UNBEATABLE BUTTOCKS

for injury free performance

A SPECIAL REPORT FROM

PEAK PERFORMANCE

The research newsletter on stamina, strength and fitness

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FROM THE EDITOR

In November 2005 I ran an article in *Sports Injury Bulletin* by one of our top contributors, Sean Fyfe, called 'Weak Buttocks ruin the Runner'. It is a good bet that this has become probably the most widely read of any article ever published in SIB. The original version is quite technical, written mainly to help sports therapy professionals assess their clients. But it also contains key messages, tests and exercises that are perfectly accessible to a wider readership and I feel confident that over the five years since its publication, Sean's advice will have helped many a runner to avoid injuries and layoffs from their beloved pursuit of running.

You could say that this book is about a lot more of the same – buttocks, buttocks and more buttocks. But actually it is probably best read as the natural companion to SIB's best-selling 'Core Stability' book. As various of the contributors point out, the gluteal muscles, for sure, are crucial for strength and power in athletic movement, but they are also key to stability control of the trunk. The problem is that we rather take our butts for granted, and fail to appreciate the different roles for which we need to condition and balance the musculature. Nowhere is that more true than with the multi-tasking gluteus medius. And nowhere will you find a more concentrated dose of glute med conditioning advice than in these pages.

Whether it's pain relief for low back and butt, core conditioning, or kicking power that you seek, this book has valuable answers – and as always with SIB, loads of practical exercises, from the very simple to the fearsomely challenging, to help lift you out of injury and put you on track for performing to your max. Or should that be glute max?....

Jane Taylor, Editor SIB

If you only ever do one glute strengthening exercise, it should be 'the Bridge'

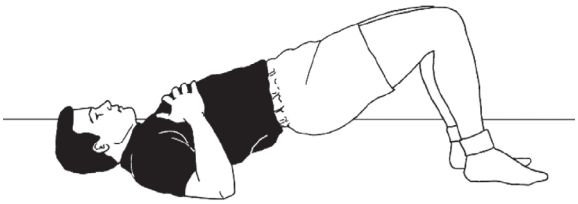
Strength in specific positions and movements can be important both for athletic performance and injury prevention. Sometimes this is less about the maximum weight the athlete can lift and more about the ability to recruit muscles to perform a specific function during a sporting movement. The bridge develops strength in the gluteal muscles in what is called the 'inner range', which is important for running-based sports.

The inner range for the gluteal muscles refers to the position with the hip extended and pelvis in neutral. Often athletes lack strength in this position. Norris[(1)] talks about how the peak tension of muscles can change at specific positions. An athlete may have good gluteal strength when performing an exercise such as the squat or leg press, yet at the same time be unable to use their gluteal muscles to stabilise the hip effectively in an extended position with pelvis held in neutral. This variation in gluteal strength depending on position is common in athletes and non-athletes alike, and is an example of how the gluteals need to be able to act as either a prime mover or a stabiliser, depending on the task.

When running, it is crucial to be strong in the inner range, because the gluteals support the upright position of the trunk, and help maintain the pelvis and lumbar spine in neutral. If an athlete cannot maintain an upright trunk or has a lordotic position (pelvis tilted down at the front) while running, this is in effect the same as flexing the hip. Lack of inner-range strength in the gluteals can place greater strain on the low back, or affect the biomechanics of the lower limbs, increasing the risk of injury.

It is common for the gluteal muscles to become lengthened (chronically stretched), thus reducing the tension in the range

Gluteal bridge



around hip extension. The bridge works the gluteal muscles in this position. The illustration above shows how the hips are extended with a straight line running through knees and hips to the shoulders.

How to do it

- Lie on your back with knees bent, feet and knees hip-width apart
- Squeeze the gluteal muscles and lift hips until you have a straight line running through knees and hips to the mid-back. Leave the shoulder blades on the floor
- Hold the position, focusing on using the gluteal muscles, for 10 sec
- Place the hips back down, maintaining neutral spine
- Build up the length of hold gradually to 30 secs, and three repeats (sets)

Technique points

- It is important to perform this exercise as an isometric contraction (a holding position) because this mimics the stabilising role of the gluteal muscles more closely. Building up the length of time you can position will improve strength-endurance of the gluteals in the inner range position. Be sure to keep breathing throughout
- Check where you feel the contraction. If you feel it strongly in the hamstrings or lower back, the gluteals are not doing their share of the work. Focus on squeezing the gluteals harder to

ensure most of the support is coming from them.

- If you start to feel the exercise moving out of the gluteals into the hamstrings, and maybe even cramping the hamstrings, it's time to rest, as this is a sign that the gluteals have fatigued
- Do not push the hips up too far as this arches the lumbar spine into a lordotic position. Place hands on hips to help maintain the neutral position, and think about gently pushing the knees away from the body
- Check that knees and feet remain steady in alignment, hip-width apart: no knock- or bandy knees!
- Be aware that gluteal strength can be affected by the flexibility of the hip flexors and the ITB (iliotibial band). So your ability to perform the exercise may vary from one week to another, if you have been doing activities that result in tight hip flexors or ITB (or if you've been failing to stretch adequately). If you are struggling, drop back to a previous level of difficulty and work up from there again, rather than struggle and lose good form at the higher level

Progressions

Once you can maintain the bridge position with perfect alignment and using only the gluteals for three sets of 3o seconds, try the following progressions, in order.

1. Lift the heel of one foot. This places more load on the opposite side gluteals. Practise until you can hold this position each side for 30 sec, with a focused contraction of the gluteals throughout
2. Bridge completely on one leg. Build up by lifting each leg just off the ground and holding briefly, then swap to the other side. When you lift the leg off the floor it is essential that the lumbar spine remains in neutral and the pelvis level. If the gluteals are not stabilising effectively, the opposite-side pelvis will probably drop down. In my experience, once you can bridge on one leg perfectly for three sets of 30 sec, you have developed good inner range strength.

Raphael Brandon

Reference

1. C Norris, Back Stability. Human Kinetics, 2000

Injury-free athletic power is all about the right muscles working together. Here's how to create a strong and stable back

Anyone involved in sport, from gentle jogger to elite athlete, relies on their muscles to operate in good synchronisation. Even though we might train individual muscles in the gym, in reality, for any kind of sporting movement it is the way the muscles work together, rather than in isolation, that makes the difference. And if there are broken or weak links, as a result of unbalanced training, injury or poor technique, the rest of the muscles will be affected and will work sub-optimally. This article explains one of the key muscle groups for athletes, the 'posterior chain', and how you can train to ensure balanced strength and minimal injury.

The posterior chain (PC) muscles provide the major torque-producing capacity of the body during locomotion. From hip extension in walking, to powerful hip extension in sprinting and back extension in sprint starts, the PC are the key muscles in use. A strong PC will help an athlete to produce the explosive movement that is so necessary in competition: witness the lower back, gluteal and hamstring musculature of elite level sprinters.

The PC, along with the abdominals, also provides gross global stability for the lumbo-sacral spine (the low back). While the deep multifidus (small dense muscles that span one to three vertebral segments, lying close to the axis of rotation), the transversus abdominis and the internal abdominal oblique provide intrinsic segmental stability through the spine, power-based athletes need much more stability than can be provided by these specialist stabilisers alone. The bulkier PC muscles

give additional stability in the lumbo-sacral spine to counteract the large forces acting across this area in power-based sports.

Which muscles are involved?

The PC group is made up mainly of the back and hip extensors. The key back extensors are the force-producing muscles of the lumbar and thoraco-lumbar erector spinae (long back muscles), quadratus lumborum and superficial (surface layer) multifidus. The hip muscles involved in the PC include the gluteus maximus, adductor magnus and hamstring muscle group: the major torque producers of the hip. The latissimus dorsi is also involved via its attachment to the thoraco-lumbar fascia and its corresponding attachment to the gluteus maximus on the opposite side.

Injury prevention

In fast ballistic movements, large forces act across the lumbar spine. Without muscular protection, the joints in the lumbar spine would suffer an excessive amount of shear force, leading to breakdown and injury, such as disc prolapse/degeneration, facet joint sprain and nerve damage. But the smaller transversus abdominis and multifidus alone will not have sufficient strength to counteract the shear forces produced by explosive movements. A well-developed PC system allows the athlete to secure global stability on a base of efficient local stability.

An emphasis on PC exercises in strength programmes will help to address some of the typical muscle imbalances that athletes tend to have. Many strength-trained athletes, for instance, are 'quadriceps dominant', because of their excessive reliance on squat-type exercises, which disproportionately build up the front of thigh muscles. Step-ups and leg press work have the same effect. As a consequence, the athlete becomes quadriceps dominant over hamstrings. The injury manifestations of this can be as simple as strained hamstrings to as complex as chronic discogenic (disc) back pain. Hence the importance of undertaking hip-dominant or posterior chain exercises.

The Romanian Deadlift

Along with traditional deadlifts, the RDL is grouped under the 'hip dominant' or 'posterior chain' list of exercises. Because the regular deadlift also involves knee bending, it is less 'perfect' than the RDL as a hip-dominant exercise.

The basic goal of the RDL is to lower a weight from the hips down to the knees and back again. This is achieved by bending from the hips (and slightly from the knees) while holding the bar with elbows in full extension and scapulae retracted in the initial set position. The force for the lift comes from:

- the powerful hip extensors, such as the gluteals and hamstrings;
- the lumbar and thoracic extensors.

'A well-developed PC system allows the athlete to secure global stability on a base of efficient local stability'

The RDL is not a true deadlift, because the weight is not lifted from the floor and therefore is not a dead weight. Legend has it that the exercise is not even very Romanian: a solitary Romanian power lifter performed this type of lift many decades ago at a competitive meet and the American competitors liked what they saw, so they 'borrowed' the idea and started training with this exercise. It has since become a boutique exercise used by strength athletes. It is, in fact, much safer to perform than regular deadlifts.

For the average gym-goer or non-strength athlete, the RDL probably represents a better and safer alternative to deadlifts for training the posterior chain muscles. This is mainly because of the different types of muscle contraction involved in executing the two lifts.

