for economy, although the effects weren't quite as pronounced: thickening the Achilles tendons by 10% harmed economy by about 4%, for example, while thinning the strange things assisted economy by 3%.

Is Achilles tendon length set at birth? If so, running economy would at least be partially genetically determined. Observations of élite Kenyan distance runners – currently the best in the world – reveal that they tend to have very long, very slim Achilles tendons, while runners from other parts of the world are more likely to come from the 'short and broad' Achilles tendon factory. The Kenyans are also extremely economical. In fact, they often possess a rare mix of physiological attributes – great economy *and* superb aerobic capacity – which is rarely seen in endurance athletes (usually, an individual with superior aerobic capacity will be mediocre in economy, and vice-versa).

Is it the hill running?

However, that doesn't tell us a thing about genetics, because the Kenyans spend a lifetime running up and down hills and gambolling along on the soft, red-dirt trails of Kenya. Running uphill puts tremendous stretch and pressure on the Achilles tendons, because each footfall allows the heel to descend to a level lower than the rest of the foot, elongating the Achilles tendon dramatically. Likewise, running on soft dirt permits the heels to gouge out little foxholes on each footstrike. This foot-in-foxhole phenomenon also elongates the Achilles tendons mercilessly. It could be that the constant hill and dirt-trail efforts – not the genetic endowment from mum and dad – lead to the greater length and stretchiness of the Kenyans' Achilles tendons, and thus their incomparable economy.

Whatever the reason for the Kenyans' efficiency, the lesson for runners is clear: stretch out those Achilles tendons! The more elastic they become, the more powerfully you will run. And the way to extend them is to run on hills, train on dirt trails, stride on soft ground in bare feet, and stretch them carefully but thoroughly *after* your workouts are over, when your Achilles tendons are warm and distensible.

Reference

('Influence of Achilles Tendon Variables on Mechanical Efficiency,' Paper Presented at the Second Symposium of the International Society of Biomechanics Working Group on Functional Footwear, June 1995, Cologne, Germany)

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