

RUNNING INJURIES

prevention and treatment

A SPECIAL REPORT FROM



**PEAK
PERFORMANCE**

The research newsletter on
stamina, strength and fitness

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From the editor

The majority of runners whether fun, club or elite have had to go through the irritation and frustration of injury. In most cases, as an athlete, it's not the pain of the injury that's the problem, it's the unknown parameters and consequences of this injury that is the real thorn in the side. How did I get this injury, have I been over training, how long will it last and most importantly will it re-occur. If you are lucky enough never to have experienced a running injury, then no doubt you have trained with people who have been plagued by injury problems. The fact is that we all know that 'prevention is better than cure' but until we have experienced the aggravation of a running injury we are usually too complacent to accept this rule of thumb and do anything about it.

With this in mind I'm pleased to introduce the long awaited report on Running Injuries. Drawing from the knowledge and experience of our panel of sports scientists, physiotherapists and sports therapists from both Peak Performance and the Sports Injury Bulletin we have compiled a holistic, technical and hands on approach to understanding, treating and managing your running injuries. The report covers the assessment and importance of the kinetic chain, bio mechanics and training tips to prevent injury. The next section is slightly more technical and takes an in-depth look at the physiology behind specific injuries that may be affecting you. The final section of the report looks at the POSE running technique and the problems of muscle imbalances while running and practical exercises to address these important concerns. Plus the perfect way to execute the squat, one of the frequently contested and often controversial exercises that we see carried out in gyms today.

Thanks to our panel of experts, we hope this report will stay with you as an invaluable reference point through your running career, and not only help you stay injury free but also increase your biomechanical efficiency for long term gains.

Lotty Skinner,

Clinical Director, Full Fitness Sports Injury Clinic

Taking a robust approach to running

There's more to reducing the risk of sustaining a running injury than incorporating a couple of stretches and the odd weights session into your training routine. As Matt Lancaster explains, a structured approach to build 'running robustness' is a much better approach...

Oscar Pistorius is able to run 400 metres in less than 47 seconds. While this does not mark him as a serious medal contender, his determination to compete in the Beijing Olympics has become a big story in athletics. However a recent announcement by the IAAF ruled that he would not be allowed to do so.

Pistorius was born without fibulas (the smaller of the two bones which form the lower part of the leg) and he has never walked without the aid of prosthetic limbs. He began running competitively in 2003 and after winning the 200 metres at the Athens Paralympic Games, turned his attention to competing against able bodied athletes.

The IAAF ruling was based on an investigation by Professor Gert-Peter Brueggemann, and concluded that an athlete using the carbon fibre prosthetic blades has a more than 30 percent mechanical advantage over an athlete not using the blades. Once Pistorius reached a certain stride the blades, known as Cheetahs, behaved like stiff springs and he was able to run at the same speed as able-bodied runners using about 25% less energy. However, Pistorius' prosthetist Trevor Brauckmann has argued that the athlete still has to produce the energy to propel the blades and Pistorius has appealed against the ruling.

The IAAF decision and Brauckmann's defence of the Cheetahs tell us a great deal about both the fundamentals of running mechanics and the stresses which running places on the

human body. This article draws together key aspects of running mechanics and the principles of biological robustness to explore practical ways in which you can adapt your own training to minimise the stresses and strains on your body.

Running mechanics

Locomotion requires us to propel ourselves forwards, while at the same time counteracting the force of gravity, which is constantly pushing us down ⁽¹⁾. In order to overcome this gravitational force, we have to push down into the ground with each foot strike, and (as anyone who recalls high school physics will know), if we are transmitting a force into the ground, an equal and opposite force is returning through our feet and ankles. This force is called a ground reaction force (GrF).

When you run, vertical GrFs can exceed three times your body weight, depending on your mass and the speed you run at ^(2,3). In order to move forward, we simultaneously pull our leg backwards beneath our torso, creating a horizontal GrF. The effort amount of muscle activity and force production required to do this increases as we run faster ⁽⁴⁾. This muscular action, along with the impact of GrFs, produces a considerable amount of stress and strain, which our tissues have to absorb if we are to avoid injury.

At a Glance

- The general mechanics of running and potential for injury are discussed;
- The concepts of biological and running robustness are explained;
- Conditioning approaches to develop running robustness are outlined.