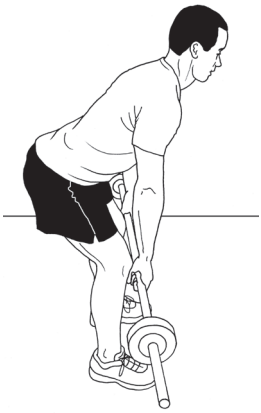
Because the RDL starts from the hips and the bar is lowered to the knees, tension is gradually built through the first part of the downward phase. This is an 'eccentric' contraction, in which the muscles are assisted by passive tension as they elongate. The tension in the hamstrings and erector spinae is thus shared between the active and passive tension components, so the muscles are in effect not contracting as hard as they would be in a deadlift, and there is less compressive load on the lumbar spine (by contrast, the compressive load during the regular

deadlift is massive). The upward (concentric) phase is then completed on the back of a lot of stored elastic/passive tension in the hamstrings and erectors.

How to do Romanian deadlifts

- Stand up tall at the start, chest out and shoulders retracted
- Look directly forward
- Initiate movement with an anterior tilt of the pelvis. Knees should be slightly bent (up to 5°), as locking out the knees causes the trunk to start to flex and the weight ends up being far too front of the body
- Slide the bar down in front of the thighs (not touching the thighs) towards the knee
- Look forward and keep chest out. Take care to avoid any hyperextension of the neck or lower back
- The knees should bend slightly as the lift progresses (no more than 10°, depending on lifter's height)
- At the bottom of the movement the lifter should feel a stretch sensation in the hamstrings.
- Hold the position briefly, then return under control to start position.

RDL: bottom of movement

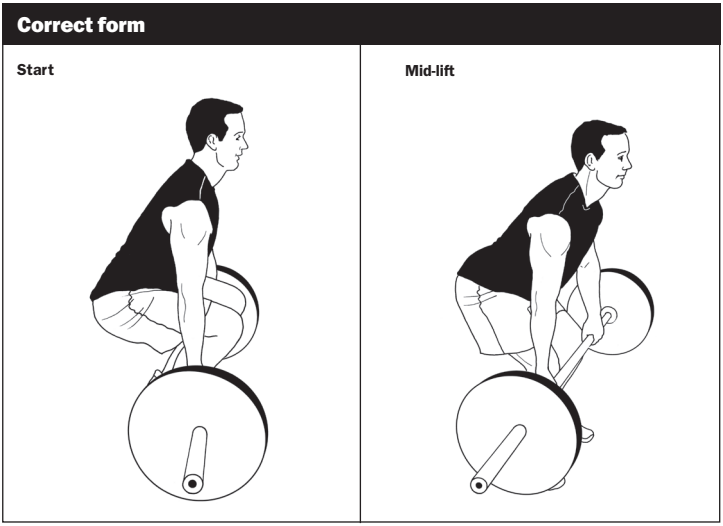


More posterior chain strengthening exercises

One-leg Romanian deadlifts

Similar to the Romanian deadlift above, but the weight is taken on only one leg. The benefit is that the adductors and abductors are then required to stabilise the pelvis and stance leg whilst performing the movement. If done one-handed, say, on the right leg, holding the weight in the right hand will focus on adductor recruitment; if held with the left hand it will focus on abductor recruitment.

Power-lifting deadlifts

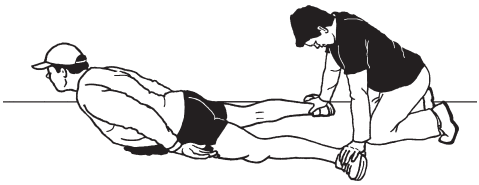


This is the traditional power-lifter's deadlift, lifting a barbell from the floor to the hips. Concentrate on keeping chest high and shoulders retracted during the lift. This will ensure that the lumbar spine remains in neutral-to-slight-extension, and that the force is generated by the hip extensors.

Back extensions

Can be done on a traditional roman chair bench, on the floor

Back extension



(with a partner sitting on your legs), or on a weights bench. Can be performed as a repetitive movement or as a sustained hold in extension. A good yardstick for the strength athlete is to be able to hold the body horizontal for three sets of 45 secs before noticeable fatigue sets in.

Reverse hyper-extensions

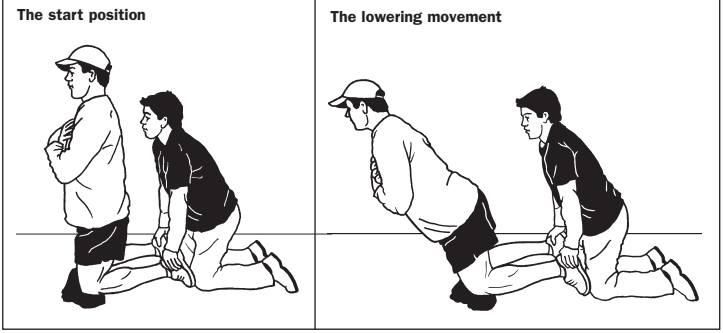
Lie prone on a bench with the hips at the end of the bench and the legs hanging over. Support is generated either by a partner applying weight to the upper body or the lifter holding on tightly to the bench. Holding your knees in extension (straight legs), and with feet and knees together, contract the glutes and lift legs to horizontal. This can be done as a slow steady movement, an isometric hold or ballistically (bouncing).

Nordic hamstrings

A fantastic exercise to develop eccentric loading in the hamstrings. You need a partner: kneel on the floor or on a bench while your partner firmly holds on to your ankles. Keeping arms folded across body, and maintaining your spine in neutral-to-slight-lumbar-extension, contract the glutes firmly to lower your body forward – all the movement comes from the knee. Viewed side-on, the thigh, hip, back, shoulders and head should all remain aligned.

Continue forwards to the point where you feel you can no longer hold it, or you feel the need to bend your hips to maintain the position; then return to starting position. Top-heavy athletes (eg rugby players) will not drop as far as bottom-heavy athletes

Nordic hamstrings



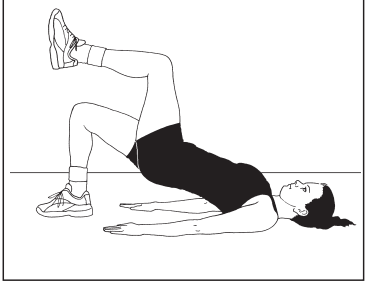
(eg sprinters) because of their centre of mass being higher.

A caution for the uninitiated: this exercise will cause hamstring cramps and spasms the first time you do it!

A variation on this exercise is to lower to the point where you feel you can no longer hold the position; then, maintaining body alignment, fall forwards to the floor using your hands to break the fall. This adds in a component of rapid eccentric contraction.

Single-leg bridge

Single-leg bridge



Lie on your back with knee flexed to 45 degrees and foot on the ground. Lift the knee of the non-working leg so that the foot rests in the air with knee bent. Raise hips and trunk off the floor until knee, hip, trunk and shoulders are diagonally aligned. Hold and lower hips down under control.

To progress, place the heel of the working leg up on a chair or (even tougher) swiss ball and lift until weight is taken only on the heel of the foot and the shoulders, keeping good alignment. A variation is to lift with knee flexed to 90 degrees. Each position loads the PC in slightly different ways.

Programme structure

The above exercises can form the focus of an entire lower-body weight-training session (*see Table 1 below*). Do not be afraid of adding resistance for greater challenge – once you have built up to it. Even Nordic hamstrings and bridging can have weight added to ensure you are working to failure.

Table 1: Sample programmes for posterior chain strengthening

Exercise	Sets and reps
Example: Beginners	
1. Single-leg Romanians	1 x 10 (3 sec lower; 3 sec hold; 3 sec return)
2. Romanian deadlifts	1 x 10 (3; 2; 3)
3. Back extension holds	2 x 30 sec holds
4. Reverse hyper-extensions	1 x 10 (slow speed eg; 3; 3; 3)
5. Reverse hyper-extensions	1 x 10 (moderate speed 1; 2; 1)
6. Nordic hamstrings	2 x 6 (2; 2; 2)
7. Single-leg bridge (0 degrees)	1 x 10 (2; 2; 2)
8. Single-leg bridge (45 degrees)	1 x 10 (2; 2; 2)
9. Single-leg bridge (90 degrees)	1 x 10 (2; 2; 2)
Example: Intermediate	
1. Romanian deadlifts	3 x 6 (2; 1; 2)
2. Deadlifts	3 x 6
3. Back extension holds	3 x 45 sec holds
4. Nordic hamstrings	3 x 6 (weight)

Chris Mallac

Searing pain in the bum and leg isn't always a herniated disc. Check out piriformis syndrome

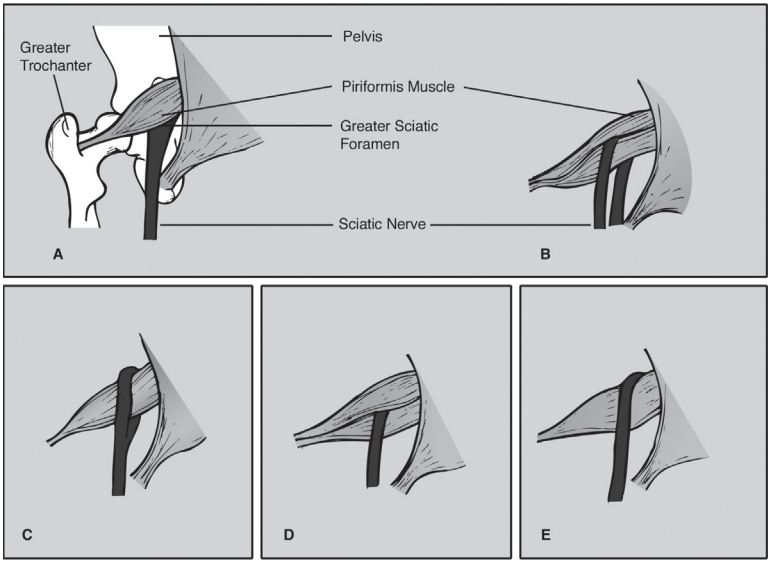
The piriformis is a muscle that lies deep within the buttocks, covered by the gluteal muscles. As the diagram below shows, it originates on the front surface of the sacrum, passes through the greater sciatic foramen and inserts into the greater trochanter of the femur (thigh bone). Its job is to externally rotate the hip when it is extended, and abduct the hip when it is flexed.

