KNEE PAIN

prevention & treatment

A SPECIAL REPORT FROM

PEAK PERFORMANCE

The research newsletter on stamina, strength and fitness

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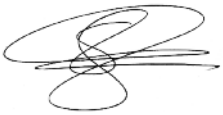
CONTENTS

From the editor

It would be unfair to suggest that there is consensus among scientists on the design flaws of the human knee, but you can't help thinking that if you could re-engineer this particular joint, you wouldn't start from here. Backs, necks and shoulders all cause their share of problems, but knees just seem to be permanently problematic. It is a rarity to find a seriously active or sporty person whose knees have never given them grief.

We at *Peak Performance*'s sister publication *Sports Injury Bulletin* are all too well aware of this, and our multi-disciplinary team of writers – physios, osteopaths, physicians, conditioning coaches – have between them probably written more about knees than any other single subject. We do have something of an advantage: SIB's editorial consultant Fares Haddad is also one of the world's leading knee specialists. Thanks to the dedication and professional curiosity of his team, we get some privileged insights into how surgical techniques are developing in astonishing ways. Indeed, the fact that surgical knee repair has been transformed in the past 10 years is a cause for great cheer among all sportspeople. While the horror of a single career-ending incident does still happen among elite athletes, for the vast majority of us, these days, knee injuries may bring pain, disruption and frustration, but not disaster.

This latest addition to the *Peak Performance* library will give you a thorough education in the mysteries of the knee, glimpses of what will soon be possible in repair techniques, and of course, most importantly of all, lots of self-help tools to assist you in tackling your own niggling knee pain and injuries. It was never our intention to cover every known sporting knee injury– but you will find all of the major ones here. And if your knees tend to grumble but you're not sure why, Cate Streeten's specially written guide on page 85 is a simply invaluable starting point for sorting them out.



Jane Taylor
Editor, Sports Injury Bulletin

Clicking, locking, giving way, pain on bending… sounds like another case of torn cartilage

Cartilage tears in the knee are ten a penny among sportspeople. Some of us remain blissfully untroubled by them, while others experience discomfort, pain and even disability. Happily this is one area where science is moving forward briskly.

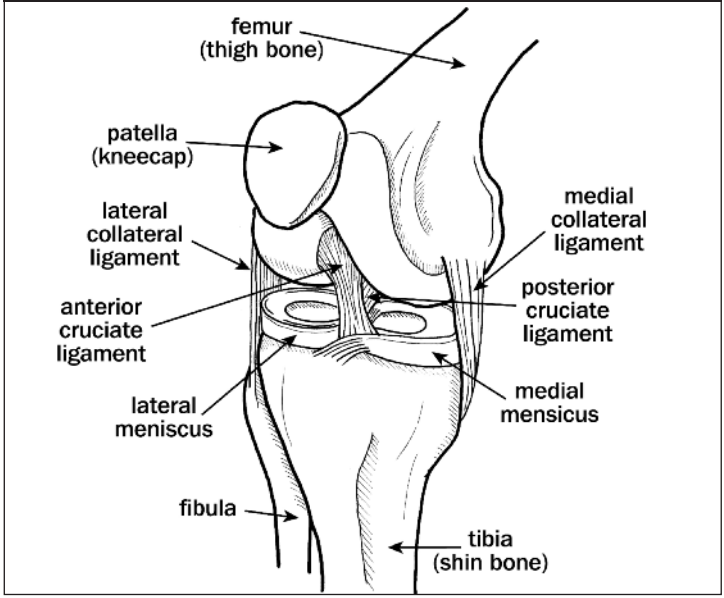
A word about terminology first. What is commonly known as 'shock absorbing cartilage' in the knee joint, the experts tend to refer to as 'menisci'. This distinguishes the shock absorbers from the other type of cartilage associated with the knee: the 'articular cartilage' which cushions the ends of the leg bones. This article is concerned with the first type, and see page 41 for an update on articular cartilage repair.

The menisci are two crescent-shaped pads of cartilage present in both knees. The pad on the inner side of the knee is the 'medial meniscus', the outer one is the 'lateral meniscus' *(see Figure 1, overleaf)*. Together these structures act in four different ways to improve knee function:

- they spread load across the joint. In standing, this is up to 50% of the supported load; in flexion (bending at the knee) it increases to 90%
- they improve joint congruency or stability
- they increase the contact surface area of the main leg bones, helping to spread the weight of the body across a greater area of articular cartilage
- they help to circulate synovial (joint) fluid around the knee.

To carry out these functions, the menisci have a complex structure. They are composed of a specialised type of

Figure 1: The knee joint and its shock absorbers



fibrocartilage, the high water content of which allows them to resist the forces they must withstand.

The menisci have limited healing potential. Their blood supply only reaches the outermost 10% to 30% of each meniscus, and within this region tears may heal. More centrally placed tears have very little chance of healing.

How the menisci get damaged

Meniscal injuries are relatively common, with the medial meniscus being more likely to suffer damage. As well as the functions detailed above, the rear part of the medial meniscus also supplements the anterior cruciate ligament (ACL) in helping to stop the tibia (the main lower leg bone) from sliding forwards against the femur (upper leg bone). This puts the meniscus at risk from injury in any trauma that disrupts the ACL. It also means that if the ACL is weakened or not functioning, the meniscus is more vulnerable to tears, as the knee becomes more heavily reliant upon it.

More usually it will be a twisting injury to the knee while the foot is anchored to the ground that causes meniscal damage. A knee specialist looking at how to treat the knee will consider this kind of 'traumatic' damage (*ie*, the result of an adverse event) differently from how they might treat 'degenerative' damage. In the latter case, the menisci may tear with little or no trauma involved, as part of the natural process of wear and tear and ageing in the knee (although sometimes this can happen to people still in their twenties).

Signs of meniscal tear

If you have done something to your knee, typical signs of a meniscal tear will include swelling of the knee and difficulty moving through its full range. If there is a 'bucket-handle' tear, where a mobile segment of torn meniscus can lodge in the joint, you may feel frequent locking of your knee, or be unable to fully extend your leg. More frequently symptoms may simply be of discomfort over one side of the knee, rising to pain when you squat right down. Indeed, you may be unable to kneel or squat, and may feel you cannot 'trust' the knee. The knee may be tender to touch around the joint line.

Confirming the tear

The specialist will manipulate your leg through a series of tests to check both for meniscal damage and other associated injury. Meniscal injuries can be diagnosed with magnetic resonance imaging (MRI) scanners, but this is not necessary if it is an isolated tear – the manipulation tests are good enough to confirm the presence of meniscal damage.

Treatment

If your torn meniscus is causing you pain, movement restrictions or other symptoms that are interfering with your normal routine or sporting activity, an orthopaedic surgeon should assess the case for a possible operation.

It is best not to leave the tear unattended if it is causing you problems, because this may result in further damage to the

cushioning ends of the main leg bones at the knee. And if you carry on doing a lot of activity on the torn meniscus, it may cause degeneration of the torn segment, such that meniscal repair may not then be possible. So it is preferable to get a prompt assessment before secondary damage sets in.

If you have few or no symptoms, and are able to carry out a full range of physical activities, you may not need surgical attention. Physiotherapy helps to regain range of motion and strengthen muscle groups. It may also be that physiotherapy can sort out associated problems such as patellofemoral pain, which will in turn relieve the symptoms of a minor or borderline meniscal tear.

'If you are getting recurrent symptoms and significant pain, you should seek an operation, which nowadays will mean keyhole surgery known as arthroscopy'

If, however, you are getting recurrent symptoms and/or significant pain, you should seek an operation, which nowadays will mean keyhole surgery known as arthroscopy. The location and nature of the tear will determine how the surgeon treats it.

If the tear is outside the zone where there is decent blood supply, or if it is degenerative tissue, a 'partial meniscectomy' will be done to cut out the damaged section. During this procedure, specialised instruments are introduced through the arthroscopy tube to remove the torn piece of cartilage, leaving a stable rim of tissue behind. The least possible amount of tissue is removed, so as to leave in place the largest amount of healthy, stable tissue to continue protecting the ends of the leg bones from increased stress.

In those tears that lie within the blood-supply zone, the surgeon may be able to repair the tear by fixing the damaged part to the meniscus behind it and the joint capsule.

Results for meniscal repair are very good, especially when carried out during reconstruction of the ACL. The long term effects on articular cartilage are not yet well understood, but we believe that meniscal preservation offers the best hope of avoiding further damage. In functional terms, most people recover all but the final 5 degrees of knee flexion, which is inconsequential for most sporting needs. But you should be aware of this likelihood when deciding whether to go ahead with surgery.

It is very important to undertake a post-operative rehabilitation programme, supervised by a physiotherapist.

There is some evidence[1] that an accelerated rehab programme, allowing a full range of motion and weight bearing as tolerated, has results comparable to the conventional, more restrictive post-op rehab in terms of meniscal healing – but check this out with your consultant or physio first.

Work in progress

Tissue engineering techniques are being developed to address the problem of how to get tissue to heal in the parts of the meniscus lacking a blood supply. One possible solution is to deliver cells surgically to a tear together with the specific growth factors necessary for repair to take place. So far animal work has focused on discovering which materials are needed to effect a repair. This type of approach may well yield clinically significant results in the not too distant future.

Meniscal transplant, using preserved tissue from cadavers (corpses) is an option for the treatment of severe meniscal damage. As yet results for this are mixed; associated problems include the availability of meniscal tissue for graft, its preservation, possible transfer of disease, shaping of the graft and potential immunological reactions to it.

In trying to overcome some of these concerns, attention has turned to alternative sources of graft material. One such alternative is the use of bovine-derived collagen. However, in order for tissue ingrowth to occur, there must still be a rim of the original meniscus left in place. Again, results for this technique are rather poor.

The purpose of all of these procedures should be to prevent damage to the soft ends of the long leg bones, while restoring knee function. As yet this has proved to be a difficult target to attain.

Sam Oussedik & Fares Haddad

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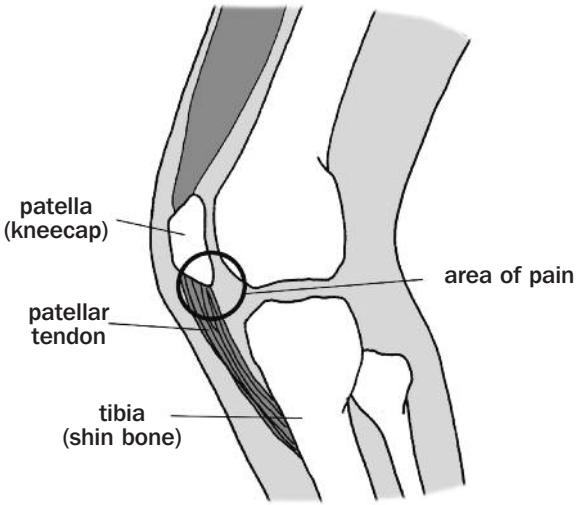
Patellar tendinopathy is common, obstinate and a real pain in the front of the knee

Patellar tendinitis is the most common knee disorder found among competitive athletes. Known as 'jumper's knee', it is most likely to affect you if you play high impact sports involving bursts of intense or repeated stress, notably basketball and volleyball (these sports demand twisting on the spot, deep knee bends and sprinting). However, anyone from the casual jogger to contact sport players may develop the condition – all too often with far-reaching consequences. One study has estimated that more than half of athletes diagnosed with patellar tendinitis were forced to retire from their sporting activity[1].

Classically patellar tendinitis has been explained as chronic inflammation of the tendon connecting the kneecap (patella) to the main shin bone (tibia), at the point of connection to the kneecap (*see Figure 1 overleaf*). Recent research has, however, revised our understanding of the condition – and with it a change in terminology: it is more correct these days to refer to the condition not as tendinitis but tendinosis. This reflects the understanding that the tendon pain does not come from inflammation, but rather degeneration and fibrosing of the collagen that makes up the tendon, as a result of a failure of microscopic damage to heal over time.

Symptoms start with pain after exercise, which can progress to pain during exercise. In extreme circumstances the tendon may weaken and rupture. The pain can be debilitating and even force you to retire from high level sport.

Figure 1: Patellar tendinosis (jumper's knee)



Who is at risk and why

Ferretti [2].was the first to describe the causes of patellar tendinosis, dividing them into intrinsic (specific to the individual) and extrinsic (environmental) factors. Intrinsic causes were:

- gender
- age
- knee alignment
- Q-angle (longitudinal angle of the front of thigh muscle)
- position of the kneecap
- rotation of main leg bones (tibia and femur)
- the overall shape and stability of the knee.

Extrinsic causes were in essence:

- the nature of the activity (jumping and continuous stress being the major culprits); and
- the consistency of the playing surface (hard surfaces such as concrete being most risky).

Ferretti established the school of thought that extrinsic factors were the more significant, causing chronic overload of the front thigh muscles which inflamed and weakened the patellar tendon.

In the 1990s a British research team came up with an alternative explanation, suggesting that the tendon was being crushed by the kneecap when it was forced into the sharp angle created by extreme bending at the knee (flexion)[3], in effect producing an impingement syndrome. A more recent study on the motion of the knee in flexion has shown that the tendon is not being kinked and crushed[4].