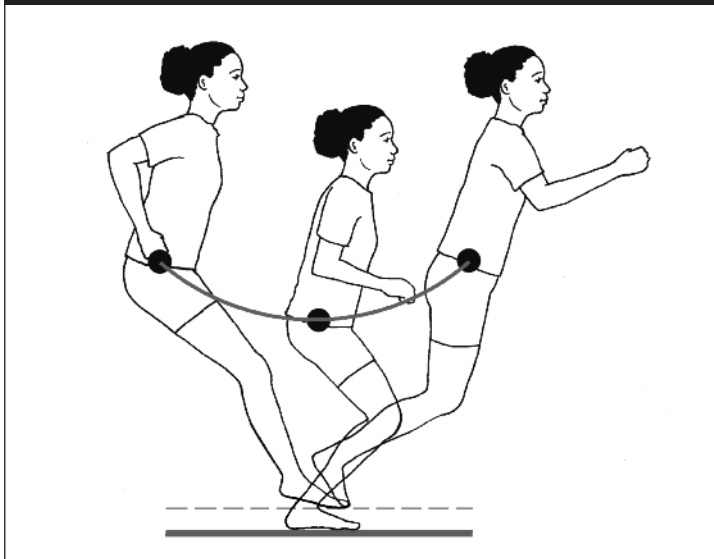
So, how do we accommodate these stresses while at the same time propelling ourselves upwards and forwards? Well, like Oscar Pistorius, we have springs too, only instead of being made of carbon-fibre they are composed of a complex system of muscles, tendons, ligaments and other connective tissues ⁽⁵⁾.

In simple terms, when your foot strikes the ground you absorb and dissipate energy by lowering your centre of mass (compression)

“There is no simple or sure-fire way to avoid injury, but if we combine our basic understanding of running mechanics with the principles of biological robustness, it may give us an insight into how we can structure our training to help reduce the risk of injury”

before generating energy to extend the leg and propel us up and forward (recoil)⁽⁶⁾. In this way, energy is constantly stored (largely within the tendons) and recycled using a mechanism known in biomechanics as the spring-mass model (see figure 1)⁽³⁾.

Figure 1: Compression and recoil of the 'spring-mass model'



However, running is not quite as straightforward as this. In addition to moving forward, up and down we also shift from side to side while our limbs and torso rotate. There are three reasons for this. Firstly, our joints are shaped irregularly and are neither perfect hinges nor spheres, meaning our movement has to occur in multiple planes. Secondly, these sideways and twisting movements help absorb GrF (Braukmann makes the case that as Pistorius does not have feet or ankle joints there is increased shock through his stumps into his knees, hips and back). And finally, if we tried to run without shifting our centre of mass from side to side, we'd almost certainly fall over! The primary purpose of running is to move forwards, but our body is subjected to stresses and strains acting in every possible direction.

Biological robustness

Biological robustness describes the ability of a biological system to maintain its core function in the face of stresses and uncertainty occurring within the system or its environment ^(6,7). Another way to consider this may be to think of an organism continuing to perform despite ongoing changes and adaptations in either its components or surroundings ⁽⁸⁾. If the organism can't adapt successfully, then disease or injury may follow ⁽⁹⁾.

Thinking about biological systems in this way draws on the principles underpinning a branch of science called complexity. Complex systems, such as our nervous system, circulatory system or indeed the entire human body, consist of a large number of components interacting together. Crucially, the overall function cannot be explained by examining the components alone ^(6,8,9). Put simply, the performance of a complex system is greater than its parts. For instance, a function as basic as running cannot be described simply by studying anatomy.

Developing running robustness

There is no simple or sure-fire way to avoid injury, but if we combine our basic understanding of running mechanics with the principles of biological robustness, it may give us an insight into how we can structure our training to help reduce the risk of injury. The remainder of this article considers different forms of training in relation to both a specific training goal and a robustness goal. Training types and goals are summarised in table 1 below:

Table 1: Training and robustness goals

Training type	Training goal	Robustness goal
Strength	Specific tissue capacity	Enhanced modularity
Conditioning	Non-specific tissue capacity	Diminished fragility
Coordination	Skill	Enhanced system control
Running	Specific performance adaptation	Environmental buffering

Strength and modularity

Far from a single sprung structure, the human leg has three segments acting around joints – the ankle, knee and hip – which combine to produce the overall biomechanics required for running⁽¹⁰⁾. We can consider each of these segments a separate module able to absorb energy, primarily around the knee and ankle, and then produce a rapid propulsive force, which is supplemented by the recoil of the springs. Within this modular architecture, the calf, thigh (quadriceps and rectus femoris) and hip extensors (gluteal and hamstring muscles) are the key running muscles^(1, 10).