The sciatic nerve, which comes from the spinal cord at the level of the lower lumbar and sacral vertebrae, is the largest nerve in the body. It lies in close proximity to the piriformis – in the majority of the population it emerges from the pelvis just below the piriformis muscle. However, surgical observation and cadaver (corpse) studies reveal that more than 1 in 5 people have a different arrangement of sciatic nerve to piriformis muscle *(see diagram overleaf)*.

Piriformis syndrome is an irritation of the sciatic nerve caused by an inflammation of the piriformis muscle. It may feel like a deep aching pain in the buttock or a radiating sharp nerve pain that extends along the middle of the rear thigh. Occasionally numbness and tingling can continue to the calf and toes. These symptoms can be accompanied by low back pain and worsen after prolonged sitting. Because the symptoms of piriformis syndrome mimic those of a herniated disc pressing upon the sciatic nerve, the problem should be properly investigated by a medical professional to rule out more serious possibilities.

However, you should also understand that a diagnosis of disc disease, which is common in older runners and cyclists, does not exclude the possibility that piriformis syndrome is the cause of pain.

Anatomical variations in the relationship of the sciatic nerve to the piriformis muscle[1]



(A) Typical course of the sciatic nerve exiting the pelvis through the greater sciatic foramen and below the piriformis muscle. (B) The sciatic nerve splitting with one branch passing through the piriformis. (C) A split sciatic nerve wrapping around the piriformis. (D) The entire sciatic nerve passing through the belly of the piriformis muscle. (E) The sciatic nerve exiting the pelvis superiorly to the piriformis.

Studies have shown that both disc disease and piriformis syndrome can manifest no back pain, or conversely that either can create a painful back. Because piriformis syndrome is often a diagnosis of exclusion, it is difficult to pinpoint its true incidence among the population.

Testing for piriformis syndrome

There is no definitive test to diagnose piriformis syndrome. One way to discern the origin of the sciatic pain is to reproduce it. A positive 'straight leg raise' test (SLR) usually suggests a cause originating in the spine or sacrum rather than piriformis syndrome. With the client lying on their back, legs extended, an

examiner lifts the leg on the side of the pain. If the sciatic pain is reproduced, the SLR is positive. Keep in mind, however, that in a California study of patients with low-back pain, 41% of those diagnosed with piriformis syndrome exhibited a positive straight leg raise test upon initial examination [(2)].

If the pain is reproduced in the FAIR (hip flexion, adduction, internal rotation) position, then it is more likely due to piriformis syndrome. In the FAIR test, the client lies on the non-painful side and places the painful leg in a position of 60° hip flexion, knee flexion, hip adduction, and internal rotation. The examiner applies pressure to the knee in a downward direction, placing the piriformis on a stretch that compresses the sciatic nerve (*see below*).

Upon examination, there may be tenderness over the piriformis muscle, which may it be felt as a sausage-shaped mass. Postural changes may include sacral rotation toward the painful side, misalignment of the sacroiliac joint, and rotation of the lumbar vertebrae. With the client lying on their back, the painful leg may rest in external rotation due to a shortened piriformis muscle.

The FAIR test for piriformis syndrome

The athlete places the painful side up in a position of hip flexion, abduction, and internal rotation. The examiner applies downward pressure to the knee attempting to reproduce the buttock pain.

Treatment

Piriformis syndrome begins as an inflammatory response to overuse, trauma, or postural misalignment. If the inflammation is severe, impingement of the sciatic nerve results. Treating the pain with over-the-counter non-steroidal anti-inflammatory (NSAID) medications can reduce the pain and decrease inflammation. Other conservative treatments are recommended, such as rest, compression and ice to the area.

As the syndrome progresses, a cycle of muscle spasm, pain and postural compensations can ensue. Treatment at this stage usually requires referral to a physiotherapist. The kinds of treatment that the therapist will use to manage inflammation and decrease muscle spasm include ultrasound and cold spray. Manual therapies address soft tissue problems such as myofascial tightening and trigger points. The therapist will then prescribe exercises and stretching to lengthen the shortened muscle, strengthen the pelvic girdle, and correct postural imbalances. A 10-year study by researchers in New York found that physical therapy two to three times per week for up to three months, yielded a 60% to 70% improvement in symptoms for most patients [3].

While athletes are usually symptomatic in only one leg, the pain-free leg should be treated as well. In the New York study, investigators found that the most common causes of piriformis syndrome were overuse (43% of 876 patients) and trauma (18% of 892 patients). When they did nerve conduction studies on the 'good' legs of the patients, the results showed that even these legs were significantly impaired when compared to non-injured controls. Overuse and trauma are usually experienced in both legs; both legs should therefore be included in any treatment programme.

If conservative measures don't provide relief, an injection to the piriformis can be done. When the researchers in the Californian study above [2] suspected a patient had piriformis syndrome, they injected the muscle with anaesthetic and corticosteroid. Those patients who experienced complete, or near complete resolution of symptoms were confirmed to

have had piriformis syndrome. Patients whose symptoms returned in less than one week were referred for piriformis surgery. Those whose symptoms returned after one week were treated with up to two additional injections at four-week intervals. If the subsequent injections did not provide complete relief, these patients were also referred for piriformis surgery.

Of the 239 patients evaluated, 68% were diagnosed with piriformis syndrome. Of those, 23% experienced complete relief after one or two injections. Thirty-seven percent experienced prolonged relief from the injections (more than six months) followed by a recurrence of symptoms. However, the treatment with injections was not accompanied by follow-up physiotherapy, and this may explain why the symptoms returned.

When surgery is performed, the tendon of the muscle is released, easing the tension that compresses the sciatic nerve. The sciatic nerve is also examined for scarring or connective tissue adhesions that may be causing irritation. Of those who were referred for surgery in the California study, 59% rated their initial surgical outcome as excellent. Those who participated in long-term follow up (greater than two years after surgery) reported excellent results in 62% of cases.

'Trying to compensate for stronger muscles is how the piriformis becomes strained'

What was once a major surgery (with an incision similar to that of a hip replacement) is now conducted via an incision roughly 3cm long. Consequently piriformis surgery is no longer a career-threatening procedure. Most people return to daily activities within two weeks and athletes can return to training activities such as deep water running or swimming fairly quickly.

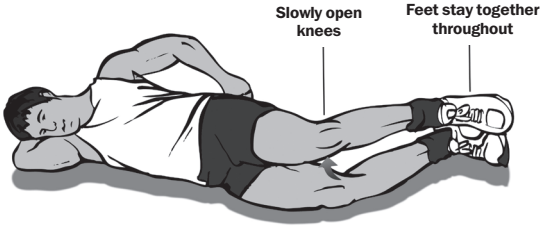
Small muscle, big problem

Releasing the piriformis has only a small impact on hip biomechanics, because the piriformis is a fairly weak external rotator and abductor. So how does this pip-squeak of a muscle become such a pain in the bum? Both internal and external factors influence the progression of piriformis syndrome. Internal (intrinsic) factors include the anatomical configuration of the piriformis in relation to the sciatic nerve, postural

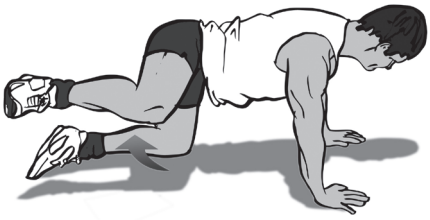
Stretching and strengthening

Stretching and strengthening are the keys to preventing piriformis syndrome. The following exercises are specific to the piriformis and are easily incorporated into a core-strengthening program for the pelvic girdle.

Piriformis stretch: Lying on your back, bend one knee and place that foot on the floor. Cross the other leg over the bent knee at the ankle. Bring the knee of the crossed leg toward the opposite shoulder. For a deeper stretch, cross the knees closer together. Hold for a slow count of 20. Repeat on other leg.



Clam exercise: Lying on your side, bend your hips and knees to about 60° of flexion. Rotate your top hip forward slightly ahead of the lower hip. Maintain the hips in this position throughout the exercise. With feet together, slowly open knees, keeping kneecap facing forward. Hold for a count of 3 then return to starting position. Perform 10 on each side.



Hydrant exercise: On all fours, lift knee until thigh is parallel to the ground. Hold for a count of three. Return to starting position and repeat 10 times on each side.

misalignments such as a leg length discrepancy, infection in the muscle and tumour.

In runners, overuse results from external (extrinsic) factors such as excessive mileage, increasing the mileage too quickly, or poor running technique. Changing terrain, wearing worn shoes, or running on banked surfaces can also over-tax weak muscles. As the primary muscles of the hip become fatigued, the smaller accessory muscles, such as the piriformis, must work harder to maintain form.

Trying to compensate for stronger muscles is how the piriformis becomes strained. A traumatic fall or blow to the buttocks may also injure the piriformis and trigger the inflammatory response.

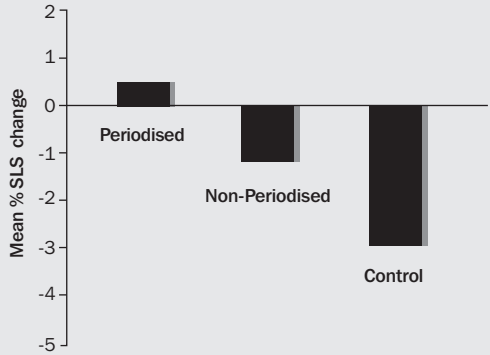
A good rule of thumb for increasing mileage is no more than 10% per week. It is important to remember to vary the direction of running on a track or banked road. The functional leg length discrepancy that results when running on a tilt, places an added strain on the pelvic musculature. An actual leg length discrepancy of 1cm or more affects pelvic alignment. A physiotherapist can evaluate the need for a shoe lift in such cases. Core strengthening of the pelvic girdle musculature is the best way to ensure that the muscles are prepared to handle any external factors you may encounter.