More recent research has shifted the focus of blame away from environmental factors and towards more individual causations. In an American study of healthy competitive athletes, Witvrouw *et al*[5] used a series of body measurements to try to detect a link between intrinsic risk factors and the development of tendinosis. All 138 trial participants performed the same amount of high intensity, highly competitive activities, across a variety of disciplines, and 19 of them developed tendinosis. The only identifiable common risk factors were poor flexibility of the hamstrings and quadriceps (rear and front of thigh) muscle groups. Contrary to Ferretti's belief, there was no apparent gender difference. This research suggests that you may be able to reduce your tendinosis risk with a good stretching programme.

'Research suggests that you may be able to reduce your tendinosis risk with a good stretching regime for the front of the thigh'

Another recent US study supports these findings, and underlines the importance of intrinsic risk factors. This study shows a higher incidence of tendinosis among subjects whose kneecaps naturally had a higher tilt when they did knee bends[6]. It would seem logical that if the patellar tilt is greater (producing more tension on the top of the patella from the quadriceps tendon), then a front-of-thigh stretch regime ought to be able to reduce the strain on the tendon.

Likewise, the greater your 'Q' angle, the more strain is likely on the knee, increasing the risk of knee pain and tendinosis. The Q angle is an estimate of the alignment of the knee in relation to the angle of the thigh and lower leg. Variations in the angle are usually related either to rotation at the hip joint or the shape

of the foot on standing. Thus someone with 'knock knees' would have a large Q angle. People with flat feet force the outsides of their feet out and push their knees inwards. Studies have shown that some athletes with patellar tendon problems have an increased Q angle.

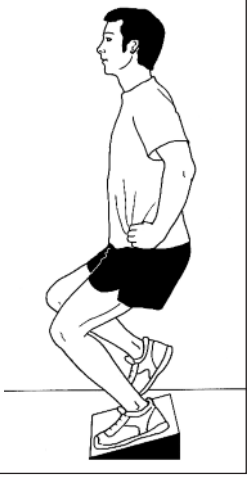
Treatment

Physiotherapy can stabilise the condition, avoiding the need for surgery. The therapist will test key muscle groups such as quadriceps (front of thigh) and hip flexors for tightness, and recommend a stretching regime. Eccentric (anti-gravity) loading of the tendon, as happens when performing a decline squat, seems to give good results, although it is unclear exactly why this should be. Recent research has recommended a protocol for this rehab regime[7] (*see box opposite for a summary of the research test*).

Single leg decline squat (*Fig 2*)

- Stand on a decline board (optimum recommended angle is 25 degrees).
- With feet facing forwards, lift one foot off the ground
- Lower slowly from standing upright on one leg to as deep a knee bend as pain allows
- Perform 3 sets of 15 repetitions, twice daily
- For best results, exercise through moderate pain, gradually increasing the load by holding weights in both hands.

Figure 2:
Single-leg decline squat



Your rate of progress will depend on how bad the tendinosis is in the first place: you may initially need to perform the return to standing using two legs, but aim eventually to be performing the entire manoeuvre using the affected leg only.

The decline squat research protocol

The research used elite Australian volleyball players with patellar tendinosis in a randomised controlled trial lasting 12 weeks, with a 12-month follow-up. Participants had to complete their exercises twice a day for 12 weeks. They performed 3 sets of 15 repetitions during a session. All exercises were completed on a single (affected) leg to about 60 degrees of knee flexion, with participants being taught how far to squat down during their initial session. Participants progressed load by adding weight to a backpack in 5kg increments.

The group used a 25-degree decline squat board. They completed the downward component (eccentric phase) of the squat on the symptomatic leg, and the upward component (concentric phase) on the asymptomatic leg. They were instructed to exercise into moderate tendon pain and to progress by increasing load if this pain eased.

By the end of the 12-month follow up period, there was a significant improvement in the ability of this group to carry on their full sporting activities compared with a control group who had undertaken a more conventional rehab programme.

Research reported in MA Young, JL Cash *et al*, 'Eccentric Decline Squat Protocol for Patellar Tendinitis in Volleyball Players', *Br J Sports Med*, 39 (2005) 2, pp 102-105.

Further research is needed to decide how useful rehab aids such as orthotics and knee braces might be in treating or preventing patellar tendinosis.

Surgery

Where surgery is necessary, the inflamed fat pad surrounding the tendon is removed; the visibly abnormal areas of tendon are cut out and any abnormal blood vessels are cauterised. Any abnormal tissues on the kneecap at the site of tendon attachment will also be removed. This can be done either as open surgery or a keyhole procedure (under local or more usually general anaesthetic). Overall outcomes are comparable, whichever procedure is used, but on average the arthroscopy

(keyhole surgery) patient will enjoy a four-month advantage in their time to recovery and return to full sporting activities, because of the less invasive approach.

Work in progress

The most exciting development has been the introduction of prolotherapy, claimed to be as successful as surgery in treating symptoms[8]. This claim is based on studies that show an increased formation of blood vessels in the affected tendons, along with nerve growth and unusually high levels of pain receptors and stimulators. When these blood vessels are destroyed with a sclerosant (injectable irritant) using ultrasound guidance, pain is relieved. The reduction in symptoms appears to be related to how much of the abnormal blood vessel growth is eradicated.

The researchers are still unsure what exactly triggers the pain of patellar tendinosis, but what is clear is that the pain and collagen damage are not a result of inflammation. None of the usual chemicals or cells associated with inflammation are present in patellar tendinosis. This would cast doubt on the value of treatments using steroids or non-steroidal anti-inflammatories (NSAIDS).

In another development, animal studies of blood injections have shown some promising results for tendon strengthening[9]. Tendons are notoriously slow to heal and have high rates of re-rupture because of their poor blood supply. This study only assessed short-term strengthening, but if it gets past the hypothetical stage it could have broad implications for the treatment of damaged or ruptured tendons.

Conclusion

Patellar tendinosis can be a disastrous condition for the sports enthusiast if not dealt with promptly. It may be impossible to eradicate the condition from sports that carry the highest risk, but prolotherapy and autologous blood injection could one day substantially reduce the need for surgery.

Malcolm Davies & Fares Haddad

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The lesser known cruciate ligament may not be as painful when injured, but that's no reason to ignore it

Deep inside the knee joint, two little ligaments provide crucial stability to help our knees cope with the tremendous forces that many sports subject them to. One of these ligaments – the anterior cruciate ligament or ACL – has achieved celebrity status, mainly because of the tendency of sporting celebrities (especially footballers) to injure it. The second ligament -- the posterior cruciate or PCL – is hardly ever in the spotlight, and because it is less commonly injured, our understanding of how to treat it is less advanced than for the ACL.

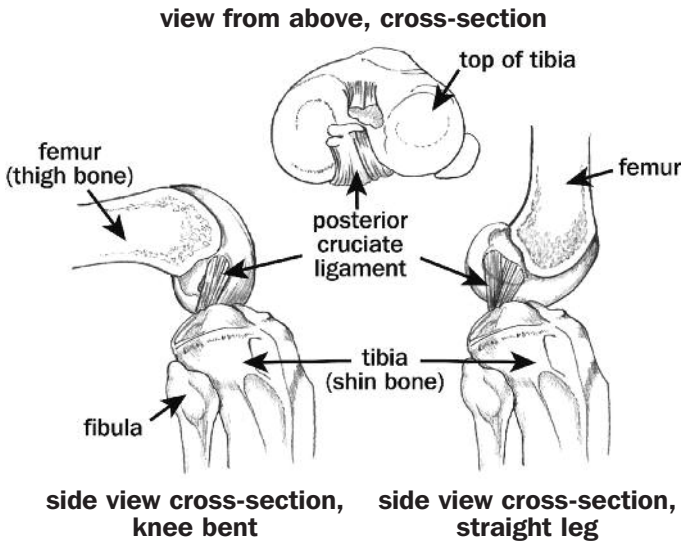
Acute PCL injuries are often overlooked, sometimes because the physician misses them, other times because the affected individual does not realise they might have done some serious damage and so delays seeking treatment.

What the PCL is for

The primary role of the posterior cruciate ligament is to prevent the main lower leg bone (the tibia) constantly sliding backwards relative to the upper leg bone (femur). The PCL provides 95% of this restraining force. It also plays a secondary role in providing resistance at the knee joint to inward and outward forces, and to the turning-out of the knee (external rotation).

The PCL is approximately twice as strong and twice as thick as the ACL. Its average size in an adult is 13mm in diameter and 38mm in length. It fastens to the outer front surface of the end of the femur and the rear of the tibia just below the joint

Figure 1: The posterior cruciate ligament



line (*see Figure 1, above*). It may be partially separated into two bundles, the anterolateral (accounting for about 95% of the total ligament) and the posteromedial. When the knee bends, the anterolateral bundle is tight and the posteromedial bundle is lax. When the knee is straightened, these tensions are reversed.

How to injure your PCL

It is generally people in their twenties and thirties who do acute damage to their PCLs. Isolated PCL injuries (where no other knee joint structure is injured) are usually caused by a direct blow to the front of the tibia while the knee is bent, forcing the backwards jolt of the tibia against the femur.

Sporting incidents are responsible for two out of five PCL injuries, second only to traffic accidents (which cause 45%). Specifically, motorcycle accidents (28%) and soccer-related injuries (25%) are the main culprits. In sport, the usual cause is a fall on to the knee while the foot is plantar-flexed (*see Figure 2, opposite*). However, in Western countries, nearly

all PCL damage (96.5%) occurs in combination with other ligament injuries.[1]

Isolated rupture of the PCL leads to an increase in back and forwards movement on the inner side of the knee. The effect of this persistent shifting of bones during weight-bearing is to increase your risk of early osteoarthritis.

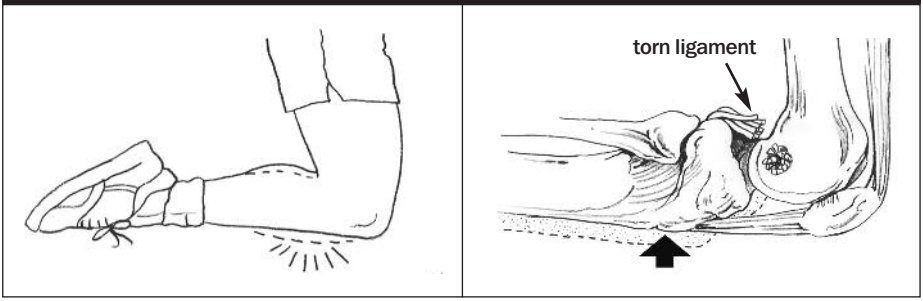
There are also reports[2] of increased forces on the front of the knee after PCL rupture, associated with a greater force acting on the kneecap from behind, which may increase the risk of front of knee pain and arthritis.

Symptoms of injury

After trauma, symptoms of acute isolated PCL damage are often mild: you may believe the injury to be a sprain and be tempted not to seek medical advice. But this would be a mistake, especially if you have had a direct blow to your tibia near the knee. At first your knee may swell up, feel painful and have a limited range of movement. The front of the knee may be bruised or cut. Over the next few days bruising may develop in the back of your knee. After a week or two the pain may have disappeared.

If you have chronic PCL damage (developed over time or because you failed to get it checked out when you did the initial injury), you may develop aching pain in the inside and kneecap areas of the knee. It's possible you will feel that your knee is unstable, but if it is persistently 'giving way', the likelihood is you have done more complicated damage than just a PCL injury.

Figure 2: How the PCL ruptures



CASE STUDY: It took Ryan Shulman 10 years to discover he'd damaged his knee

My visit to the Brisbane Orthopaedic and Sports Medicine Clinic was the culmination of more than 18 months of physiotherapy, GP and orthopaedic reviews. I had developed an interest in triathlon and wanted to get serious about training, particularly some longer distance running. However, after increasing my training load and intensity I had started to develop a vague pain along the inner-front joint line in my right knee, as well as spasm in my right popliteus muscle.

'After increasing my training load and intensity, I had started to develop a vague pain along the inner-front joint line in my right knee'

I attempted to train through the pain (being a physiotherapist and a doctor the old axiom of 'do as I say, not as I do' clearly applies here). The symptoms worsened to the point where I had to rest from any training that involved my legs. I could not cite any recent incidents or particular training sessions to which I could attribute the onset of the pain. Even back to my high school rugby and basketball days, I'd never had to stop play because of knee pain.

Visits to numerous therapists and my GP failed to shed any light on the cause of the pain. I was referred to a local orthopaedic surgeon for assessment. After 15 minutes he seemed as mystified as I was.

A magnetic resonance image scan (MRI) at this time showed up possible signs of past trauma, but that made no sense to me. The scan also noted that both the anterior and posterior cruciate ligaments were intact. Finally, the scan showed chronic medial femoral and patellar trochlear degeneration – exactly the kinds of secondary damage that can happen with an untreated PCL rupture, but these signs were not picked up.

Confirming the rupture

The specialist will manipulate your leg in a set of tests to determine whether the PCL is damaged, and will usually be able to grade the severity of damage from I (least serious) to III. If you are found to have other associated injuries, especially to ACL and / or the 'posterolateral corner' (outer rear edge) of the knee, you will generally need surgery.

Routine x-rays can show up an 'avulsion fracture', where a piece of bone attached to the ligament has torn away from the

I persevered with physiotherapy and anti-inflammatories and managed to compete in about five triathlons over the next 12 months. But the pain worsened and I asked for a referral to a reputable and experienced knee surgeon in Brisbane. He noted that I had some wasting of my quads on the right, and had a subtle loss of flexion range (ability to bend) at the right knee. It was when he noted the extra backward-forward play of my right knee compared to the left that he asked me when I'd ruptured my posterior cruciate ligament.