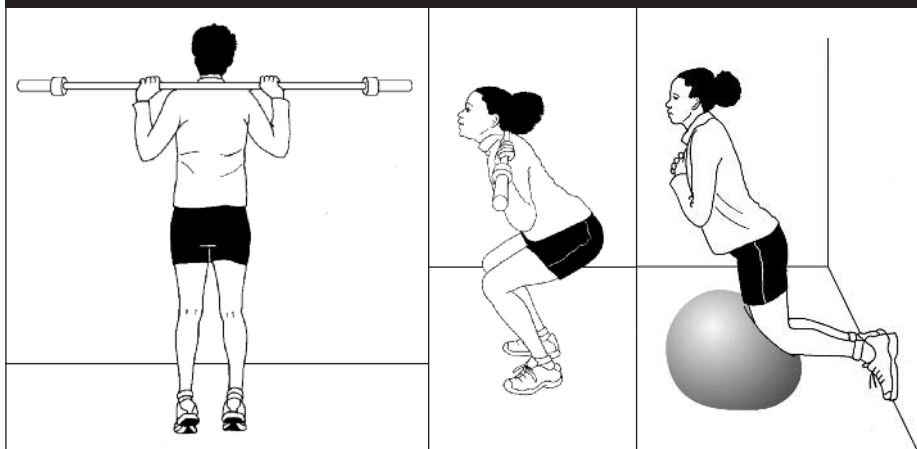
In biological systems, each individual module must meet the stress demands placed upon it to ensure robustness⁽⁶⁾. Modules need to have a recovery capacity to repeat their function, which probably means that even for power-based athletes, developing local endurance properties over a period of time is important.

“Remember, the goal is not necessarily to make each exercise progressively harder, but to expose tissues to a broader range of stresses than they are subject to when running”

Interaction between modules, including their relative stiffness, also determines the distribution of stresses between the hip, knee and ankle joints⁽¹⁰⁾. A module with poor capacity may increase the stress demands placed on a neighbouring module. Finally, a strong modular structure can help contain excessive stress or local damage, minimising the effects of injury on the whole system⁽⁶⁾.

Strength training is ideally suited to increasing the specific capacity of these modules to meet the demands of running. Working against resistance, whether gravity or weight training, can be an effective method for improving the capacity of muscle-tendon units to absorb and produce force. Progression of strength exercises is usually aimed at developing more of a specific capacity, while training phases often follow a similar series progression: first endurance, then strength and then power. Examples of strength exercises for key running muscle groups are shown in figure 2, overleaf.

Figure 2: Strength exercises for key running muscles: calf raise, squat and Nordic hamstring curl



Conditioning and fragility

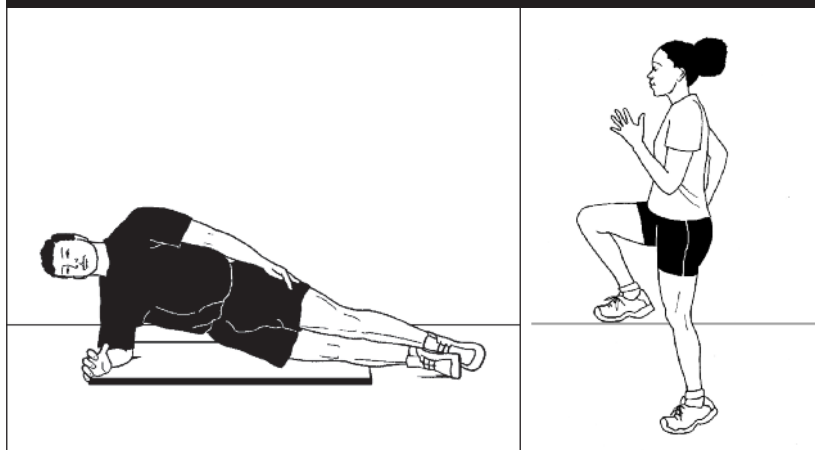
There is a price to be paid for developing specific robustness, and it goes some way to explaining how highly trained athletes can still be susceptible to injury. As training and strength progress we become increasingly adapted to the stimulus our body expects. However, high levels of adaptation to a familiar stress may conversely leave you potentially fragile to an unexpected stress. And as the highly adaptable and complex being that you are, it is often tiny unexpected stresses that may prove catastrophic. This is referred to as the robustness-fragility trade off^(6,7,8).