The need to stay strong

Endurance athletes, especially runners, are notorious for ignoring the strengthening portion of their training programme. Many assume that merely performing their sport will produce adequate strength, but in running the opposite is true. Endurance runners performing longer running workouts actually lose muscle strength in their legs. Fitness experts in New York evaluated hip strength in eight men and eight women before and after a two-hour run[4]. Hip abduction strength decreased by 17% in men and 12% in women; adduction strength decreased by 18% and 17% respectively; and hip flexion strength decreased by 19% in both.

Researchers from Minnesota conducted a descriptive

Comparison of the mean percentage of stride length (centimetres)/speed (metres per second) (SLS) change between the 3 study groups



Periodised = periodised strength training group;
nonperiodised = nonperiodised strength training group; Control = no strength training group.

analysis of hip strength in runners with a running injury[5]. A significant relationship was found between hip weakness and running injury in 30 recreational runners. The musculature of the injured leg was significantly weaker than that of the non-injured leg. Moreover, a matched control group of injury-free runners did not exhibit the disparity in hip strength between legs that the experimental group did. While not proving a causal relationship, it highlights the role that hip strength plays in the prevention of injury.

Improving hip strength may also improve performance. Scientists in Spain and the US jointly examined the effects of a sport-specific, periodised strength-training programme on the loss of stride length in endurance runners[6]. Eighteen sub-elite runners were randomly assigned to one of three training scenarios. For eight weeks during the training cycle, the subjects performed either a periodised strength-training programme, a non-periodised strength-training programme, or no additional strength training.

The stride length to speed (SLS) ratio was then measured

during training intervals at race speeds for up to 20 repetitions of the racecourse. Comparing the SLS from the first and last third of the repetitions, researchers found that those who participated in a running specific, periodised, strength-training programme did not show any decrease in the SLS between the first races and the last. On the other hand, the runners in the other two categories both showed significant decreases in the SLS, with that of the non-strength training group being the greatest *(see graph, left)*.

Clearly, the longer you can hold off muscle fatigue, the more consistent your stride length, and therefore, the better your performance. Training the appropriate muscles to do their job through specific strength training prevents accessory muscles from having to stand in for them. This brings better results on the racecourse and keeps athletes injury free.

Alicia Filley

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Weak buttocks ruin the runner. Here's how to test whether your glute med is fit for purpose

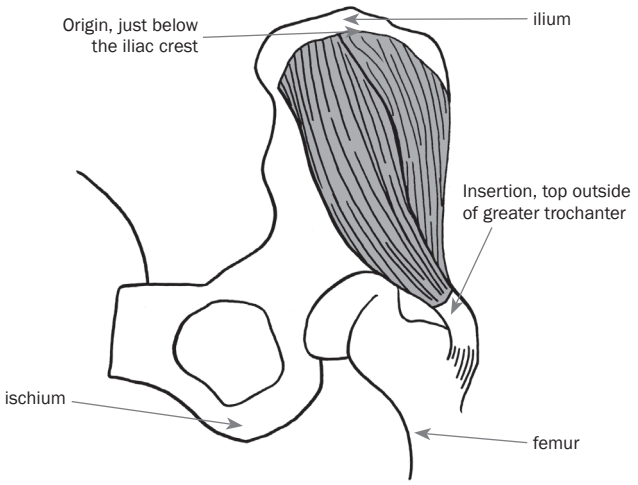
In my professional career I have seen so many athletes with running overuse injuries of the lower limb who have poor gluteus medius function that I have come to the view that the strength and function of this muscle is probably the most important active component of an efficient running technique. This is not so surprising when you consider that during running you are always either completely in the air or dynamically balanced on one leg. The gluteus medius should be considered in every running injury.

Where is it and what's it for?

The gluteus medius muscle originates at the top of the ilium (hip bone of the pelvis) below the iliac crest, and runs to the top outside surface of the greater trochanter (outer side of the thigh bone), as shown overleaf. It is the major abductor of the thigh (lifts it away from the body to the side). The fibres at the front rotate the hip internally and the rear fibres rotate it externally.

During closed kinetic chain actions (foot on the ground), such as the stance phase of running, the normal role of gluteus medius as a mover muscle is reversed, causing it to act as a pelvic stabiliser. So, for instance, during right stance phase (right leg on the ground), the muscle contracts to slow the downward motion of the left side of the pelvis so that the pelvis doesn't tilt more then 7 or 8 degrees from parallel to the ground. If the gluteus medius is not functioning well enough to achieve this control, the athlete is said to have a 'Trendelenburg gait'. Often, you can see the same weakness in walking

Gluteus medius: origin and insertion



(producing a waddling motion or in extremis a limp), and the dysfunction will be more marked when that person runs.

Athletes can adopt all sorts of cheating adaptations to their running technique adopt to offload a weak or fatigued gluteus medius muscle, something that the sports therapist needs to be alert to when making an assessment. The best way to look at glute med function dynamically is to use video analysis.

Table 1 (*opposite*) lists the adaptations or cheating movements that occur through the stance phase of running.

Adaptations 2 and 3 clearly cannot occur simultaneously, but a runner's technique may demonstrate a combination of adaptations, such as a mild Trendelenburg, medial knee drift and an same-sided trunk shift.

In my experience, runners with poor dynamic pelvic stability, (lacking vital gluteus medius strength) will decrease their stride length and adopt a more shuffling pattern to reduce the ground reaction force at contact and thereby the muscle control

required to maintain pelvic posture.

Weakness in gluteus medius will have implications all the way down the kinetic chain. Take adaptation 2. From heel strike to mid-stance phase, gluteus medius weakness allows…:

- … the femur (thigh bone) to shift inwards and internally rotate excessively
- … the knee to fall into a knock-kneed position
- … the lower leg to rotate internally relative to the foot
- … weight to be excessively transferred to inner side of the foot.

As a result the athlete is at increased risk of any condition relating to excessive and/or prolonged pronation of the foot, such as medial tibial stress syndrome or Achilles tendinitis.

Adaptation 3 is particularly interesting, because it is not very common, so may be missed by the therapist. It occurs when the athlete is running in excessive anterior pelvic tilt and forward body position. At ground contact the knee is thrown laterally so that the gluteus medius is offloaded and the foot is forced into a more supinated position (rolling outwards). Shock absorption through the lower limb is affected.

Table 1: Adaptations to weak gluteus medius in stance phase

Adaptations	Areas at risk of structural overload
1. Trendelenburg (pelvis sags on the opposite side)	Lumbar spine, sacroiliac joint (SIJ), greater trochanter bursa, insertion of muscle on greater trochanter, overactivity of piriformis and tensor fascia lata (TFL)
2. Knee drifts medially (in towards the body)	Lateral tibiofemoral compartment (via compression), patellofemoral joint, patella tendon and fat pad, pes anserinus, iliotibial band (ITB)
3. Knee drifts laterally (outwards)	medial tibiofemoral compartment (via compression), ITB, posterolateral compartment, popliteus
4. Trunk shifts on same side (lateral flexion of trunk)	Lumbar spine (increased disc and facet joint compression), SIJ (increased shear)

Testing the muscle strength

My approach is threefold. Let's imagine we are testing the right gluteus medius. First, I ask the athlete to perform the 'clam' exercise. They lie on their left side, both hips are flexed to 30 degrees with knees bent and hips and feet stacked in line. The athlete has to open their knees while keeping heels together, and most importantly, holding the pelvis completely still *(see p43* for step by step instructions. I feel the gluteus medius to see whether it is activating. If the pelvis moves, it means the athlete is unable to isolate the muscle and is trying to recruit 'cheating' muscles such as TFL.

The second test is side-lying hip abduction, performed in the same position, but with the right (top) leg straight and in slight hip extension (ie, just behind the line of the body). The athlete must raise the leg up away from the ground without hitching the right side of the pelvis, or falling into anterior pelvic tilt or letting the pelvis tip backwards.

You can further test the strength of the muscle by getting the athlete to resist your attempts to push the abducted leg down. Check for any compensatory or cheating recruitment. To assess muscular endurance, ask the athlete to hold the abducted (raised) leg steady at about hip height for 30 secs.

Lastly I ask the athlete to perform a single-leg squat while I observe control at the foot, knee and pelvis. This also gives me an idea of the stability of the whole lower-limb-to-pelvis chain. All this should be compared to the uninjured or 'good' side.

In a very interesting study from 2000, the researcher Fredericson measured hip abductor strength in a group of injured male and female subjects, and found they had statistically significant deficits in gluteus medius strength on the injured side compared to the uninjured. After a six-week retraining programme, average hip abductor strength improved by 34.9% for females and 51.4% for males; 22 of the 24 injured athletes were able to return to running pain free. Most importantly, at a six-month follow-up, no injury recurrences were reported.

Case study: Chris's knee pain

Chris presented to the clinic after experiencing pain on the inner side of the knee resulting from the first four weeks of training for his lifetime goal: a marathon. He'd not done any running before, having previously concentrated on upper-body weight training. Assessment revealed:

- right-sided tibiofemoral medial joint line tenderness
- a painful medial restriction to squat and end-of-range knee flexion
- medial discomfort when tested for meniscus damage

Chris was unable to activate gluteus medius in side-lying and had absolutely no control with single leg squat and single leg knee bends: he was unable to maintain pelvic alignment or keep his knee tracking in line with his foot. His hip was falling and turning inwards, causing his knee to turn in and his already flat foot to pronate further.

My video assessment revealed a classic case of Adaptation 3: extremely anteriorly tilted and forward trunk position; and the right knee being thrown into a lateral position on ground contact.

It was now clear why the medial compartment of his knee was so irritated. Every time his leg hit the ground, the meniscus and articular cartilage was being compressed. Trying to train for a marathon with this level of control and technique would have severe consequences for the long-term health of Chris's knee.