After some consideration I remembered an incident from roughly ten years previously: I had been tripped during a lunchtime football game. I'd landed on my knee and was sore for a few days, but it was nothing that slowed me down much at age 14.

My knee was relatively stable; I was in pain because of chondral damage (to the ends of the long bones), so I opted for an arthroscopy to tidy this up. The damage to articular cartilage at the end of my femur received microfracture in an attempt to fill the defect, which also meant a much shorter rehab schedule. I did not have a PCL reconstruction.

Just to prove that physiotherapists/doctors make the worst patients, it took me about six months to really begin working hard on rehab. After a further six months of regular quads work including cycling and balance exercises, my pain has almost resolved. I've decided to avoid any running training to focus on cycling, given that the offending pathology (PCL laxity) still exists and I want the microfracture treatment to last as long as possible!

Ryan Shulman

tibia. However, the best way of confirming isolated PCL damage visually is with magnetic resonance imaging (MRI).

MRI is also useful in assessing the healing of a PCL injury , but your specialist will need to interpret the images with care. Recent reports suggest that up to 93% of partial or complete PCL ruptures may regain continuity, which means that the ligament joins up again and appears intact on MRI scanning, even though it may not be working properly[3,4]. It is probably for this reason that MRI is less reliable at diagnosing chronic

PCL injuries: 43% of the time in chronic cases the ligament will appear to be uninjured[5].

A major pitfall in diagnosis is the inaccurate diagnosis of an anterior cruciate injury, where apparent laxity of that ligament is the result of PCL injury.

Some specialists will want to undertake keyhole investigation (arthroscopy) under anaesthetic to confirm the nature and extent of damage and decide how best to treat it.

Treatment

Recent reports have failed to find any convincing correlations between the severity of an isolated PCL tear, treated non-operatively, and subsequent problems with knee function or pain.

One study on the non-operative treatment of PCL injuries in athletic patients reports that irrespective of the extent of laxity, half of the group returned to the same sport at the same or higher level, one-third returned to the same sport at a lower level, while one in six did not return to their sport[6].

Where the tear is mid-ligament, acute isolated PCL injuries may heal[4], a compelling reason why many knee experts believe most of these injuries should be treated conservatively. Surgery will probably only be recommended if you are getting major symptoms, such as instability, and / or where the likelihood is that there is more complicated damage involved.

If your isolated PCL injury is being treated conservatively, you can expect to have your knee immobilised in a brace for six weeks, after which you may start rehab: targeted training of the front of thigh (quadriceps), hip and core stability muscles. You should avoid any hamstring strengthening in the early stages of rehab.

Reconstruction

Operative repair may be either open surgery or by arthroscopic keyhole procedures. Most reconstructions involve a 'single-bundle' technique, which aims to replace the strong anterolateral bundle of fibres. But there are now ways to replace both the anterolateral and posteromedial bundles. Several different types of graft material may be used.

Conclusion

Although isolated PCL injuries are rare, it is important that athletes and physicians remain on the lookout, to avoid missing the diagnosis. Current research suggests that isolated acute injuries should be treated conservatively, but improved techniques may make surgery the treatment of choice in the future.

Simon Ball & Fares Haddad

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For some athletes a new ACL repair technique sounds promising. And further advances are on the horizon

The anterior cruciate ligament is the most commonly injured of the four main knee ligaments, and operations to reconstruct it are becoming more common. Standard reconstruction involves the use of hamstring tendons or patella tendon passed through a bony tunnel in the tibia (main lower leg bone), through the knee joint and into a tunnel in the femur (upper leg bone). These procedures have gained an 80% to 90% success rate in recent times. Research has therefore focused on trying to improve the procedure for the remaining 10% to 20% of injuries.

The procedure itself has evolved over many years with the use of more sturdy graft materials and numerous variations and improvements to surgical technique. Recent advances have allowed surgeons to attempt more complex reconstructions, including the 'double bundle' reconstruction, which aims to reproduce more accurately the natural anatomy of the ACL within the knee (*see diagram on page 12 for anatomical location of the ACL*).

The ACL is responsible for maintaining the correct anatomical relationship between the femur and tibia throughout the range of knee movement. Its main role is to stop the tibia from sliding forwards against the femur; but it is also a secondary restraint against side-to-side forces and tibial rotation. Anatomical studies have shown that it is able to do both things because it is made of two separate fibre bundles, the antero-medial (AM) and postero-lateral (PL) bundles, each of which has different

attachment points on the tibia and femur. Each of the two fibrous bundles is about 3.5cm long, and while they have a relatively good blood supply, complete ruptures have virtually no capacity to heal in their normal anatomical position.

Reconstructive surgery at present focuses on replacing the AM bundle, and thereby stabilising the knee against forward slippage of the tibia. Most people who have this surgery will successfully return to their chosen sport after a thorough rehabilitation programme, lasting six to 12 months. But some find that their knee remains unstable.

'If you have damaged several knee ligaments in the same injury, you may be more susceptible to rotational instability and may therefore also benefit from double-bundle reconstruction'

Researchers have suggested that a standard ligament substitute may lack sufficient endurance strength in athletes and physical labourers1. These individuals put greater loads through their knees than the averagely active person, and therefore may require the greater strength of double bundle reconstruction (*see Figure 1 opposite*), which confers the added benefit of securing stability against rotational forces – the role of the PL bundle.

If you have damaged several knee ligaments in the same injury, you may be more susceptible to rotational instability and may therefore also benefit from double-bundle reconstruction.

Hara et a[1(1)] described a double bundle reconstruction in 2000, using a patellar tendon graft for the AM bundle and hamstring graft for the PL bundle. Other surgical techniques have used different tendon substitutes, independent or shared bony tunnels or have varied the insertion points of the PL bundle.

Double bundle reconstruction results in two separate replacement grafts existing within the knee, which theoretically has several advantages, including added strength and some degree of back-up if either graft fails. Moreover, because the PL bundle is thought to stabilise rotation, it may decrease the rate at which osteoarthritis develops in the knee in the future.

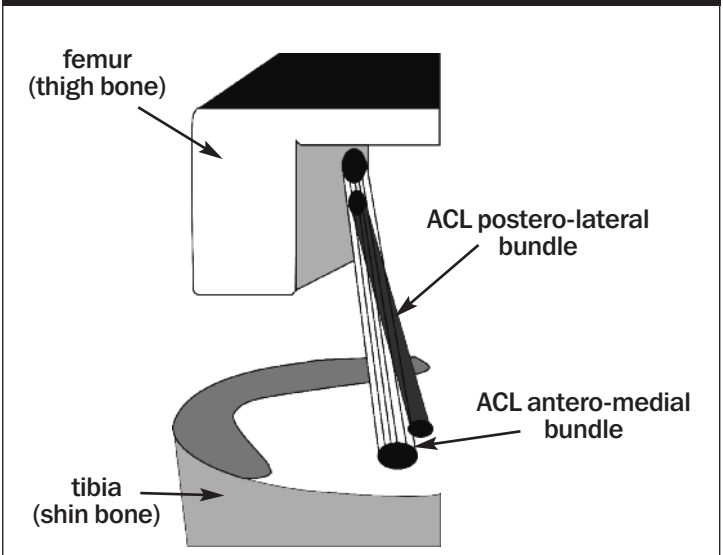
Being a relatively new procedure, there are few completed trial results to tell us whether these benefits hold true in practice. Certain groups have reported good results with a double bundle reconstruction[(2,3)]. Muneta *et al*[(2)] showed a trend that suggested better forwards-backwards stability after aggressive rehabilitation when compared with a single bundle

reconstruction using the same rehabilitation programme. A prospective randomised trial by Adachi *et al*[4] looked at more than 100 patients who had either a single or double bundle repair, and found that there was no significant difference in the stability or proprioception (joint position sense) of the knee at the end of their two-year follow-up.

So little evidence exists as yet to support the use of the double bundle technique in preference to traditional reconstruction. The key is likely to be to find a way of identifying the individuals who are most likely to benefit.

Double bundle repair requires the surgeon to make a larger bone tunnel within the tibia and femur, which may make it tricky to undertake any subsequent attempts at further reconstruction. We also do not know whether the double tunnels will increase the risk of fracture, particularly within the attachment point on the femur. And the use of more graft material inside the knee may increase the chance of impingement (catching) inside the joint.

Figure 1: Double-bundle ACL repair



The failure rates of single bundle reconstruction vary between centres and surgeons, from 5% to 20%[3]. The variation is largely accounted for by differences in tunnel placement, which underlines the importance of having the surgery carried out by a specialist surgeon.

The theoretical benefits of double bundle reconstruction mostly concentrate on the longer term outcome of such repairs and it is still too early to assess their longevity in relation to single bundle reconstruction. Many of these questions can be answered over time with further clinical and biomechanical research.

Work in progress

New work is also being done on tissue engineering. Pascher *et al* [5] have shown that introducing genes that help ligament cells to migrate across a gap of scar tissue can lead to ligament regeneration. This work is at the laboratory testing stage. Lu *et al* [6] have used stem cells seeded on to a bioabsorbable scaffold to reconstruct the ACL, causing the graft to be generated from the patient's own progenitor cells rather than having to be harvested from elsewhere. This technique is showing encouraging results at the in-vitro stage.

'It has been shown that in athletes, cruciate deficiency leads to an increased likelihood of injury to the shock-absorbing menisci'

Stem cells have also been used to improve the way in which a traditional graft heals into its bony tunnels. Lim *et al*[7] have shown that coating the graft in stem cells before positioning it helps it to grow more securely into the surrounding bone.

Other researchers are studying the long term health of both cruciate-deficient and cruciate-reconstructed knees. Long term cruciate deficiency is associated with an increased chance of developing osteoarthritis (OA). While little evidence exists to support a direct link, it has been shown that in athletes, cruciate deficiency leads to an increased likelihood of meniscal injury, which in turn is associated with the onset of OA.

Recent evidence supports the idea that the trauma which leads to ACL injury may be the trigger for developing OA. Lohmander *et al* [8] studied 84 female football players who had sustained an ACL injury 12 years previously. Of this group 51% had signs and symptoms of OA, and reconstruction appeared

How to rupture your ACL

In sporting contexts, ACL rupture will typically occur in athletes who suffer a sudden twisting injury, such as the basketball player who suddenly changes direction with their lower leg planted on the ground and turned inwards; the football or rugby player who gets their boot stuck in the turf while in full flight; the skier whose binding does not release; and the athlete who lands awkwardly, hyperextending their knee.

If you suffer an acute ACL injury, your knee will quickly become swollen and painful. Tears to the relatively oxygen-rich ACL cause an accumulation of blood within the knee joint (haemarthrosis), which may need to be drawn off (aspirated) out of the knee. If you don't get the injury treated at this stage, you may later find you are getting problems of your knee 'giving way' or feeling unstable.

Not everyone needs ACL reconstruction: it is perfectly possible to get by without a functioning ACL. However, for active and sportspeople, there is evidence that being ACL deficient in the long term may predispose you to further meniscal damage and early degenerative changes within your knee. ACL reconstruction is now an accepted treatment with a high success rate.

not to confer any protection. However, this study was limited in both the number of subjects and the way they were assessed. Patients who undergo ACL reconstruction tend to be the more active and hence may well damage their knees more than people who limit their activities and do not undergo reconstruction.

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Here's another bit of joint damage to worry about: the ends of bones. And here's how they can be repaired

The ends of the body's long bones are covered with articular cartilage (*see Figure 1, overleaf*). This highly specialised tissue is principally made up of hyaline cartilage secreted by chondrocytes. Because of the poor blood supply at the ends of the bones, these cells work in a low oxygen environment and are vulnerable to injury.

Hyaline cartilage has a complex structure arranged in layers (*see Figure 2 on page 43*). This allows it to carry out its functions of load-bearing and reducing friction, but it means the task of restoring this structure after injury is particularly difficult.

Damage to articular cartilage has long been linked to a range of symptoms which vary according to the size and depth of the lesion. Articular cartilage has very little capacity for spontaneous repair, although fortunately partial thickness defects (shallow nicks and tears that do not penetrate all the way through to the underlying bone) are rarely associated with significant symptoms. However, because even the slightest change to the shape of a structure alters the way it transmits forces, damage to any part of the articular cartilage can change its biomechanical properties, leading to further degeneration. Ultimately such injuries may lead to post-traumatic arthritis.

How chondral damage happens

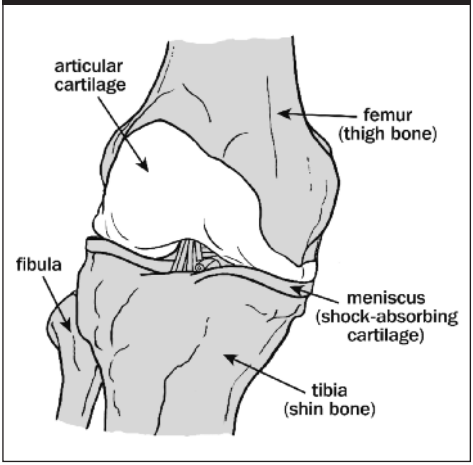
Articular cartilage can be damaged by excessive shearing (sliding) forces, and is a common feature of sports injuries to the

knee. High impact combined with a twisting injury can generate a shearing force at the chondral (articular cartilage) surface, as one surface impacts against the other. Even minor trauma can lead to a disruption of the superficial layers of cartilage, which may then initiate a cascade of changes leading to degeneration. Higher energy trauma can lead to fissuring or partial thickness loss of cartilage, and full thickness injuries may result in osteochondral fractures: breaks that run through the whole thickness of cartilage to damage the underlying bone.

Even if you have sustained what appears to be a simple sprain or strain, you may have damaged the articular cartilage, particularly if your knee fails to recover and continues to give you pain and stiffness for a longer time than you would expect with a simple strain or sprain. Knee injuries that cause tears to a meniscus or anterior cruciate ligament may well also have damaged articular cartilage.

X-rays often fail to show any abnormality. Magnetic resonance imaging (MRI) has revolutionised the investigation of suspected chondral injuries, allowing detailed imaging of the articular surface along with the underlying bone and clearly showing up chondral damage and injuries to the subchondral bone, such as 'bone bruising' – inflammation within the bone itself. Chondral damage is usually graded I (superficial) to IV (most serious), Arthroscopy (keyhole surgery) allows the surgeon to examine the surface of the lesion and carry out therapeutic work. For many people this will be the first line of operative treatment, during which any loose edges are removed from the chondral lesion, and the joint is thoroughly washed out. This leads to a decrease in mechanical irritation from the loose flaps, and washes out any harmful inflammatory mediators (chemicals released by

Figure 1:
Articular cartilage, thigh bone

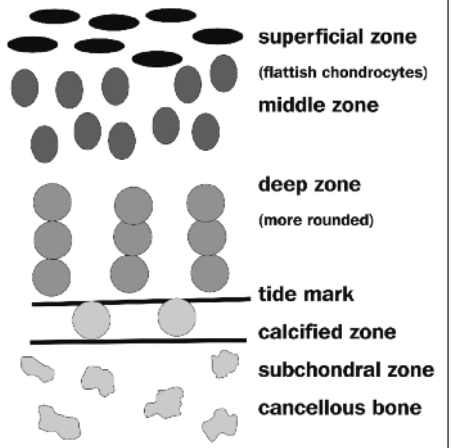


damaged tissue which increase inflammation). This can provide good relief of symptoms.

For lesions that involve the full thickness of the articular cartilage and the bone beneath it, there are techniques to repair the damage. In addition to trimming back the defect's loose edges, new repair cells and growth factors can be stimulated by the technique of microfracture.

A small pick is used to create tiny fractures in the base of the subchondral bone. This allows blood to enter the damaged area, and a clot to form. Over time this can organise itself into scar tissue, helping to restore some function to the deficient area. As this scar tissue does not have the same highly specialised structure of hyaline cartilage, full function is not restored. But it is often enough to significantly improve symptoms.

Figure 2:
Articular cartalige in layers



Work in progress

Research is focused on moving beyond basic repair, to try and restore the missing articular cartilage, in the hope of returning normal function. This involves transplanting the patient's own articular cartilage to fill the defect, either taking it from another part of the joint where it is not needed, or harvesting a sample and growing it in the laboratory. The resulting tissue can then be implanted into the site of the defect.

Autologous cartilage implantation (ACI) is now widely used in the treatment of full thickness chondral injuries. This technique involves harvesting chondrocytes from the patient, culturing these in the laboratory, and introducing them into the defect.

Initially implants were secured in place by fixing a layer of periosteum (bone membrane) over the top. More recent work has explored using synthetic materials to keep implants in place, such as animal-derived collagen. But this approach can create

an uneven distribution of chondrocytes, so further work has led to the development of matrix-induced autologous chondrocyte implantation (MACI). In this technique, the chondrocytes are cultured on a collagen membrane, where they can be evenly distributed, and then the collagen/chondrocyte construct is implanted whole into the defect. Although MACI would appear to have advantages over the ACI technique, no significant difference has yet been shown[1].

Stem cell research also offers potential treatment options. A sample of the patient's bone marrow is taken, and the stem cells are isolated. These can then be cultured to expand their numbers. One of the properties of stem cells that makes them attractive is their ability to multiply almost without limit. Thus from a very small sample a large number of chondrocytes can be produced. This expansion allows potentially large defects to be treated.

Once cultured, the cells can be delivered in much the same way as discussed above. Early results for this type of treatment are encouraging, although a great deal more work is required before this becomes a viable treatment option.

Sam Oussedik & Fares Haddad

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Can a new joint propel your sporting career into old age?

In the past 20 years there has been an explosion in the number of total joint replacements performed throughout the world. Hips and knees are the most commonly replaced joints, but shoulders, elbows and ankles can all be done, too.

Hip and knee replacements were originally designed for elderly people, generally over the age of 70, who led relatively sedentary lives and who were not expected to outlive the lifetime of the prosthesis (artificial joint). The ability of these artificial joints to relieve pain and maintain everyday mobility has been a revolution in the treatment of arthritic conditions, and we would expect a new hip joint in these elderly patients to be good for 15 to 20 years.

With increasing confidence, hip and knee replacements are being given to an ever younger population, who are much more likely to outlast the expected life of their replacement joint and who also place demands on the implants that the original designers would not have considered. Although the technology behind joint replacement surgery continues to evolve, people are pushing the implants to the limit and causing them to fail earlier – after 10 years or less in the case of hips. Because knee replacements are more recent, we can be even less certain about their longevity and what might influence it. While we have data giving more than 95% "survivorship" of knee implants at 5 to 10 years' follow-up, this is among the more elderly and less active population[1]. We simply do not yet know how younger patients will fare.

So what's the best advice for pursuing a healthy lifestyle if

you are facing or have gone through a total joint replacement? Are you going to be better off stopping all exercise, or is it a case of being able to do some kinds of activity but not others?

'The more activity you do, the quicker you will wear out your implant. What we're less clear about is whether impact in particular makes much difference'

While there are numerous published guidelines on what types of activity people should do after joint replacement surgery, none of them is based on proper randomised control trials. Nevertheless, there is plenty of evidence that the more activity you do, the quicker you will wear out your implant. What we're less clear about is whether impact in particular makes much difference. Most studies recommend a reduction in impact sports to minimise the likelihood of wear on the bearing surface and decrease the chances of loosening the implant[2-4].

There is no doubt that if you continue to take part in sport after a knee or hip replacement, you are at higher risk of traumatic complications, including dislocation, fracture around the prosthesis and even failure of the implant. The likelihood of doing serious injury to the replacement joint while playing rugby is far greater than if you restrict your activity to playing a sedate round of golf!

While you need to be aware of the relative risks involved, the current literature does not offer a great deal by way of helpful advice, with opinion – even among orthopaedic surgeons – divided as to what exactly we should be recommending as harmless or beneficial.

Hips

For total hip replacement, there is general consensus that impact sports should be avoided, including:

- running
- water skiing
- football
- basketball
- hockey
- handball
- karate
- rugby
- squash.

What the surgeons advise

For hip arthritis
If you are keen to continue your sporting activities, hip resurfacing might be the best option if you are also:

- a woman aged less than 55 years with good bone density; or
- a man under the age of 70

Note that there are no long-term results for this partial replacement procedure. Note, also, that if a resurfacing fails, you can still have a conventional total hip replacement.

For knee arthritis
You need to be aware that you may lose some flexion and that kneeling is often not possible after replacement surgery.

For anyone considering replacement surgery
These operations are done to relieve people's pain. They cannot be guaranteed to improve function or enable you to maintain your sporting activities. If you are relatively young, you must understand that, especially if you are very active, your first implant will probably not last the rest of your lifetime, so you will need further surgery at some stage.

The materials used in total hip replacement vary but these days most implants consist of a metal head articulating on a polyethylene cup. The polyethylene has been shown to wear more with increased weight-bearing activities. Work has been done on other kinds of bearing surfaces, such as ceramic heads articulating with ceramic cups.

Also in the past 10 years there has been a resurgence of interest in "hip resurfacing", a procedure that aims to preserve a significant proportion of the top of the thigh bone (the femoral head). This produces a bigger ball and socket joint, which holds out much better prospects for the stability of the joint. The new generation of hip resurfacings tend to incorporate a metal head with a metal cup articulation in the belief that this will produce less "wear debris" and reduce the chances of the implants working loose.

Studies have shown that after hip resurfacing, people are able to undertake sports that would have been on the banned list for a total replacement, including downhill skiing, squash,

football, judo, horse riding, triathlon and running. There is a big proviso, however: we still have only a few years' worth of evidence of joint performance among hip-resurfacing patients, so it is too early to tell whether these dramatically increased levels of activity involving high impact sports will also cause a decrease in the durability of the prostheses. Likewise, we have no long term follow-up studies yet on how the new materials affect the longevity of resurfacings.

Knees

With the exception of cross-country skiing, the general advice about avoiding impact sports is much the same as for hip replacements. But the reality is that when it comes to sports activities, total knee replacement seems to be far less forgiving. Several studies show that a significant number of patients do not return to their pre-replacement sporting activity[5,6]. At present artificial knee joints don't seem to be able adequately to reproduce the complex twisting mechanism of the natural knee and many enthusiasts find they are unable to maintain their chosen sports.

Diane Back & Angus Lewis

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These two cases reveal how the source of pain is not always the cause of the problem

CASE STUDY 1: The footballer's dodgy leg

Plagued by a succession of injuries to his right leg over the years, a semi-professional football player came to see me at my osteopathy clinic to help him sort out the sore right knee he'd had throughout pre-season training. After a match the knee would stiffen up and it would take a few days of icing to relieve the stiffness. This pattern had worsened to the point where he was no longer able to train.

His patellar tendon (lower knee cap area) was very tender. He'd had this tenderness before, he told me, but had always been able to run it off. Now, however, he could not train and his knee was stiffening up towards the end of a game. All the usual treatments of ice, stretching and rest worked only temporarily, with knee soreness always returning.

There was nothing immediately obvious when I examined the footballer's knee. But he did have a tight hip flexor muscle on that leg. He also had a sore Achilles tendon and transverse arch on the right foot, which he put down to old age (he was 31).

A case history that reveals recurrent niggling injuries over the years, especially on the same side of the body, is a big hint that core stability may be at the heart of a problem, because of poor functioning of the kinetic chain and lumbopelvic-hip complex (core area).

The kinetic chain

The 'kinetic chain' is the term we use to describe the interdependent operation of the body's:

- soft tissue system (muscle, tendon, ligament, fascia),
- nervous system, and
- articular system (joints).

These three major systems together enable us to make movements with the correct pattern – everything working in the right order and on cue. If they are not working together (muscles, nerves, joints), you will place increased demands and strains on the body, leading to fatigue and injury.

'Good core stability and neuromuscular efficiency protect us by allowing optimal shock absorption and the body to decelerate against gravity without injury'

How good the muscles in the kinetic chain are at working together to produce force, help decelerate, and maintain stability is known as the 'neuromuscular efficiency' of the kinetic chain. Good core stability and neuromuscular efficiency protect us physically by allowing optimal shock absorption and the body to decelerate against gravity without injury.

One of the most common reasons for poor neuromuscular efficiency in the core area is 'reciprocal inhibition'. The principle is that a tight muscle will cause a weaker nerve signal to be send to its opposing muscle. From a mechanical perspective a tight muscle will limit the range of movement through which its opposite muscle can move.

For instance, in the case of gluteus maximus (the large buttock muscle), a tight hip flexor muscle at the front of the hip mechanically will limit hip extension (backwards leg movement) and neurologically will decrease the force of the nerve signal to the buttock. In other words, the tight muscle at the front of the hip will make the rear hip muscle less efficient and weak, which in turn will adversely affect the function of the kinetic chain, increasing strain on the lower leg.

Back with my footballer, I noted that he had a hollow back, a slightly swayed-back posture, protruding abdomen, and when relaxed his feet pointed outwards slightly. He had a good foot arch. I decided to assess his kinetic chain and neuromuscular efficiency by asking him to perform an overhead squat test.

This would reveal whether his movement patterns were working in the right order and would show up any muscular weaknesses or imbalances.

When performing the overhead squat test, the footballer's feet started to collapse inwards and he felt much more comfortable with his feet turned out; his right knee buckled inwards during the squat and his lower back arched inwards even more, with his long back muscles being very tight. His neck also arched backwards.

From this, I could see that my client looked to be having a few problems with his right leg: tight calves, weak buttock muscles and a tight front hip. Among the potential resultant problems are increased strain on the knee (because of the inhibited buttock muscle); and overloaded front-of-thigh muscles, which will try to decelerate knee flexion and internal rotation, increasing the stress on the knee.

The weak buttocks may also cause overloading on the calf muscles, leading to a similar strain which can cause a sore arch and plantar fasciitis or an Achilles tendinitis. So some of the footballer's symptoms were starting to fit together.

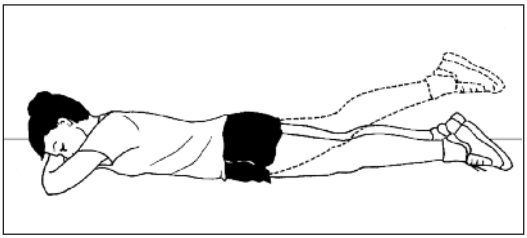
The footballer's rehab

What we needed to do here was to improve the footballer's neuromuscular efficiency, teach him to engage (switch on) his buttock muscles, and keep his lower back and front hip muscles well stretched. The starting point was to get my client to be able to switch his buttock muscles on and off. Once he could feel and use his gluteus maximus properly I used the following exercises[1]:

Prone hip extension

Technique

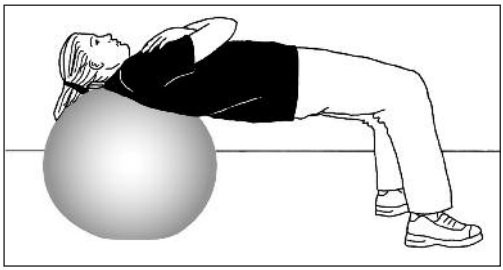
- Lie on your front, head resting on arms. Draw in abdominals,



relax neck and shoulders and tighten bum muscles (gluteals)
- Hold for 5 to 10 sec, then release
- Progress this to drawing one leg off the floor from the hip (don't bend knee), as high as the gluteal contraction will allow – without arching through the lower back or tilting pelvis.