I had to advise Chris to abort his marathon campaign for the moment. Still determined to achieve his dream, he began a retraining programme. Chris's journey was a particularly interesting one, because he was starting at such a poor level and aiming to attempt an activity that requires a very high level of strength and control.

The initial aim of the retraining regime was to gain activation and strength of gluteus medius while being able

to maintain correct alignment. To start with, Chris did the clam exercise, feeling his own gluteus medius for activation; and practised holding a single leg semi-squat position on a 15-degree downward sloping board, using a mirror for visual feedback on his lower limb posture. The decline board helps to increase activation of vastus medialis (the lower quad muscle) and it also offset Chris's limited ankle flexibility, which would otherwise compromise his ability to perform the squat with correct technique.

Chris gradually lengthened the time he could maintain the static squat and deepened the squat position. He also increased repetitions of both exercises. We progressed the clam exercise to side-lying abduction to increase the load, and Chris began dynamic single-leg squats, slowly but steadily improving his level of control and squat depth. We then introduced single leg knee bends on the decline board. These differ from the single leg squat in that the trunk position is held upright and the knee should bend forward PAST the toes – but still tracking in alignment. The movement pattern is slightly different from the squat, with a close focus on control of the knee.

Once the gluteus medius and single leg control reached a suitable level, we introduced more dynamic exercises to retrain the muscle's timing and effectiveness as a shock absorber on impact. This must be done with a mirror. The first exercise is single-leg jump and hold (ie, hop and hold), ensuring correct alignment is maintained. The athlete should focus on pre- tensing gluteus medius and VMO before impact.

Once this was achieved, we progressed to continual single leg jumping (hopping), before allowing Chris to return to running.

During running, the athlete should concentrate on pre-tensing before heel strike and maintaining alignment. Chris's training programme now includes the single leg

squats and knee bends to maintain and improve the strength and endurance of his gluteus medius in conjunction with the other crucial muscles that are required for lower limb/pelvic posture during running. His training mileage is increasing steadily as he builds up to his big day.

This rehabilitation programme was a joint effort over three months between physiotherapist and podiatrist. Once a reasonable amount of control was reached, an orthotic was introduced to help Chris maintain alignment, which in theory should also help the activation of his key stability muscles.

Sean Fyfe

Reference

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Research report I: Weak buttock, painful heel?

Achilles tendinopathy is particularly prevalent in distance runners. A multinational research team from South Africa and Ireland looked at the kinetics, kinematics and muscle activity in runners with Achilles tendinopathy *(Biomechanical variables associated with achilles tendinopathy in runners. British Journal of Sports Medicine Online First, published on October 23, 2008 as 10.1136/bjsm.2008.0534212008)*. During each trial, the researchers measured kinetic and lower limb kinematic data, along with EMG data from six relevant buttock and leg muscles.

Their results suggest that altered knee kinematics and reduced muscle activity are associated with Achilles tendinopathy in runners. But also of interest are the gluteus medius results: the researchers found that glute med strengthening helped reduce pain associated with PTFPS. This does not tell us whether glute med weakness is a contributory cause of Achilles tendinopathy but some preventive strengthening is not going to go amiss.

And now, discover even more reasons to get working on this crucial muscle...

It's time to take another look at the gluteus medius muscle. The fact is that the basic function of glute med has not been truly appreciated until very recently. The muscle's familiar role is that of a strong hip abductor and the major stabiliser of the pelvis on the weight-bearing leg during stance phase of gait. It prevents the hip on the opposite side from 'dipping' during single-leg stance (the 'Trendelenburg' sign, *see P31*). However, this small but valuable muscle has a more extensive role to play.

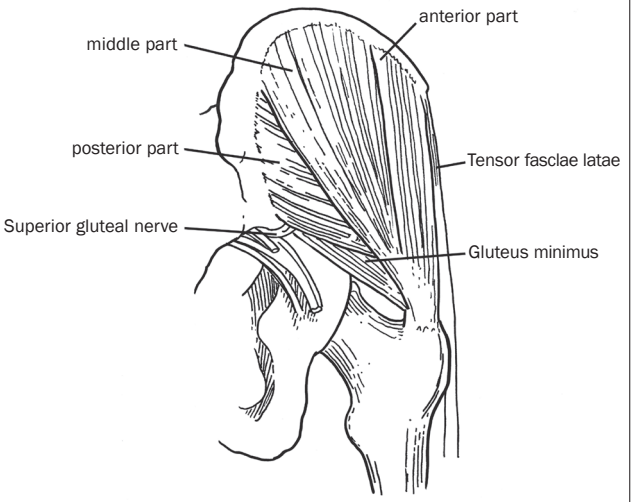
What glute med really does

The most significant anatomical and functional study to date conducted on the gluteus medius muscle was undertaken by Gottschalk et al in 1989. From their anatomical dissection studies, they suggested that the gluteus medius attaches to the outer edge of the iliac crest (top of the hip), starting at the anterior superior iliac spine (ASIS) and extending all the way to the posterior superior iliac spine (PSIS), as shown in the diagram overleaf.

The gluteus medius attaches to the top centimetre of the iliac crest but not to the blade of the ilium. It runs downwards in a fan shape and attaches to the upper front aspect of the greater trochanter (outside of the thigh bone). This is important, as it allows the tendon to contribute to anterior hip stability when the hip is in an extended position.

The muscle is divided into three equal components: anterior (front), middle and posterior (rear). The fibres of the posterior portion run almost parallel with the neck of the femur (top of

Gluteus medius fibres



Source: Gottschalk et al 'The functional anatomy of tensor fascia latae and gluteus medius and minimus'. Journal of Anatomy. 166: 179-189.

the thigh bone), while the middle and anterior parts run vertically from the iliac crest to the greater trochanter.

Each of the three parts of gluteus medius has its own nerve supply running from the superior gluteal nerve, suggesting that the muscle actions of the three portions are independent of each other.

Gottschalk et al reported that gluteus medius is not all that active in isolated abduction of the hip (when the leg is lifted away from the side of the body). This finding is contrary to what has been taught for years in anatomy and biomechanics lectures and textbooks. They observed that the tensor fascia lata (TFL) is significantly active in isolated hip abduction.

They went on to suggest that the three heads of the gluteus medius have a phasic muscle action during stance phase of gait. The posterior directed fibres are more active at heel strike, and then the muscle becomes progressively active from posterior to anterior as movement occurs from early stance to late stance phases. In other words, the front portion of the muscle (which

is anatomically similar to the TFL) is most active at full stance and single leg support phase, while the rear fibres fire strongly at initial heel strike.

Gottschalk et al suggested that the main role of the gluteus medius is to compress the head of the thigh bone into the hip socket during locomotion and to help stabilise the pelvis on the thigh bone in single-leg stance. They then put forward the notion that each of the three distinct heads of the muscle performs a unique role in locomotion:

The posterior fibres contract at early stance phase to lock the ball into the hip socket, performing in essence a stabilising or compressing function for the hip joint.
The middle/anterior fibres, which run in a vertical direction, help to initiate hip abduction, which is then completed by the TFL. These fibres work synergistically with TFL in stabilising the pelvis on the thigh bone, to prevent the other side dropping. The researchers point out that the TFL has the more important role in stabilising the pelvis on the supporting hip; the gluteus medius simply assists this action.
The anterior fibres allow the thigh bone to internally rotate in relation to the hip joint at mid-to-end stance phase. This is essential for pelvic rotation, so that the opposite side leg can swing forward during gait. The anterior fibres perform this role with TFL.

So Gottschalk et al postulated that the primary functions of the gluteus medius are:
- to stabilise the hip
- to act as hip rotators, and
- to hold the head of the thigh bone in the hip socket, in effect creating a very tight and stable hip joint during gait.

This prevents the ball and socket joint from rattling around during walking and running, similar to how the rotator cuff muscles in the shoulder work to produce a tight and stable glenohumeral joint during arm elevation.

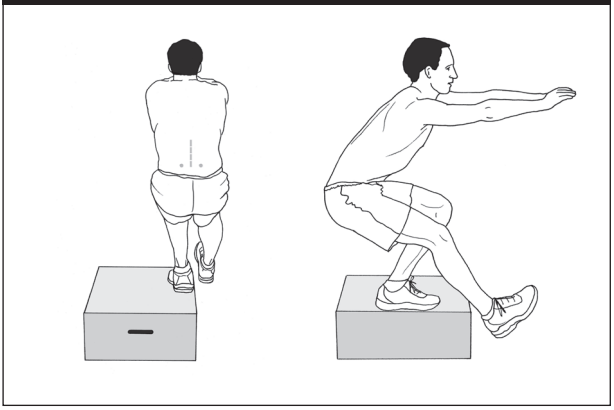
Is your glute med working properly?

Here's how to check it out:

Single-leg squat

The main purpose of the single leg squat is to test how well the chain of muscles works from the foot to the trunk when the leg is having to support the body on its own while moving. It is always wrong to ignore a poor single leg squat, as this movement shows you what will happen with the support leg during running.

The single-leg squat



Technique

- Begin the movement by flexing at the hip and continue bending the knee and ankle until your thigh is parallel to the ground
- Keep hands in front of the body
- Keep trunk as upright as possible, preferably neck above toes, avoiding excessive curving of the mid to low back
- Heel must stay in contact with the ground at all times

There are a few musculoskeletal structures that contribute to poor single leg squatting, and weak gluteus medius activity is just one factor. Table 1 (*opposite, above*) shows some of these musculoskeletal issues and how a sports therapist may correct them.