Swiss ball bridge

Technique



- Lie face upwards, with shoulders and head centrally on the ball. Feet point forwards, knees in line and flexed to about 90 degrees.
- Draw in abdominals and squeeze gluteus maximus hard to raise hips upwards into a bridge. Do not arch through the lower back
- Hold, release carefully, and repeat.

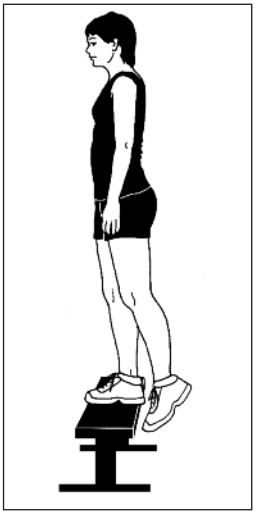
Lunge

Technique

- Stand upright, arms at sides, shoulders relaxed
- Draw in abdominals and lunge forward, maintaining good knee alignment (forward knee above second toe)
- Step back efficiently under control, and repeat
- Keep upright posture throughout
- Progress to sideways lunge and then backwards lunge (harder, needs good balance).

Step-ups

Technique



- Face a 30cm step
- Place one foot on step, draw in abdominals, raise body on to step and return slowly under control. Repeat
- Progress to a) sideways step up; b) holding dumbbells by your sides.

Conclusion

As the case of my footballer shows, core stability (or lack of it) can be the culprit responsible for all kinds of pain and/or dysfunction well beyond the core area (trunk) itself. Because of the way that the kinetic chain responds to critical weaknesses, both mechanically and neurologically, injuries arise that may initially seem to have little or no connection to core strength, but are in fact a direct consequence of the lack of it.

And finally, bear in mind that your postural problems may not have very much to do with your particular sport – they are as likely to emanate from poor posture when you are at work or simply relaxing at home.

Cameron Reid

Reference

1. V Gambetta , 'Building the Complete Athlete', *Optimum Sports Training Inc*, (2000)

CASE STUDY 2: Ben's buttock repair

I first saw Ben at my physiotherapy clinic eight weeks after a Grade II medial collateral ligament strain (inner edge knee ligament) on his right knee. He had been given very poor advice from the hospital where his knee was x-rayed (no fracture). He was told to rest for four to six weeks, after which he could return to his usual activities, which included road running and heavy physical training with the Army reserves.

After one month Ben had become concerned with his progress and sought his own treatment, so for the next four weeks a physiotherapist had given him knee massage, mobility and balance exercises, plus a homework programme to gradually increase the load that Ben's recovering knee ligament would bear. When I inherited Ben as a patient he was just starting to return to running, fully intending to enter the London Nike 10km race in a few weeks' time. But after a week of increasing his distances, he had begun to develop pain of a chronic nature towards the inside of his recovering knee.

This is a depressingly common phenomenon. Athletes frequently return from one injury only to fall victim to another; and an overuse injury that develops as an athlete increases their training load after a period of rehabilitating an acute injury is a prime example.

In my experience, most rehab programmes for athletes are insufficiently targeted to address specific muscle groups that will have become inhibited because of pain from the original injury and weakened through disuse. When the acute injury (in Ben's case, his sprained knee ligament) is physiologically ready for a return to training, these muscle groups are then expected to perform at the same level as before, despite weeks or even months having gone by since they were last functioning well.

Overuse injuries in the leg often result from the failure of stability muscles to hold the leg steady in good posture during the stance phase of running. So the pelvis, knee and foot all start to roll about, setting up faulty running mechanics and leading to overuse injuries such as Achilles tendinopathy, medial tibial stress syndrome (MTSS) or ITB friction syndrome.

Furthermore, it seems that after acute leg injury, gluteus maximus (large buttock muscle) activation decreases. This affects performance (reduced propulsive force and lumbopelvic stability), leads to overactivity of the hamstrings and lumbar spine (low back) extensor muscles, and is associated with reduced range of movement in hip extension. These changes can show up in a variety of painful ways, including low back pain or referred pain in the leg itself.

My troubled runner, Ben, was experiencing such problems. His knee had become very tender to the touch over the inner edge joint line. Video assessment of him running on a treadmill revealed his poor hip, knee and foot control on his right side. It appeared as though the stability muscles crucial for leg posture during running were functioning well below their pre-injury ability, creating this new chronic pain in Ben's knee.

I tested Ben's standing stability on his right side, by getting him to do single leg squats. The results confirmed what the video assessment had shown. Ben's squat control on the right was significantly worse than the left, with his leg and pelvis beginning, at about 50 degrees of knee flexion, to fall into the same out-of-alignment posture demonstrated on running. Ben also showed a key sign of poor buttock strength by his inability to maintain a neutral lumbar spine and bend at the hip on the lowering phase of the single leg squat.

'Video assessment revealed Ben's poor hip, knee and foot control on his right side. The stability muscles crucial for leg posture during running appeared to be functioning well below their pre-injury ability'

Ben's rehab had omitted one crucial aspect: strengthening of his buttock and lower front-of-thigh muscles. We started him on a series of exercises to make up the deficit. I prescribed two maximal repetition sets of single-leg squats. For the first set, Ben had to squat down to the lowest he could manage without losing control, to challenge his muscle groups to work through a large range. He improved at this very quickly. We then introduced the second set, in which he had to squat only to approximately half way but with dumbbells in both hands, to help build strength and endurance for his running. I asked Ben to use a mirror to ensure that he maintained correct foot, knee and pelvic position throughout.

We also included in the programme three maximal sets of

lunges (*ie*, performed at full depth and to failure or loss of positional control), with the same emphasis on control and alignment; plus exercises to strengthen the upper buttock muscle (gluteus medius) in isolation. Ben had to lie on his side with his underneath leg bent to 45 degrees and the upper leg straight and just behind the line of his back. He raised and lowered his upper leg with careful control and without shifting pelvic position.

Once Ben had mastered these exercises, there were just two more things to do before we could return him to the cold, rainy winter streets of London. Ben was already learning to pay close and continual attention to his leg posture, particularly when he was tiring. Now we added some tougher dynamic challenges to the target muscle groups:

- fast hopping, punctuated by stopping and holding a balanced position with the knee and hip slightly bent;
- quarter-turns in the air between hops;
- catching and throwing a ball while hopping;
- gradually making the hopping surface less stable.

Finally we took all this hard work and put it into Ben's running. He ran slowly on the treadmill, taking great care to resist his knee rolling in, just as he had been doing with all the exercises. As he became more comfortable with this change in technique, he gradually increased his speed and distance.

With all Ben's cross training on an elliptical trainer, bike and in the pool, the Nike run proved to be a breeze and best of all, by 12 weeks after his injury, he could run pain-free and carry 20kg packs up mountains again.

Sean Fyfe

You'll never hear a bad word about glucosamine, but here's the lowdown on whether there's any proof that it works

Glucosamine is a rare example of an 'alternative' supplement that has gained widespread mainstream credibility among both the general public and medical practitioners. Either by itself or in combination with chondroitin, glucosamine is used commonly by older people to help relieve pain from arthritic joints, and is also often advocated by therapists for clients recovering from soft-tissue injuries, in the belief that it promotes cartilage repair.

Such has been glucosamine's soaring popularity that in 2000, the US National Institutes for Health launched the biggest trial of the compound to date.

What is glucosamine?

Glucosamine is an amino monosaccharide (sugar), made within the body, and found in numerous tissues including the kidneys, liver and cartilage.

Most of the over-the-counter formulations are made from chitin, a natural polymer found typically in the shell of shellfish and other invertebrates. Manufacturers tend to offer three forms of glucosamine: sulphate, hydrochloride and N-acetyl-glucosamine, taken either as a tablet or liquid. Doses range from 250mg to 1,500mg.

Chondroitin sulphate is a glycosaminoglycan (like a sugar), and is an essential constituent of cartilage. The only way to

obtain chondroitin as a dietary supplement is from animal cartilage. There are no reputable dietary recommendations for safe consumption levels of a daily dose of chondroitin. Over-the-counter formulations vary widely, but most contain 400mg to 600mg of chondroitin.

The existing evidence base

There are no reputable studies that can answer the question of how either glucosamine or chondroitin work in the human body. We have no evidence that they repair existing articular cartilage, supplement the synovial fluid or nourish tissues in any way. While advocates of glucosamine and chondroitin report a reduction in pain and swelling, quicker soft tissue healing and prophylactic protection against damage to cartilage, we do not know how these compounds may do this.

'McAlindon's analysis highlights examples of varying doses, inadequate sample size, poor methodology, conflicts of interest and poor patient selection'

Some studies have suggested that glucosamine helps to relieve osteoarthritic pain by promoting the production of proteoglycans – an element found to be in short supply in damaged cartilage. Another theory suggests it may block the action of certain enzymes known to be increased in osteoarthritis. There is sparse clinical evidence for any of the theories.

While there is some evidence from both veterinary and human clinical trials that glucosamine may have a role in treating the pain of knee osteoarthritis, most of the trials fail to reach the most basic standards of research methodology. This doesn't stop the alternative health lobby seizing on the results as proof of glucosamine's efficacy.

If you want to read some of the studies, a good starting point is the meta-analysis (research overview) performed by McAlindon in 2000[1]. Three of the trials demonstrated that glucosamine performed better than placebo. However, McAlindon's analysis highlights among the studies examples of varying doses, inadequate sample size, poor methodology, poor randomisation, conflicts of interest with manufacturers and poor patient selection. More recent trials have been published but they also suffer from flaws[2-4].

The US trial

The US National Institutes for Health trial (the GAIT trial), launched in 2000, was a multi-centre randomised double blind control trial, comparing:

i. glucosamine hydrochloride alone
ii. chondroitin sulphate alone
iii. glucosamine and chondroitin in combination
iv. celecoxib (a Cox 2 anti-inflammatory painkiller)
v. a placebo.

This trial, based in the United States, recruited 1,583 participants in 16 trial centres. Patients over the age of 40 with knee osteoarthritis were eligible. All subjects participated in the main trial. This looked at pain reduction in patients suffering from knee osteoarthritis over a 24-week period. The participants were reviewed at 4, 8, 16 and 24 weeks. A subset of subjects continued taking their formulations over an 18-month period, to examine any effects in moderating the progress of their osteoarthritis.

Initial results were presented in November 2005 at the annual meeting of the American College of Rheumatology and a definitive article was published in the New England Journal of Medicine in 20065. We are still awaiting the report of the trial on whether glucosamine or chondroitin were found to have any effect in slowing down the progression of knee arthritis.

What the GAIT trial found

Remember, this study was the gold standard, a randomised double blind trial on more than 1,500 patients, taking glucosamine hydrochloride or a combination of other drugs. Overall the results showed no difference in pain reduction in those patients who took a placebo, versus only glucosamine, versus only chondroitin, versus a combination of glucosamine and chondroitin.

However, the researchers analysed a second subset of patients selected from the original 1,583, who were classed as having moderate to severe osteoarthritis. These patients

recorded a significant improvement when using a combination of chondroitin and glucosamine. They have now concluded that a combination of glucosamine and chondroitin sulphate 'may be effective in the sub-group of patients with moderate to severe knee pain'.

To complicate matters…

Further confounding the issue is a European study[6] which was also randomised and double blind, performed in Spain in 2003, which compared glucosamine sulphate, acetaminophen (Tylenol) and a placebo. This study showed a significant reduction in pain in the glucosamine group.

Why the results are different is hard to explain. The Spanish study was industry funded and did have significantly fewer participants. The Spanish researchers have claimed that what made the difference was their use of glucosamine sulphate as opposed to the hydrochloride used in the US study. The American researchers feel that the discrepancies may be explained by higher pain thresholds and more severe pain at the starting point in the European patients.

A further three-year trial, looking at knee osteoarthritis in post-menopausal women[7], reported in 2004 that participants did get a significant benefit. Here again, though, the scoring methods they employed are controversial and not properly validated for the researchers' purpose.

So despite more trials being published, as it stands there is some evidence that glucosamine sulphate on its own and glucosamine hydrochloride with chondroitin may reduce the pain of knee osteoarthritis in moderate to severe cases.

We have no evidence for repairing cartilage, maintaining cartilage health, promoting joint lubrication or any of the many other claims. Can we say it is of use to athletes as a prophylactic measure to prevent cartilage damage? No. Can we say it will quicken healing? No. It feels, for all the weight (and the wait) of the five-year US trial, that we are no nearer an answer on which to base therapeutic advice.

Diane Back

Is glucosamine any good? The bottom line

The following extract taken from the editorial of the New England Journal of Medicine, reporting the full results of the five-year GAIT glucosamine trial

On the basis of the results from GAIT, it seems prudent to tell our patients with symptomatic osteoarthritis of the knee that neither glucosamine hydrochloride nor chondroitin sulfate alone has been shown to be more efficacious than placebo for the treatment of knee pain. If patients choose to take dietary supplements to control their symptoms, they should be advised to take glucosamine sulfate rather than glucosamine hydrochloride and, for those with severe pain, that taking chondroitin sulfate with glucosamine sulfate may have an additive effect. Three months of treatment is a sufficient period for the evaluation of efficacy; if there is no clinically significant decrease in symptoms by this time, the supplements should be discontinued. Furthermore, there is no evidence that these agents prevent osteoarthritis in healthy persons or in persons with knee pain but normal radiographs (x-ray).

Marc C. Hochberg, 'Nutritional Supplements for Knee Osteoarthritis – Still No Resolution', *NEJM* 38 (2006) 8, pp 858-860

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What the sports scientists have been discovering recently about knees – and what our own expert makes of their findings

Report 1: women and their ACLs

It is widely accepted that women and girls are more vulnerable to ACL injuries than men. The anterior cruciate ligament (ACL) is the most commonly damaged ligament of the knee, accounting for up to half of all knee ligament injuries. But among women ACL injury rates are four to eight times higher than for men. In the US alone, 38,000 women a year injure an ACL.

When you take part in sport, and especially team sports, you accept as an occupational hazard the fact that you are going to have a 'contact' injury from time to time. But it seems that women are not damaging their ACLs through contact injuries. The leading causes are non-contact mechanisms such as landing badly, heavy impacts and rapid decelerations.

Researchers in the United States, aware of these predisposing factors, set about developing and testing out a 'prehab' (preventive) training programme to help reduce non-contact ACL injuries. Twenty-eight women were randomly assigned into control and treatment groups. The treatment group took part in two 'prehab' training sessions a week for nine weeks, while the control group did nothing.

To assess improvements in landing strategies, the scientists measured how heavily and fast the women landed during a 'step land assessment' (step from a height of 69cm, landing with

both feet on a plate that measures the force of landing). Measurements were taken before and after the nine-week training period.

Compared to the control group, the women who had been through the prehab training managed to lower their impact levels. The scientists felt that this reduction of impact forces was conducive to a lowered risk of knee injury during landing. They believe their low intensity and low volume training programme could be incorporated into an individual's conditioning schedule with minimal disruption to overall training.

Nick Grantham comments:

Why wait until you get injured? Check out with your team coach, personal trainer or sports conditioning coach whether you are at risk by getting them to assess and correct your landing technique when you jump. In particular, be sure that you are:

- positioning your hips, knees and ankles correctly when landing
- aware of the sound of your impact – you shouldn't sound like a fairy elephant

And why not incorporate the researchers' nine-week programme into your conditioning routine, with two sessions per week of the following:

Phase 1 (2 weeks)

Wall jumps: stand facing a low wall, jump on and off on your toes with arms overhead. 10 reps, 3 sets
Jump tucks: jump bringing knees up to chest. 10 reps, 3 sets
Standing broad jump: stand feet shoulder-width apart, and jump forward as far as possible landing with both feet. 10 reps, 1 set
Bound in place: jump off one leg and land on the opposite one. 10 reps, 2 sets each leg.

Phase 2 (2 weeks)

Wall jumps: 10 reps, 3 sets
Jump tucks: 10 reps, 3 sets

180 turns: make a vertical jump with a 180-degree turn. 5 reps, 2 sets each direction
Double leg hops: two consecutive broad jumps 5 reps. 2 sets

Phase 3 (2 weeks)

Jump tucks: 10 reps, 3 sets
Single-leg lateral hop: hop sideways diagonally at 45 degree angle. 5 reps, 3 sets each leg
Single-leg forward hop: 5 reps, 2 sets each leg
Combo: Double leg hops x 3 with vertical jump at end. 5 reps, 1 set
180 turns: 5 reps, 3 sets each direction
Single-leg lateral hops: 10 reps, 2 sets each leg.

Phase 4 (3 weeks)

Wall jumps: 10 reps, 3 sets
Single-leg forward hop: 3 reps, 3 sets each leg
Combo: Double leg hops x3 with vertical jump at end. 5 reps, 2 sets
180 turns: 5 reps, 4 sets each direction
Standing broad jump 10 reps, 2 sets
Single-leg lateral hops: 10 reps, 2 sets each leg

Research reference:
'Effects of a Knee Ligament Injury Prevention Exercise Program on Impact Forces in Women', *Journal of Strength and Conditioning Research*, 2004; vol 18, no 4, pp 203-207

Report 2: gender shifts

Part of the explanation as to why women are more prone than men to ACL injury and patellofemoral pain is thought to lie in gender differences in leg biomechanics. Trunk, hip and knee muscles influence the orientation of the leg during weight-bearing activities (running, jumping, walking, standing *etc*). US researchers recently investigated core strength and lower limb

alignment during single-leg squats, using 24 male and 22 female athletes.

The research team wanted to explore three types of difference between men and women:

- orientation of the leg during single-leg squats
- strength of the muscle groups in the trunk, hip and knee
- the association between trunk, hip and knee strength and the orientation of the knee during the squat.

The results confirmed that men and women move in opposite directions during a single-leg squat. The women typically moved into a more forwards posture while the men tended to move toward a more neutral alignment. For every muscle group except for the lumbar extensors, the female athletes demonstrated lower average isometric torque (holding muscle power) values than males.

Put more simply, the less gluteal strength you apply, the more likely you are to push your knee forward during the squat down. It would make sense to suggest that female athletes should work hard to optimise their strength around trunk, hip and knees, focusing especially on developing the strength of the external hip rotators (gluteus medius and maximus).

Nick Grantham comments:

The single-leg squat is a great way to develop leg strength, control and stability, but if you have trouble stabilising during this movement, try a couple of preparatory exercises that isolate the appropriate muscles.

i. Bent leg hip abduction (resisted clam)

Lie on side with knees bent to 90 degrees and hips flexed to 45 degrees. The soles of your feet should be in line with your spine. Wrap a resistance band around both thighs to resist the movement. Raise the top knee, keeping the feet together, and without rotating your spine or moving your hip at all. The hip and shoulder should remain in line. Aim for 10 reps during week 1, and add two reps each week.

ii. Straight leg hip abduction
Lie on side with both legs straight and the body in a straight line. The top leg is slightly pulled backwards (hyper-extended) from the hip, and the leg is turning inwards so the toe points down (internally rotated). From this position, raise the leg straight up, taking care not to move the position of the hip, pelvis or leg rotation. Aim for 10 reps with good technique to start, adding two reps per week.

Research reference:
'Core strength and lower extremity alignment during single-leg squats', *Medicine and Science in Sports and Exercise*, 2006: vol 38, no 5, pp945-952.

Report 3: decline to squat

The single-leg squat performed on a decline board (downward slope) is a key knee rehab exercise, particularly for patellar tendinopathy. It is thought to be one of the best ways to achieve maximum loading of the quadriceps muscles working against gravity. Now researchers based in the Netherlands have investigated this movement to examine just how effective it is at doing this job.

Trial participants performed single-leg squats at decline angles of 0, 5, 10, 15, 20, 25 and 30 degrees on a board that was placed over a force plate. At angles of more than 30 degrees they tended to slip off the slope because of the steepness – which is interesting because the standard recommended decline angle used to be 45 degrees!

All subjects performed the squat standing on their dominant leg. The other leg was kept forward during the downward movement. The investigators also wanted to see what effect different limb positions and additional weight would have on the outcomes. With the board at a decline angle of 25 degrees, the subjects performed the following variations:

- squatting down using additional weight (10kg backpack);
- returning to the starting position using the dominant leg;
- keeping the other leg backward instead of forward.

The researchers found that performing a single-leg squat on a decline board of 15 degrees or more results in a 40% higher knee moment and thus patellar tendon force compared to the same exercise performed on a flat floor. It did not make any difference whether the non-squatting leg was placed forwards or backwards. Adding a 10kg backpack produced a 23% increase in knee moment – more than anticipated, but explicable by the positioning of the load on the back.

The research team concluded that any board between 15 and 30 degrees could be used as a rehabilitation tool. They suggested that athletes who need to withstand high tendon loading should consider adding weight to the exercise.

Nick Grantham comments:

As with all rehab and training work, make sure you apply the principle of progressive overload, by following these tips.

1. Start with a gentle decline and gradually increase the angle up to a maximum of 30 degrees.
2. If you need to generate greater tendon loads, increase loading gradually.
3. Choose the most comfortable position for the non-squatting leg, as it makes no difference to the effectiveness of the movement
4. To prevent potential problems with excessive patellofemoral load (kneecap strain), avoid squatting down to more than a 60 degree bend at the knee.
5. Start conservatively with a low number of repetitions (*eg* 2 to 5) which can be completed with perfect technique and minimal fatigue. It is pointless training this type of movement in a fatigued state.
6. Don't change too many variables (angle, reps, loading) at once. Take one step at a time.

Research reference:
'Biomechanical analysis of the single-leg decline squat', *British Journal of Sports Medicine*, 2007: vol 41, no 4, pp264-268

Report 4: VMO strengthening

Patellofemoral pain, which used to be more commonly called 'anterior knee pain', is often associated with the atrophy of the vastus medialis obliquus (VMO) muscle: part of the quadriceps group located on the inner side of the lower thigh, just above the kneecap *(see page 86 for illustration)*. Numerous studies have shown the importance of developing appropriate levels of VMO strength as part of the successful treatment of knee disorders.

'Cycling forms the cornerstone of many early exercise and rehab programmes for people suffering from patellofemoral disorders'

Cycling forms the cornerstone of many early exercise and rehab programmes for people suffering from patellofemoral disorders. With this in mind, a research group based in Texas has been investigating the most effective cycling technique to maximise VMO muscle activation. The researchers postulated that preferential VMO activation would take place during cycling if the heel was placed on the pedal instead of the ball of the foot, and the foot was turned outwards.

To test the theory the research team enlisted the help of 40 men and women: 22 asymptomatic controls plus 18 symptomatic subjects. The 'symptomatic' group had all been diagnosed by an orthopaedic surgeon as having patellofemoral pain after they had answered yes to one of the following questions:

i. Do you experience pain from ascending or descending stairs?
ii. Do you experience pain from squatting?
iii. Do you experience pain from being seated for long durations or 'stadium seating'?

Each subject completed a series of rides using either a traditional cycling foot position or the 'open stance' cycling foot position. The riders had to maintain a cadence of 85rpm at a previously established personal 'maximum resistance'. Electrodes were

attached to the vastus lateralis (VL) and VMO muscles, and surface electromyography (SMEG) recordings were taken at 5, 10, 15 and 20-minute intervals.

The results indicated that there was a significant difference in the ratio of muscle activity between the VL and VMO between the two different cycling positions. The researchers concluded that biomechanical alteration of the foot position was responsible for the increased activation of the VMO.

Research reference:
'Preferential Vastus Medialis Oblique Activation Achieved as a Treatment For Knee Disorders', *Journal of Strength and Conditioning Research*, 2005; vol 19, no 2, pp 286-291.

Report 5: more VMO strengthening

This alternative approach to VMO activation comes from Canada, where researchers have come up with two more ways to recruit this key muscle. Twelve symptomatic subjects (suffering with anterior knee pain) completed the study: four men and eight women aged 15 to 22. The subjects undertook a series of exercises in which VMO activity was measured and compared. The two main exercises were squats and leg extensions, and each movement was performed with three different variations: internally rotating the leg, keeping it in 'neutral' and externally rotating it. Each exercise was performed three times and held for 5 secs to determine the level of VMO activation.

The results showed that the position of the lower leg clearly affects the muscle activation of the VMO. During the leg extension movements the study showed that inward rotation brought about the highest level of muscle activity – a very interesting result, as this particular way of performing the exercise is not commonly prescribed at the moment. During the squats to 60 degrees, the highest levels of VMO recruitment were found when the hips were turned outwards.

Nick Grantham comments:

If you are interested in incorporating the researchers' results into your knee rehab, try the following regime:

i. seated knee extensions with foot pointing inwards: slow and controlled tempo, 15 to 20 reps, 1 to 3 sets
ii. partial squats with hips turned out: slow and controlled tempo, 10 to 15 reps, 1 to 3 sets

Research reference:
'Activation of Vastus Medialis Obliquus Among Individuals with Patellofemoral Pain', *Journal of Strength and Conditioning Research*, 2005: vol 19, no 2, pp302-304.

Report 6: magic shoes?

The knee joint is a common site of osteoarthritis, causing sufferers pain and stiffness and decreased physical function. It has been suggested that proper footwear can help to reduce the pain of arthritis by improving balance and/or increasing leg muscle strength. This is, however, a relatively unexplored area.

MBT makes a shoe that is used as a medical training device. The concept of the multi-layered sole is to change flat, hard surfaces into natural, uneven ground, which demands increased leg muscle activity. Anecdotal evidence suggests that the proper daily use of the MBT significantly reduces pain and discomfort by strengthening the small leg muscles, and one research study has linked reduced knee-joint loading during walking with reduced pain in people with osteoarthritis.

Canadian researchers from the University of Calgary put the MBT to the test, using 123 subjects with knee osteoarthritis. The researchers measured a large number of indicators, such as pain levels, joint stiffness, balance, ankle power and range of movement at weeks 0, 3, 6, 9 and 12.

Each subject in the MBT group was given an instruction session to ensure they walked according to MBT technique.

'Canadian researchers put the MBT to the test, measuring a large number of indicators, such as pain levels, joint stiffness, balance, ankle power and range of movement'

They were asked to increase their wearing of the MBTs over three to four days, and thereafter to wear the shoes as much as possible. The control group received a pair of high-end walking shoes (New Balance 756 WB) and an identical wearing schedule.