Table 1: Single-leg squat assessment prompt sheet

Musculoskeletal issue	Observed compensations	Corrective measures by sports therapist
Excessive and uncompensated mid-foot pronation	Pronation leading to tibial internal rotation	If client normally wears orthotics then re-assess using orthotics or a towel wedge
Reduced ankle dorsiflexion	Midfoot pronation leads to tibial internal rotation and makes support leg appear to 'drop' inwards	One-inch heel block to eliminate dorsiflexion restrictions
Knee pathology eg: patella tendinopathy	Increased inclination of trunk (increased hip flexion) to move centre of mass directly over knee joint – reduces quads activation	Teach correct alignment and posture to a more vertical position. If this increases knee pain, knee may be a limiting factor
Poor knee proprioception	Increased hip and knee flexion to lower centre of gravity – increases ability to balance	Allow one-finger balance on supporting structure and re-assess the squat. If much improved, balance may be a limiting factor
Weak gluteus medius	Opposite side hip drops and/or lateral trunk flexion over the supporting foot	Provide visual feedback (mirror or video) to allow correction. If gluteus medius is truly weak, poor pattern will continue
Tight hip external rotators	Pelvis on non-support side will rotate backwards to reduce 'stretch' on hip rotators	Stretch/massage hip rotators and re-assess
Tight medial hamstrings and adductor magnus	Starts with neutral pelvic tilt and moves towards excessive posterior pelvic tilt at 60-70 degrees hip flexion	Trigger/massage/stretch hamstrings and re-assess

The Clam

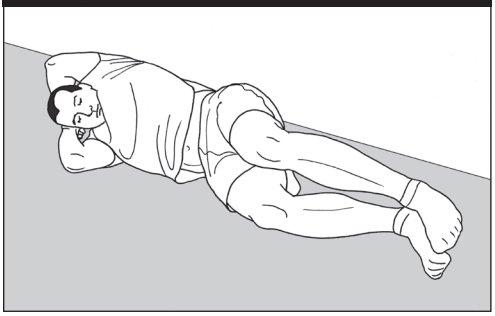
Technique

- In side-lying, bend knees and hips to 30 degrees and align the ankles and knees
- slowly part the knees, ankles still touching, until they separate by 2 to 3in to allow the uppermost thigh to go slightly past horizontal
- bring the knee back to its starting position under control

Some common 'cheating' movements are:

Hip hitch: overactivity of trunk lateral flexors such as the quadratus lumborum. The QL 'helps' the pelvis to lift to make

The clam test



the gluteus medius appear to be causing the movement.
Posterior pelvic rotation: pelvis rotates backwards to force the femur (thigh bone) into a horizontal position.
Anterior pelvic rotation: the result of overactivity of the TFL

To date the clam test is probably the best test to assess isolated function of the posterior fibres of the gluteus medius. It assesses the muscle's ability to slightly externally rotate and abduct the non-weight-bearing hip. It does not, however, assess the ability of the muscle to contract and close the hip joint to create a stable ball and socket joint. We will have to wait for the researchers to come up with a clinical test that assesses the hip closure role of gluteus medius.

Strengthening exercises

There is no shortage of source materials to find exercises for retraining glute med function. But not all of them exercise the muscle equally effectively for the different roles outlined above. The three exercises below are particular favourites of mine. The distinguishing features of all three are:

- they are performed in weight-bearing or simulated weight-bearing;
- they are performed in neutral hip position or positions of slight hip extension (most glute med exercises are done in positions of hip flexion, which tends to preferentially recruit the TFL in a hip abduction or hip stabilisation role).

Tai Bo exercise

Technique

- Stand upright with feet externally rotated to 30 degrees.
- Place one foot behind the knee of the other leg (swing leg behind stance leg).
- Make a knee bend on stance leg to 30 degrees and then as you extend the knee again, move the swing or floating leg into flexion and abduction. Hold the position for 1 second before returning to start position. You should feel the posterior fibres of glute med contract at the top of the movement.

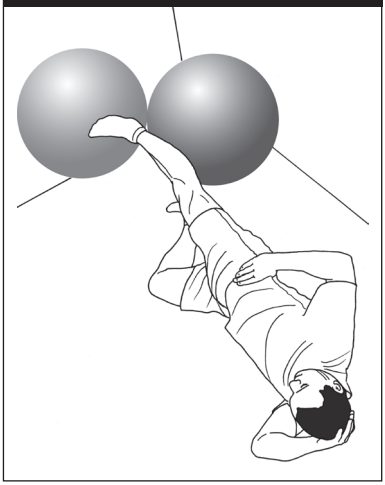
Double ball wrestle

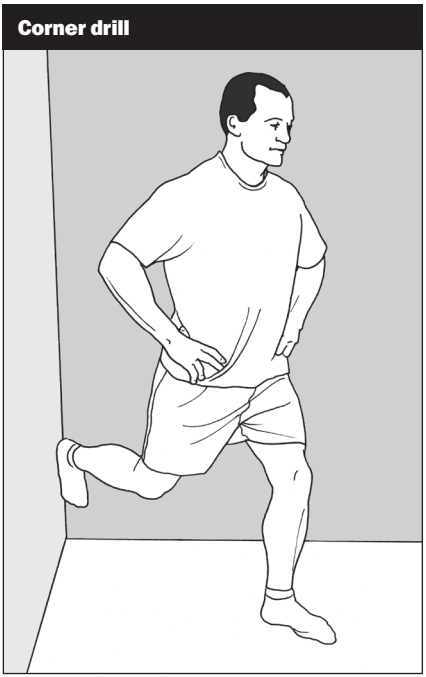
Technique

- side lie with uppermost leg in a neutral extended position, foot resting against a Swiss ball, and calf touching a second Swiss ball
- Externally rotate the hip 30 degrees and push foot into the first Swiss ball
- Keeping the foot pushed in, press the calf against the second ball and slowly raise both balls up along the wall a few inches. Hold the position.
- Lower and repeat

Tai Bo exercise

Double ball wrestle





Corner drill

Technique

- stand with feet in split stance, forward leg bent and rear leg extended at the hip
- Place foot of extended leg into the corner of the room, toes about 15cm off the floor. Push foot backwards and sidewards into both walls
- Keep upper body perfectly straight with hands on hips. You should feel contraction in gluteus medius in both stance leg and push leg.

Chris Mallac and Dirk Spits

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No more room for excuses: this really is the ultimate guide to glute med strengthening

A weak gluteus medius muscle is often linked to injuries such as patellofemoral pain, anterior cruciate ligament injuries, iliotibial band syndrome, ankle injuries and Achilles tendinopathy. In 2008 researchers in New Zealand and Australia reviewed the available literature linked to glute med function and conditioning, in an attempt to explain how this muscle can be the root cause of so many lower extremity injuries, and to offer some guidance on rehabilitation *(Gluteus Medius: Applied anatomy, dysfunction, assessment, and progressive strengthening. Strength and Conditioning Journal 2008; 30 (5): 41-53)*.

For a detailed explanation of what glute med does, read the previous two articles. But to summarise: this buttock muscle abducts the hip joint, the anterior fibres contribute to hip flexion and hip internal rotation, and posterior fibres to hip extension and hip external rotation. It helps prevent the opposite side of the pelvis from dropping during the stance phase of gait and plays a vital role in providing frontal stability for the entire pelvis during walking and other activities.

So how can such an important muscle become weak? Several factors can contribute:

- Medical – hip rotator tears and congenital dislocation of the hip;
- Lifestyle – standing predominantly on one leg with the pelvis swayed sideways and hip joint adducted (the classic hip-hitch slouch, often used by mothers when they stand with a child in their arms);
- simply sleeping on your side with the top leg flexed and

adducted over the other leg: maintaining an elongated position for sustained periods can weaken the glute med.

The Antipodean researchers trawled through all the literature on conditioning and rehabilitation of glute med and developed their own exercise model, based on current strengthening guidelines. This was a pretty hefty undertaking

Research report II: Weak buttock, bad knee?

Patellofemoral pain syndrome (PFPS) is a common problem with an intriguing gender bias: PFP problems occur twice as often in females as in males. While the exact cause of the condition remains unknown, researchers have now come up with an association between PFPS and hip muscle weakness or motor control impairment. Poor hip control may lead to abnormal patellar tracking, increasing patellofemoral joint stress and causing wear on the knee's articular cartilage.

A group of Brazilian scientists completed a study to establish whether additional strengthening of hip abductor and lateral rotator muscles in a quadriceps rehabilitation programme would work in patients with patellofemoral pain syndrome *(The effect of additional strengthening of hip abductor and lateral rotator muscles in patellofemoral pain syndrome: a randomized controlled pilot study, Clinical Rehabilitation 2008; 22: 1051-1060).*

Fourteen patients with PFPS were randomly assigned to the intervention group (strengthening of quadriceps plus strengthening of hip abductor and lateral rotator muscles) or to the control group (strengthening of quadriceps). Both groups took part in a six-week home exercise protocol.

The researchers found that perceived pain during functional activities improved only in the intervention group; this group alone also increased their gluteus medius electromyographic activity (muscle stimulation) during isometric voluntary contractions. They concluded that supplementing a quads strengthening regime with hip abductor and lateral rotator strength exercises provided additional benefits in pain reduction for PFPS patients. That adds up to a big thumbs up for specific glute med conditioning!

and the progressive strengthening programme that they developed includes a total of 17 graduated exercises.

Their programme progresses from initial assessment through to a return to full function, in this way:

1. Glute med strength is assessed in side lying. The client holds their straight leg in full hip abduction with slight hip extension and external rotation for 10 seconds. If they can perform this isometric hold, they can begin weight bearing exercises. If there is movement of the pelvis, or if the hip flexes or internally rotates, the client must begin at the non-weight bearing stage.
2. The programme has three stages. Stage 1 focuses on non-weight bearing activities, progressing to static weight-bearing. Stage 2 increases the stability challenge, firstly using hopping and stepping, then decreasing the base of support, then increasing the height of the centre of mass or performing tasks on unstable surfaces. At Stage 3 the client performs functional exercises that also have greater sports relevance.
3. The protocol includes some simple milestones for progression.
4. Initially a relatively high rep range is recommended (up to 15 reps). Once technique has been established and milestones achieved, the repetition range can be lowered and resistance added to help develop strength and power.

What follows is our interpretation of the 17-exercise programme. The research report merely lists the source references for the exercises, so we have sought out the originals, which in some cases has meant filling in gaps, if the information given was particularly sparse. Where any major guesswork has been involved we have flagged that up for you!

Each exercise described here has a grading to denote its difficulty / complexity, and the progressive programme splits into three main stages plus two additional sub-phases. The research team drew up a protocol with milestones for the athlete to achieve in order to progress through the programme, reproduced below at Table 1 on p55.