The research team concluded that there were no significant differences in pain reduction, nor improvement in static balance, between the MBT shoe and a good walking shoe. They did find that the MBT shoes were effective at reducing their subjects' knee pain after 3, 6 and 12 weeks. The subjects' standing balance also improved during the 12-week period.

A good walking shoe was also effective at reducing pain after 3 and 12 weeks. The main difference between the two shoes was that the reduction in pain was more immediate for those using the MBT shoe. Overall, however, the reduction in pain during the 12-week period was similar for both groups.

Nick Grantham comments:

Should you rush out and buy a pair of MBTs? I would suggest you may want to invest in a pair of high-end walking boots and use them to walk over some natural uneven ground for similar results. Combine that with simple balance exercises each day, such as standing on one leg with eyes open and eyes closed, and I reckon you will be able to get similar benefits to those experienced by the subjects in the study using the MBT shoes. The research shows that both types of shoes help reduce the symptoms of knee osteoarthritis; the question of which method you prefer really is up to you.

Research reference:

'Unstable shoe construction and reduction of pain in osteoarthritis patients', *Medicine and Science in Sports and Exercise*, 2006: vol 38, no 10, pp1701-1708.

Report 7: Winning poles

Hiking is one of the world's most popular recreational pursuits. Whether you take a short hike or embark on a major expedition, the chances are that you will use a backpack to carry your essentials (flask of tea, Kendal mint cake *etc*). While there are many positive effects to be gained from taking to the hills, hiking is often not an injury- or pain-free pastime – with leg joints and muscles being the obvious vulnerable spots.

Indeed the forces generated by a combination of a heavy backpack, undulating terrain and significant amounts of downhill walking expose the body to impacts similar to those experienced during running.

'The use of trekking poles helps to reduce muscle activity around the ankle and knee, and limits potentially damaging loading at the hip'

This isn't such a huge problem if you are already fit, but hiking is a mass participation pursuit and many of its adherents may not be in great physical condition. Research has already shown that the use of hiking poles can reduce the forces placed on the lower limbs. Now, a team based at the University of Western Illinois has investigated how useful these poles are if you are carrying a heavy pack.

Fifteen male hikers who volunteered for the study were required to walk down a 20-degree gradient. All participants repeated this exercise while wearing a large expedition pack (30% of participant's body weight), a smaller day pack (15% of body weight), and no backpack, while using two hiking poles and no hiking poles.

The results showed that the use of trekking poles was effective in reducing many of the contributing factors to pain and overuse injuries during downhill hiking. The use of poles helps to reduce muscle activity around the ankle and knee and limits potentially damaging loading at the hip. The study also showed reductions in eccentric loading of the lower limb musculature, thereby reducing the potential for damage at a cellular level and problems associated with DOMS (delayed onset muscular soreness).

It would appear that the trekking poles reduce the loading in two ways: by absorbing some of the potentially damaging impact forces; and by increasing the walker's stability.

Nick Grantham comments:

If your holiday budget doesn't stretch to the purchase of trekking poles, here are a couple of exercises that will help to strengthen the legs ready for the impending expedition.

i. Lunge

Hold barbell on shoulders or dumbbells at sides and stand in a split stance, feet about 3ft apart. Bend knees and lower into lunge position, keeping body erect. Keep both knees at 90-degree angles. Push through the front heel, squeeze your bum muscles and slowly lift up to starting position. Make sure your front knee stays behind the toes. Perform 2 to 3 sets, 5 to 10 reps each side, slow and controlled

ii. Swiss ball squat

Begin by placing the Swiss ball between a wall and your lower back (in the small of your back). Place feet shoulder width apart and far enough forward to perform a squat. Squat down until your thighs are parallel to the floor. Remember to push up through heels, not toes. Perform 2 to 3 sets, 10 to 15 reps, slow and controlled

Research reference:

'Effects of hiking downhill using trekking poles while carrying external loads', *Medicine and Science in Sports and Exercise*, 2007: vol 39, no 1, pp177-183.

Cate Streeten's guide to understanding and fixing your own niggling knee injuries

Knee pain, whatever the underlying cause, can be anything from a mild nuisance to completely debilitating, forcing a lifestyle change. One of my clients had no choice but to sell her family home, as she could no longer cope with the stairs. I hope you would have sought help long before considering selling your house!

Sporting injuries to the knee can affect people at any stage of their lives. Often the injury is directly related to the activity itself, as in the golfer who experiences a catching pain in the knee during the follow-through phase of the swing, or the tennis enthusiast whose knee gives way after being wrong-footed.

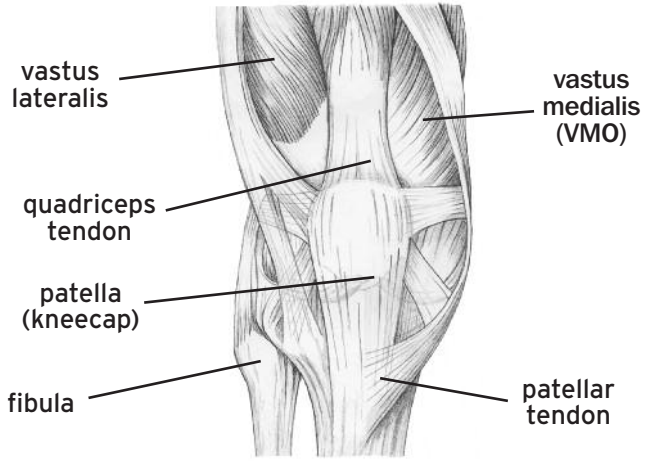
In other cases the cause of the injury may be unclear. Take for example the runner whose knee gradually tightens until it becomes painful during a seemingly innocuous run. There are likely to be many influencing factors relating to this kind of scenario. Footwear, running technique, and stretching (or lack of it) would be a few things to consider.

'Non-sporting factors can have a strong bearing on a 'sports injury'. A nurse who has had a busy duty may take certain elements of fatigue into her run'

And non-sporting factors can have a strong bearing on what seems to be a sports injury. A nurse who has had a busy duty may take certain elements of fatigue into her run; a deskbound office worker may have postural issues that affect good running technique.

In any event, a certain amount of self-assessment is always useful, especially if you want to manage the problem yourself. Consider which aspects of your lifestyle and training might have

Figure 1:
The kneecap with surrounding muscles and tendons



led to the onset of injury. How might you alter these to minimise the risk of reinjury? Even if your knee pain is the result of direct trauma such as a knock or twist, there may be factors you can change to reduce the chance of a repeat incident.

Think, for instance: if you were already tired from an extra tough day at work, might it not have been wiser to either have a 'recovery' day or just play/run a 'loosener', rather than further challenge your body's reaction times and adaptability? A little time spent reflecting will often allow you to see some startlingly obvious answers as to why you are getting pain and / or how to reduce your risk of damage in future.

When to call in the experts

It is important to be aware that we are all different and what may work for one person will not necessarily work for another. Do not be disheartened if, having performed your exercises conscientiously, you make no improvement. If this is the case or, indeed, if you are getting worse, I would urge you to seek the advice of a chartered physiotherapist who specialises in musculoskeletal conditions, or your GP.

You should also seek professional advice for any situation where there is:

- locking of the knee
- sharp catching
- definite giving way, or
- persistent swelling.

A trip to a surgeon is not necessarily going to be the outcome. Some knee complaints certainly require the attentions of the surgeons and no amount of exercise and ministrations by therapists will avoid this. But other conditions may respond favourably to manipulation and specific exercises. Physiotherapists and other health professionals can use certain mobilising techniques to decrease pain and optimise the function of your knee. They should also check and alter your exercise programme accordingly.

Self-help

The knee conditions that usually respond well to the self-help approach are:

- patellofemoral joint (PFJ) pain, and
- meniscal pain.

In both PFJ and meniscal problems the pain may present in varied ways. It may, for example, be sharp or dull, localised or general. The aggravating factors may be totally predictable – 'every time I come down the stairs' – or frustratingly random – 'one day I can run for an hour without complaint but the next day I can't rise from a chair without pain'.

The patellofemoral joint is the point where the kneecap (patella) comes into contact with the thigh bone (femur). Normally the patella fits reasonably snugly into a groove on the femur, kept in place and controlled by muscles and connective tissues. For various reasons this fine balance gets disrupted, causing malalignment or poor tracking of the PFJ.

As a result of research, certain exercises have been developed to help restore the balance of the forces that act upon the joint.

The exercises are aimed at improving the function of the quadriceps muscle group at the front of the thigh, in particular the VMO – the small muscle on the inside of the knee at the base of the quadriceps *(see Figure 1 on page 86)*.

Sports commonly associated with PFJ pain are running and cycling. They involve a relatively straight-line motion of the knee and a great deal of repetitive movement in the joint. Any small alteration in the mechanics of this joint can have a profound effect on its function and resultant pain. The initial symptoms may not even be painful: people regularly report a feeling of tightness in the knee at first. Or it may be as simple as 'just not feeling right'.

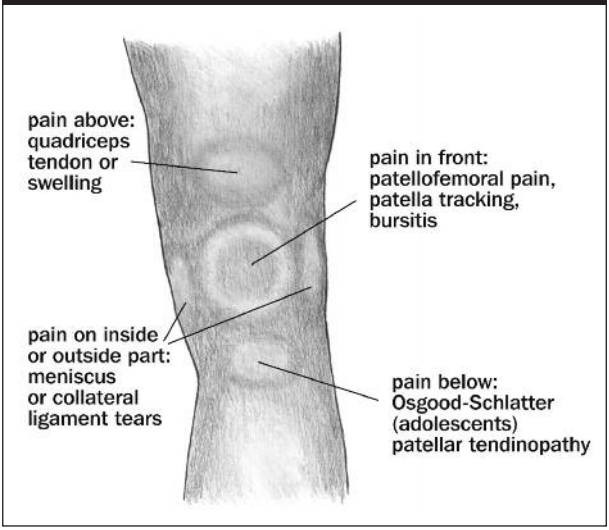
Meniscal pain arises from injury to the structures that lie between the shinbone (tibia) and the femur. These are the lateral and medial menisci, more commonly known as the cartilages. The menisci play an important role in knee motion and shock absorption. They can be damaged through trauma (as in a sporting injury) or as part of a degenerative process over time and with ageing.

'Links between injuries and types of sport are no more than a guide. Just because you are a runner, it does not mean your knee pain is automatically going to be PFJ-related'

Meniscal problems classically crop up in sports involving 'twisting' movements. The obvious ones are skiing, football and tennis, but even less apparently strenuous sports such as golf and yoga can cause problems. If you've ever attempted a technically correct drive off the tee or a half lotus position, you'll be aware of the rotational (twisting) forces going through the knee.

Remember, however, that the links between injuries and types of sport are no more than a guide to help with your self-diagnosis. Just because you are a runner, it does not mean your knee pain is automatically going to be PFJ-related. Many a doctor or clinician has puzzled over what the pain is attributable to in a particular case. The presentation of symptoms can occasionally be confusing. Many people play more than one sport, which will put the knees under a variety of stresses. A 50-year-old keen hill walker who plays singles tennis during the week could have any number of symptoms, the causes of which may take weeks to unfold.

Figure 2: Location of pain



Listen to your body

The key to self-management of knee pain lies in listening to your body. If it feels wrong, don't do it. Do not be tempted by the 'no pain, no gain' ethos.

Continuing to exercise through pain is unwise and can have far reaching adverse effects.

So once you have recognised the problem and decided to try these targeted exercises as a self-help solution, you will need to think about altering your activity schedule. In some cases you may negate or undermine the effect of a targeted exercise programme by carrying on with your usual fitness activities as well. I would firstly cut out any sports or general exercise as these are most likely to be the aggravating factors. Feel free to play around with the self-help exercises to find a routine that works for you.

The two most perplexing questions if you are trying to rehabilitate your own knee pain are probably these:

- 'How do I know I'm doing it right?'
- 'How will I know if I need to seek help?'

Put simply, you'll know you've got it right if your symptoms improve. It's mainly about patience plus common sense. No one can tell you exactly when you will be ready to resume your chosen sport, as there are no recipes. Someone who describes raging pain at the end of a 30min run may expect to take longer to recover than the hill walker who gets mild discomfort after a weekend hike. Measure your expectations and be realistic about them.

You should judge your return to your normal activity pattern and / or sport on the basis of the effort you have been putting into your recovery, as well as by how much you have managed to reduce the original symptoms. You may need to graduate your return to activity. Don't expect to be able to resume playing 18 holes immediately, if your limit has been nine holes while you've been injured.

Keep a record

I advise clients to keep a record of their exercises and symptoms, along with their return to activity. It is up to you to decide how much detail to record, and will probably be related to your sporting level and aims.

You might choose to keep a very simple note such as:
'played for 20mins before mild pain. Stretched and was able to keep playing for another 20mins before fatigue set in.'

A more detailed account might include notes on:

- daily exercises performed
- terrain you trained on
- level of exertion
- amount of pre- and post-exercise stretching.

Hopefully you'll see patterns emerging, relating to your pain levels and return to sport.

How to interpret pain

Trust your instincts on whether to seek help. Even if your symptoms don't come within the categories I listed above requiring professional attention, there are bound to be grey areas that raise doubts in your mind about what's best to do.

At no point should you feel that the exercises are aggravating your symptoms. Ideally you should not experience any pain or discomfort related to your symptoms during an exercise. But be prepared to experiment a little if you do find any of the exercises painful. In particular:

- you should perceive the pain as mild, not acute or limiting
- the pain should not linger once your programme is completed
- the pain should certainly not worsen your symptoms
- any exercise-induced discomfort should taper off over time and disappear as you progress.

A good guide is that every week you should feel less pain with the exercises. If you consistently feel pain with exercise, try changing your technique slightly. By altering your 'knee over toes' alignment, for example, you may significantly reduce or abolish the pain. Try reducing the intensity or depth of movement. Think about starting with only one exercise and building up from there. This would allow you to determine which exercise in particular may be problematic.

'If you consistently feel pain with exercise, try changing your technique slightly. By altering your 'knee over toes' alignment, for example, you may significantly reduce or abolish the pain'

Overall you should be able to chart a gradual improvement. If not, seriously consider seeing a professional. One visit may be all you need to allay your fears, and should certainly put you on the road to recovery, whether it is advice only or getting the ball rolling with further assessment and investigation. The sooner you start dealing with the problems confronting you, the sooner you'll be back playing or working out.

The rehab exercises

The following exercises are my favourites for most types of knee problem.

These exercises are designed to be used for any level of pain and dysfunction (bearing in mind my comments above about the kinds of symptoms for which you should seek professional help).

Try to think activity- or sport-specific as you exercise. The lunge, for example, is similar to some tennis shots or part of the movement required to take your successful ball out of the cup on the 18th green!

There are no hard and fast rules about how many times you need to repeat each exercise. If three repetitions is all you can do before losing your technique, then stick with three at first.

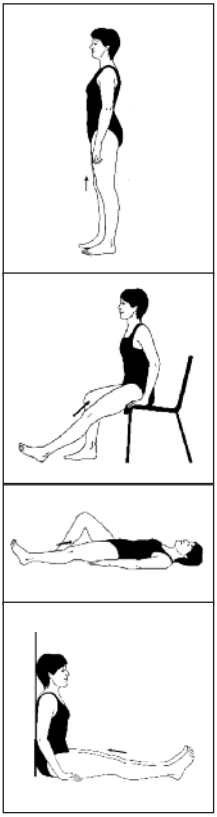
It really matters that you focus on correct technique and getting the basics right. You will achieve more by performing a few repetitions of one or two exercises correctly than five or six half-heartedly. Aim to do three formal blocks or sessions of exercise daily, but do what suits you best. A lot of the exercises can be incorporated into daily activities.

Be patient. You may notice a change within days, but it may take up to six weeks to feel an appreciable difference.

Static quads contraction with VMO focus

Muscles targeted

Quadriceps (front of thigh group), especially the VMO



Technique

Can be done in standing, lying, sitting on the floor or perched on the edge of a chair with heel resting on the ground. Perform exercise with knee(s) straight. The exercising knee should point forwards or be slightly turned out. Work both knees at the same time if possible.

Brace knee hard by tightening your thigh muscles. This will lock your knee into a fully straight position. If sitting on the floor, your heel may rise off the floor while the back of your knee remains in contact.

Imagine trying to pull your kneecap up the line of your thigh towards you, using the inner knee and thigh muscles. In standing you will feel your posture draw up with it, and you may feel the top part of your buttock tighten as well.

Draw up the kneecap, hold hard for 5 sec, relax and repeat.

Sets/Reps
Aim to do at least 10 reps like this in one session (set), but even if you only do 1, it's better than none. As long as there is no pain, repeat the set as many times as possible throughout the day.

Progression
This is a stand-alone exercise with no obvious progression. It is a staple exercise, and once you are in the habit of doing it, just carry on for ever!

Cautions
Stop if you get pain and/or swelling.

Modified thigh stretch

Muscles targeted
Quadriceps (front of thigh)
hip flexors (front hip)

Technique
Stand in front of a dining chair or furniture of similar height with your back to it. Place foot of the leg to be stretched on the chair behind you. You may want to hold on to something as you do this, to help your balance.

The sole of your foot will face the ceiling, knee bent. The other leg should be positioned slightly forwards, straight but relaxed. Stand tall and arch the top of your back. Push your hips forward until you feel a long, comfortable stretch down the front of thigh. You may feel a stretch in the front of the hip as well. Hold for 15 to 20 sec, ensuring you keep breathing and feel the stretch throughout.

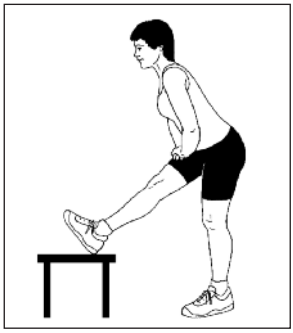
Sets/Reps
Repeat stretch 3 to 4 times. Try to perform this set at least twice a day.

Adaptations
Once you feel the stretch, keep holding it while you turn your body away from the side you are stretching. You may feel the stretch shift towards the outside of your thigh, but probably with a less intense feeling than the first stretch. Again, hold for 15 to 20 sec. Alternate this stretch with the first one, or perform it on its own.

Cautions
Do not continue if you feel pain and/or swelling. Be wary if you feel strong pressure behind the kneecap – try lessening the angle of your knee.

Hamstring stretch

Muscles targeted
Hamstrings (back of thigh)
Popliteus (back of knee)



Technique
Stand in front of a low chair or step with hips equal and facing forwards. Place the heel of the leg you wish to stretch on the chair / step. Keep the knee straight and foot relaxed, or pull the toes gently towards you. You may feel a stretch in the back of your leg already. Put your hands on the top of your knee above the kneecap and apply gentle pressure. If this is enough of a stretch you need do no more. To increase the intensity lean forward slowly from the hips, keeping your back straight. The stretch ought to be strong but comfortable. Hold for 15 to 20 sec, ensuring you keep breathing and feel the stretch throughout.

Sets/Reps
Repeat stretch 3 to 4 times. Try to perform this set at least twice a day.

Cautions
If you have a history of sciatica or back pain this stretch may

aggravate your symptoms. Be extra cautious when you start doing this stretch, and stop if you feel any such symptoms, no matter how mild. Consult your therapist if you are being treated for back-related problems.

Calf stretch

Muscles targeted
Gastrocnemius (upper calf)

Technique
Stand with feet hip- to shoulder-width apart, and then step back so that the leg you are stretching is about 2ft behind the other. Keep your hips level and back straight. Use a wall for touch balance in front if you wish. Keeping the heels down on both feet, lean forward by bending the front knee. The back leg must be fully straight. Feel a strong, comfortable stretch in the top of the calf. Hold for 15 to 20 sec, ensuring you keep breathing normally and feel the stretch throughout.

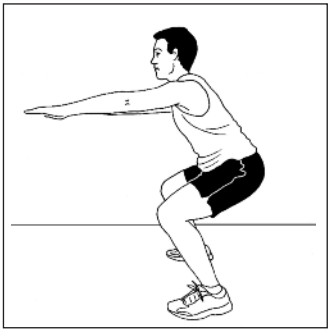
Sets/Reps
Repeat the stretch 3 to 4 times. Try to perform this stretch at least twice a day.

Cautions
If you have a history of sciatica or back pain this stretch may aggravate your symptoms. Stop if you feel any such symptoms. Consult your therapist if you are being treated for back-related problems.

Squats

Muscles targeted
Quadriceps (front of thigh)
Gluteals (buttock)

Technique



Stand with feet shoulder-width apart. Your foot position should feel natural; for most of us this is with the feet pointing a little outwards. Lean slightly forward from the hips. Arms can be relaxed at your sides or out in front. Squat down, keeping knees in line with your 2nd and 3rd toes.

Start by bending knees to an angle of about 45degrees, then straighten them, ending with a full lock. Focus on pushing into the floor throughout, as though you are trying to increase the weight when standing on bathroom scales. On the return movement, imagine you are pulling your knees up your thighs, using the inner muscles, and tighten your buttock muscles.

Sets/Reps

2 to 3 sets, 15 to 20 reps

Progressions

i. increase the depth of the squat
ii. Try to make the squat sport specific. A skier may need to increase the number of reps for improved endurance. Bring a rotation element into it for twisting activities by squatting down at an angle. Make sure you move in both directions! Keep the alignment of knees over toes when twist squatting.
iii. Hold weights in your hands to increase the force going through the knees.
iv. Challenge your balance by performing the squat with arms out straight and up on your toes.

Cautions

Stop the exercise if you get pain and/or swelling.

Lunges

Muscles targeted
Quadriceps (front of thigh)
Gluteals (buttock)

Technique
Stand with feet shoulder-width apart and step one foot about 2ft in advance of rear foot. Feet and knees point forward. Keep front foot planted on the ground throughout. Raise heel of back foot off the floor, and drop down, bending both knees. Imagine you are being knighted! As with the previous exercise, focus on pushing feet into the floor throughout, and tightening the thigh and gluteal muscles on your return to standing.

Start with a shallow movement and increase the depth of the lunge as you gain confidence that the exercise is working for you.

Sets/Reps
2 to 3 sets, 15 to 20 reps

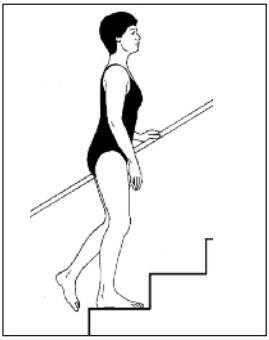
Progressions
i. Increase depth of lunge
ii. Hold weights by your sides to add resistance
iii. Start from a standing position and step into the lunge, maintaining good alignment and balance. This can be quite difficult
iv. Make it sport-specific by, for example, stepping into the lunge on an angle.

Cautions
Stop the exercise if you get pain and/or swelling.

Step-ups and step-downs

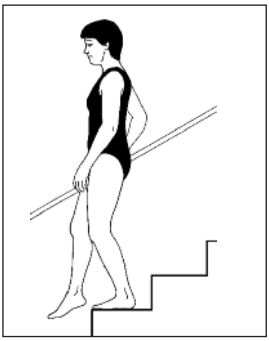
Muscles targeted
Quadriceps (front of thigh), in particular VMO

Technique
With both movements, use touch support on the banister for balance, as this will help you to maintain correct technique.



Step-ups: Stand facing a step. Place the foot of the leg with the affected knee fully on the step. Lean forwards as though about to step up -- your nose will be over your toes. Push into the step and feel the thigh muscles tense. Now push through the step, straightening your knee to a full lock as you step up. Leave the back foot behind you – do not bring it on to the step.

Now lower the back foot towards the floor, but do not let it take any weight. Push into the step again to repeat the movement. It ought to be a fluid motion without pauses. Keep hips level and maintain correct knee-to-toe alignment throughout.



Step-downs: Stand fully on the step, facing outwards. Place the heel of the uninjured leg in front of the step. Bend the weight-bearing knee (injured side) until you lower the other leg's heel down about 5cm, or as far as you can manage, while maintaining correct knee alignment and level hips. You do not need to aim to lower the good foot all the way down.

Now straighten the knee again to a full lock, making sure you do not transfer weight on to the uninjured leg (the heel should remain in front of the step throughout). Again, keep the movement fluid.

Sets/Reps
Start with 1 set of 10 reps

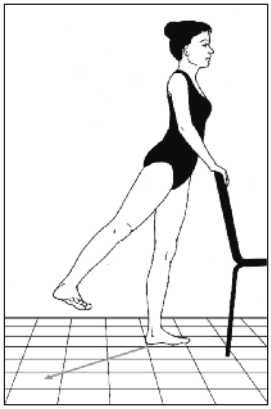
Progressions
i. Add more sets
ii. Hold weights to increase resistance

Cautions
Stop exercise if you get pain and/or swelling

Ballet barre exercise

Muscles targeted
Gluteals (buttocks), in particular gluteus medius
Quadriceps (front of thigh), especially VMO

Technique



Stand facing a wall, using one or both hands for fingertip touch support. Place feet just less than shoulder-width apart and turn out toes to 10 o'clock and 2 o'clock (as in a ballet plié). It is vital to maintain an erect posture with level hips throughout.

Shift your weight fully over your standing leg, but stay upright and do not push your hips out of line. If your posture is good you will notice the thigh and buttock muscles on that side working hard to maintain balance. Now lift the non-weight bearing foot just off the ground and slide it backwards on a 45-degree (diagonal) line away from your body.

Keep the knee straight so the buttock muscles do the work; the move is 8 to 20cm (don't go too far or you'll force your pelvis to tip), and the foot should keep its turned-out position throughout.

Do not arch back or stick your bottom out. You ought to feel the top, outer part of the buttock working. Bring the leg back

to its start position but keep the weight over the other leg and repeat the action. Keep it fluid. Note that this exercise works both sides in different ways.

Sets/Reps
1 to 2 sets, 10 reps each leg

Progression
Add ankle weights to increase resistance

Cautions
Stop if you get pain and/or swelling. Avoid this exercise if you have a history of low-back pain

Cate Streeten

Contributors

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Cameron Reid has been an osteopath for 20 years. Based in Norfolk, England, he is a member of the Osteopathic Sports Care Association (OSCA) and works with Norwich City FC and the English Institute of Sport in Norfolk.

Ryan Shulman is a physiotherapist, surgical trainee and clinical fellow in orthopaedics at BasingstokeHospital in Hampshire, UK. His main interest is clinical sports medicine and sports orthopaedics.

Cate Streeten works at Portland Physio Ltd, a busy practice in central London. She has a particular interest in the treatment of lower limb injuries with a bias towards biomechanics and functional rehabilitation.

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