The exercises

Phase 1

Bent knee turnout (Grade 1a)

Technique

- Lie on your side with knees bent 90 degrees and hips flexed to 45 degrees
- Soles of the feet should be in line with spine
- Raise top leg, keeping feet together without rotating at the lumbar spine.
- The hips and shoulders should remain in line, one over the other, and all the motion should come from the hip.

Note: this exercise is often known as the Clam (see p43 for illustration)

Hands and knees leg lift (Grade 1b)

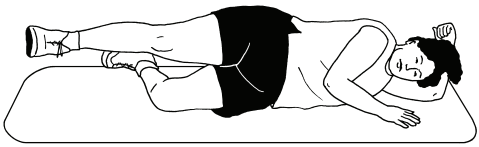
Technique

- Kneel on all fours, wrists directly below shoulders, knees below hips
- Raise opposite hand and knee 3cm, just off the floor, keeping pelvis level
- Lower hand and knee under control and switch to opposite sides

Side-lying leg lifts (Grade 1b)

Technique

- Lie on your side with upper body supported on forearm and lower leg bent
- Keep hips perpendicular to the floor and upper leg in line with body
- Lift upper leg slowly straight up about 8in, then slowly lower it. Push away into the heel as you lift the leg (flexing the foot). Do



not twist. Keep the top foot parallel to the ground throughout
- Lower the leg under control

Note: we've had to read between the lines on this one but this is what we think they mean

Phase 2

Standing hip abduction (Grade 2a)

Technique
- Tie a length of elastic x-band to the bottom of table leg or other fixed object, then loop it around the outside of one ankle, standing side-on and using a chair-back in front of you for balance support
- Keeping the foot pointing forwards, press the leg away to the side against the resistance of the band, as far as possible without tipping at the pelvis or bending the stance leg
- Lower back to start position

Note: This can be done, minus band, on a hip abduction machine

Single-leg stance hold with medicine ball press (Grade 2a)

Technique
- Stand on one leg, holding a weighted medicine ball
- Press the ball straight out in front of you
- Return the ball back to the starting position and repeat.

Trunk twist in single leg stance (Grade 2b)

Technique
- Stand on one leg and hold a medicine ball out in front at ribcage level
- Rotate as far as possible to the left until you feel the muscles on your back right side begin to stretch
- Return to start position
- Repeat on opposite side.

Phase 3

Cable kickback (Grade 3a)

Technique
- Using a cable pulley machine, attach the cable end to the

front of the ankle of the leg that is to be worked
- Stand so that when the knee is lifted in front, with the thigh slightly below parallel, the cable is vertical
- Lengthen the leg, pulling in a downwards and backwards arc towards the ground
- Initial resistance level should be set to allow you to achieve 13- 15 repetitions

Note: Alternatively you can use a length of elastic x-band, attached in front of you.

Single leg squats, machine (Grade 3a)

Technique
- Position body in the leg press machine to achieve a 90° or slightly greater angle at the knees
- Foot position on the foot-plate should have toes pointing straight up, or slightly turned out
- Maintain neutral spine
- Push against the plate until leg is almost straight
- Pause, then flex knee and hip to return to start position under control
- Initial resistance level should be set to allow you to achieve 13- 15 repetitions

Single-leg squats: supported rear foot (Grade 3b)

Technique
- Start with feet in a forward lunge position and rest the rear foot on top of a bench or box, at approx 18in height
- Keep torso erect and weight over the front foot
- Descend until the front thigh is parallel to the floor and back knee almost touching the floor. You will feel a stretch in the rear leg's hip flexor as you descend.
- Return to start.

Phase 4

Single leg dumbbell squat: standing (Grade 4a)

Technique
- Stand on a box, holding light dumbbells by your sides, and

squat down until thigh is parallel with the floor
- As you begin to squat, raise dumbbells straight out in front to shoulder level; this facilitates sitting back on the heel
- Concentrate on keeping the weight through the heel.
- Return to start position under control

Single leg hops / lunges (Grade 4a)

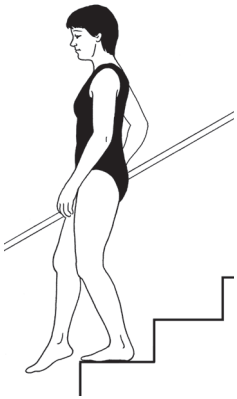
Technique

Single leg hops
- Stand on one leg and hop forwards
- Hold the landing, maintaining slight bend at knees and hips.

Lunges
- Stand with feet hip width apart
- Step forward into a lunge with right foot (the step should be long enough to feel a stretch of the hip flexor muscles of the back leg)
- Return to start by driving off the lead leg
- Alternate legs.

Step downs (Grade 4b)

Technique
- Use a 4-in (10cm) platform (this is the height specified by the researchers, but if you can complete the exercise with good technique, there is no reason why you cannot progress to deeper steps)
- Start on top; slowly step one leg back off and down, squatting the stance leg under control
- Lower the stepping leg down slowly and with full control, until the foot just touches the floor. The support leg remains in contact with the box at all times
- Forcefully push off with the foot on the floor back to the start position on the platform.
- Repeat until you have completed all of the repetitions, then switch legs.



Phase 5

Monster walks (Grade 5a)

Technique

- Loop a small length of elastic x-band securely around thighs, just above the knees
- Bend knees slightly and start stepping sideways, taking small steps
- Avoid excessive motion: shoulders should stay over hips and avoid any see-saw type action
- Change direction and repeat

Single leg resisted lateral jumps (Grade 5a)

Technique

- Attach a bungee cord / elastic tubing around waist, at left hip
- Stand on the left foot
- Jump sideways on to your right foot (side hop)
- Step back to start position and repeat
- Switch resistance cord to opposite side and switch legs to work other side

Phase 6

Single leg ball throw against wall (Grade 6a)

Technique

- Stand on one leg facing a wall
- Throw the ball at the wall and catch it on the rebound
- Repeat, varying the angle of the throw.

Basic kicking: diagonal (Grade 6a)

Technique

- Imagine kicking a football
- Stand on left leg
- Starting with right foot just behind the body, swing right leg in a diagonal movement across the centre line of your body
- Increase the difficulty of this exercise by attaching elastic tubing to the ankle of the swinging leg for resistance

Nick Grantham

Table 1: Progression chart with milestones			
	Stage 1	Stage 2	Stage 3
Level 1	No weight-bearing (Grade 1a)		
Milestone for progression to Level 2: In side lying, client can hold their straight leg in full hip abduction with external rotation and extension for 10 seconds without posterior rotation of pelvis			
Level 2	Nonweight-bearing (Grade 1b)		
Level 3	Level 2 *plus* weight bearing exercises at Grade 2a		
Level 4	Grade 2a *plus* weight bearing at Grade 2b		
Milestone for progression to Stage 2: In single leg stance, client can hold pelvis level without lateral trunk shift, for 30 seconds, keeping stance knee in line with second toe			
Level 5	Grade 2b	Compound exercises (Grade 3a)	
Level 6		Compound exercises at grades 3a and 3b	
Level 7		Compound exercises at grades 3b and 4a	
Level 8		Compound exercises at grades 4a and 4b	
Milestone for progression to Stage 3: Client can squat on one leg, keeping pelvis level, knee over second toe, without lateral trunk shift			
Level 9		Grade 4b	Functional exercises at Grade 5a
Level 10			Functional exercises at grades 5a and 5b
Level 11			Functional exercises at grades 5b and 6a

You may think your sports-mad adolescent just tore a hamstring. But check it out in case something more serious happened

Avulsion fracture of the ischial tuberosity (sit bone) is a rare condition that mainly affects athletes between 15 and 25 years old. The fracture is commonly misdiagnosed as a soft tissue hamstring injury, which leads to inappropriate treatment, resulting in chronic pain and malfunction.

Case report

A 15-year-old boy presented to the accident and emergency department with pain in his left buttock after a rugby injury. It was unclear what had caused the injury. Examination of the left hip revealed no obvious swelling or deformity. He was tender over the left ischial tuberosity and had a full range of motion in the hip. He was able to walk but unable to run. He had a pelvic x-ray, which was misreported as showing no bony abnormalities.

The young rugby player was referred for physiotherapy for a presumed soft tissue hamstring injury. He continued his physio for six months but made poor progress, so he was referred to an orthopaedic surgeon. He had another pelvic x-ray and a hip ultrasound scan. Both showed a displaced ischial tuberosity avulsion fracture. Conservative management (ie, no surgery) was continued for a further year; yet despite a structured physio programme, he remained unable to run and therefore unable to return to sport.

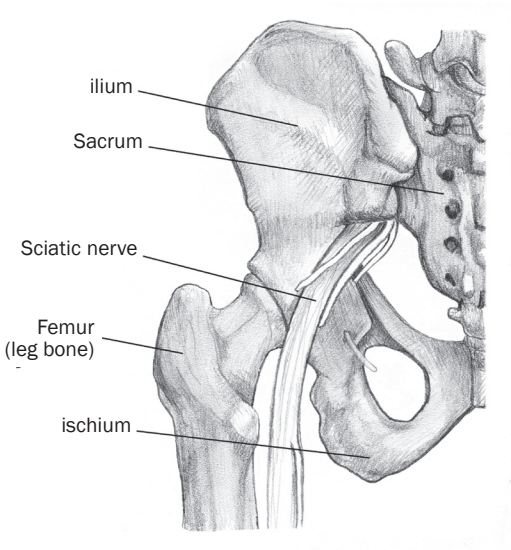
Eighteen months after the initial injury he was referred to a sports orthopaedic surgeon. A CT scan of the pelvis confirmed

his ischial tuberosity avulsion fracture. An ultrasound scan showed that the torn-off fragment of bone was moving around. Since conservative management had thus far been unsuccessful, we decided to operate to close up and fix the fracture. The patient returned to full active contact sport within six months.

The anatomy

Each side of the pelvis is composed of three bones: the ischium, ilium and pubis. The ischium is the lowest and strongest part of the pelvis (*see below*). It is attached to the pubis at the front and the ileum at the back. The upper edge of the ischium is in the centre of the acetabulum (hip socket). The lowest point of the ischium is the ischial tuberosity, which is palpable as a bony prominence in the buttock and is used for sitting (the sit bones). The ischial tuberosity is the point of attachment for all three hamstring muscles (biceps femoris, semitendinosus and semimembranosus) and for adductor magnus.

Bones of the pelvic area



Ischial tuberosity avulsion fractures occur through the 'apophysis' – a tendinous growth of new bone that appears at puberty and fuses into hard bone in late adolescence. So most ischial tuberosity avulsion fractures occur in young sportsmen and women between the ages of 15 and 25. The highest incidence is among 15 to 17-year-olds.

The apophysis of the ischial tuberosity is weaker than the hamstring tendons and muscles. If a large force is put across the hamstrings when the apophysis is open, the result is likely to be an avulsion fracture (the tearing off of a bony fragment) of the ischial tuberosity rather than a hamstring tear. After adolescence, when the apophysis has fused, hamstring soft tissue injuries are more likely than an ischial tuberosity avulsion fracture, as the ischial tuberosity is no longer the weakest link in the chain.

How it happens

Ischial tuberosity avulsion fractures occur as a result of sudden forceful hamstring contractions or stretching (the latter occurs when the hip is excessively flexed with the knee in full extension). Among athletes the injury is most commonly seen in soccer players and gymnasts[1], although fractures also occur in sprinters, long-jumpers and hurdlers.

The athlete will usually complain of buttock or groin pain, which can be severe. Sitting may be particularly painful. The patient often has difficulty walking and is unable to run. Because avulsion fractures are often misdiagnosed initially as soft tissue injuries, the patient may seek specialist medical help only by the time there is chronic pain and disability.

On examination there may be swelling over the fracture site, and the ischial tuberosity will be tender to touch. The hamstrings are weak but there is often a full range of movement in the hip.

It is often difficult to distinguish between an avulsion fracture and a hamstring soft tissue injury, but important clues that suggest an avulsion fracture include the athlete's age and an inability to weight-bear.

How to confirm the diagnosis

A pelvic x-ray should be performed in all patients with ischial tuberosity tenderness and in those who cannot weight-bear. If a fracture is seen, a CT scan will further clarify the fracture and give an accurate measurement of the distance between the fracture fragment and the pelvis. If no fracture is seen on x-ray, an MRI scan should be considered to assess whether there is a soft tissue injury needing surgical repair.

Treatment

Ischial tuberosity avulsion fractures may be treated conservatively or operatively. An absolute indication for surgery is disturbance of the sciatic nerve. Surgical treatment is recommended for all elite athletes who do not make a significant improvement after one month of conservative management[2,3].

Conservative treatment involves a structured programme of physiotherapy rehabilitation. The first aim will be to control pain with ice, rest and non-steroidal anti-inflammatory drugs and to re-establish a normal gait using weight shifts and single-leg stance balancing. The patient can then begin exercises to improve hip range of motion, hip strength and neuromuscular co-ordination. Once the athlete has achieved full strength and range of motion, they will be ready for progressive cardiovascular endurance and functional exercises in preparation for their return to full training.

The main benefit of conservative treatment is that it avoids surgical complications such as infection and nerve damage. However, conservative management does bring its own complications, the most common of which is non-union (failure of the bone to bind) at the fracture site. This causes chronic pain and malfunction. A further possible complication is 'hamstring syndrome', in which the hamstring origin shortens and fibroses, again leading to pain and disability.

There are two options for surgical treatment:

- resection (cutting away) of the loose fragment

● open reduction and internal fixation of the fragment (joining the bone back together and pinning it).

The advantage of resection is that it is a simpler and quicker procedure. The main disadvantage is that an osteoma (a mass of bone) may form post-operatively which then requires clinical and radiological follow-up. The advantage of open reduction and internal fixation is that normal anatomy is restored with a good functional outcome. The standard operative risks apply to both types of surgery but for elite athletes most authors recommend open reduction and internal fixation, as it is likely to offer a quicker return to full fitness.

Conclusion

Avulsion of the ischial tuberosity is a rare injury which tends to be missed. It should be considered in any young athlete with buttock pain, tenderness over the ischial tuberosity or difficulty weight-bearing. A pelvic x-ray will confirm the diagnosis. Treatment is either conservative or operative. Open reduction and internal fixation is recommended for all elite athletes who do not significantly improve with one month of conservative treatment.

Elizabeth Ashby and Fares Haddad

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Troy the goalie injured his quads, but the source of the problem was in his butt...

I have seen Troy on and off for the past five years to treat the injuries he sustains playing soccer/football. He certainly has been prone to injury. And unless he is very diligent with his rehabilitation, the more injuries he suffers, the more likely he is to sustain fresh ones. This is because of the 'flow on' effect that happens when a body part is not sufficiently mobile or strong to control the forces involved in the client's chosen activity.

Troy plays goalkeeper, where he must move rapidly in any direction after long periods of relative inactivity. He must take goal kicks, which require him to generate large amounts of muscular torque (force), also often after relative rest.

Troy had injured his right quadriceps muscle after a goal kick very early on in the game – but he had, he assured me, warmed up before the start. Of interest to me was what Troy reported had been going on in the days before the match. He has a very sedentary job involving long periods of sitting, and he'd had some low back pain in the previous week. This was probably postural pain from a poor sitting position, but in such cases of prolonged sitting plus pain, I am always curious to look at what may be going on with the muscle system. Then, on the day of the match, Troy had had a two-hour car journey, arriving only 30 minutes before the warm up.

Following the trail

The kicking action deploys muscles that stabilise the trunk, knee and foot alongside those that provide the power for the approach and kicking of the ball. The kicking action follows a definite timing and specificity of muscle recruitment.

Table 1: Typical muscular activation with low back pain

Muscle	Action	Compensatory muscles
Gluteus maximus and posterior gluteus medius	● Hip extension / external rotation ● Stabilise the pelvis on the hip, during eg, single leg stance	● Hamstring muscle group ● Contralateral quadratus lumborum ● Tensor fascia lata
Psoas major	● Flexes the hip ● Maintains normal lumbar lordosis ● stabilises anterior hip joint	● Rectus femoris ● Tensor fascia lata ● Erector spinae

Among those with low back pain, one very common muscular imbalance is the failure to recruit gluteus maximus at the correct time (if at all), in its role of extending the hip and stabilising the pelvis when standing on one leg. The other important muscle that is often less-than-ideally recruited is the psoas major hip flexor.

The role of psoas major can be to maintain the normal curve of the lower back, especially when people are sitting, but also to stabilise the front of the hip joint to prevent injuries such as soft-tissue tears around the hip socket. On the football pitch, psoas major is also very active in the approach to the ball and the impact phase of the kicking action. It is reasonable to suspect that the hip flexors may reflexively shorten if they are weak or unable to work throughout their whole range. Table 1 above shows which muscles can overwork or compensate for the loss of activation of these stability muscles.

If the psoas is weak the athlete may over-recruit rectus femoris (the long quadriceps muscle of the front thigh) to flex the hip, placing extra load on that muscle. Moreover, if the hip flexor does not have adequate length, it cannot be properly lengthened in the preparation phase of the kick. This might lead to poor co-ordination of the through swing, resulting in poor performance – and possibly injury.

This was certainly the mechanism behind Troy's muscle

Table 2: Contributing factors to Troy's quad injury	
Factor	**Treatment**
Long periods of sitting	● Improve awareness of ideal sitting position ● better chair support
Weak psoas major in the kicking leg	● Specific activation exercises (see below)
Short psoas/hip flexors	● Massage / trigger point therapy
Weak gluteals on stance leg	● Specific activation exercises in kicking position, involving lateral and rotatory control mechanisms
Lack of hip extension preparatory to kick	● Massage / trigger point therapy to hip flexors and adductors ● gluteal exercises to gain active hip extension
Scar tissue in the rectus femoris from previous muscle injuries	● Massage therapy

injury, as Table 2 above shows.

Troy was unable to stand on one leg for any length of time, especially when he needed to swing the opposite leg, as in the kicking action. He over- recruited quadratus lumborum (low back muscle) on the kicking side to help stabilise his pelvis and had poor awareness and control when turning his pelvis on the left hip, as in the kicking action. Correction of this was all part of his home exercise programme.

I initially gave him exercises just to activate the gluteals, first in lying, then sitting and standing. We then progressed this to the stance leg in the kicking action.

Gluteal exercises

Single-leg stance glute activation

Technique

● Stand on affected side with good alignment, and contract gluteals

● Perform 3 sets of 10 contractions, holding for 10 sec each time.

● It is essential to not switch on the hamstrings or adductors (inner thigh muscles), so keep these relaxed

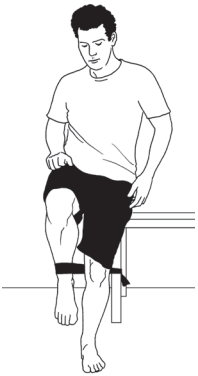
Single-leg stability against opposite side movement

Technique

● Keeping stance knee facing forwards, turn other knee outwards to rotate pelvis away and back towards the front, using the gluteals. This strongly isolates gluteus medius on stance (affected) leg

● Perform 3 sets of 10 reps under control

Hip flexor strengthening



Technique

● loop x-band around the ankle of the leg with the weak hip flexor and secure the other end behind you (eg to a heavy table leg)

● standing on opposite leg, flex the hip by lifting the knee forwards and up against the band resistance

● return leg, keeping it bent so that the foot stays off the ground and repeat the raise

● avoid hitching the hip on the swing leg side

● Perform 3 sets of 10 reps

The principle that you are only as strong as your weakest link is so true here. Troy sustained the rectus femoris strain because of muscular weaknesses away from the injury site. Core muscular control is important for all sports and it needs to be prioritised in every athlete's gym programme. It must also be speed- and direction-specific to the sport.

Scott Smith

Notes

Notes