A simple way to counteract this fragility is to increase the variety of stresses your tissues are conditioned to. Conditioning training is less concerned with the specific mechanics of running than strength training. Of course, if your primary sport is running, there is little to be gained from conditioning your body to stresses as divergent as those encountered in judo or rugby. However, conditioning your body to a range of stresses that are somewhat broader than the very specific adaptations gained from running and strength training may be advantageous.

Rather than progressing repetitions or resistance of a small selection of strength exercises, the key progression here is

adaptation to a wider variety of moderate stresses. This means choosing exercises that stress trunk and leg tissues in particular (*see figure 3*), utilising a spectrum of resistance levels and joint ranges, as well as providing multidirectional tissue challenges.

Figure 3: Examples of basic conditioning and co-ordination exercises: side plank and high knee running drill



And don't get stuck in the rut of repeating the same exercises for months at a time; adapt and then change. Remember, the goal is not necessarily to make each exercise progressively harder, but to expose tissues to a broader range of stresses than they are subject to when running. Building your condition and minimising your fragility may take time. This sort of conditioning is ideally suited to circuit training.

Coordination and system control

Within all biological systems, some form of control is essential to achieve a robust response to a particular stress⁽⁶⁾. In humans, this control is provided by our nervous system and manifests itself as coordination. Within a complex biological system, coordination requires the mastering of all the possible movements available to us into a controllable movement pattern, such as running or jumping.

Skill involves ensuring this temporary movement pattern is resistant to any environmental stresses that may challenge its stability, and is therefore probably vital for us in developing robustness⁽¹¹⁾. Regulating modules or utilising slightly different strategies to overcome unexpected stresses requires sophisticated orchestration⁽⁶⁾.

Traditionally, theories concerning movement control have considered particular movement characteristics to be stored within our central nervous system, ultimately leading to control and limited variation when we perform a particular skill.

However, consider what happens when we run on different surfaces. If our leg stiffness were always the same then our vertical rise and fall would be greater when we ran on a soft, compliant surface. But biomechanical experiments suggest that we actually adjust our leg stiffness quite quickly (possibly within a single step!) depending on the compliance of the surface. In other words, our legs become stiffer and compress less when we run on a soft surface to allow us to maintain a steady running pattern⁽³⁾.

Likewise, wearing footwear may influence our stiffness and it appears that our muscle activity is tuned to control tissue stress depending on GrFs^(5,12). Far from a single movement pattern, there is constant variability in even a seemingly repetitive skill such as running. This requires coordination and it is possible that the challenge is greater still for an amputee athlete like Pistorius who does not have feedback from the feet and ankles to assist.

So how should we incorporate coordination challenges into training? Firstly, aim to perform all training components (strength, conditioning and running) with skill. The central nervous system coordinates the activity of many muscles, tendons and ligaments to set the overall 'spring' characteristic of running, while strength training is redundant without highly developed motor control, involving appropriate timing of movements for effective force production^(3,4).

Secondly, while making a conscious effort to move well, we also need to address fragility by introducing a 'bandwidth of variability' in the way we run or exercise and challenge our coordination to accommodate this variability – *ie* taking

ourselves outside our coordination comfort zone. Running drills can be an effective way of achieving this. There are too many drills to attempt to describe here, but rehearsing components of the running action and then adding variety – speed, direction, range, rhythm – is a good place to start.

Thirdly, general coordination activities that relate to running mechanics are also helpful. Skipping with a rope or simple hopping activities, such as playing hopscotch, are examples. Base the progression on the quality and breadth of your skill. Coordination will be involved in all aspects of your training but take time to challenge and develop it further.

Environmental buffering

If you want to guarantee you don't get hurt as a result of running, don't run. But if you do want to run while minimising the risk of injury, run smart.

The volume, intensity, gradient and terrain of any training should be consistent with your capacity to cope with the stress. And here lies the inherent risk of running; in order to adapt and improve our performance, we have to expose ourselves to progressive new stresses.

Nothing enhances running robustness like running. Indeed tissues such as tendons undergo greater adaptation in response to running than other forms of exercise⁽¹³⁾. This underpins both environmental buffering and the basis of successful coaching; it's not the overall volume or intensity of a running program that necessarily provides the risk, but the rate of progression and the time allowed for adaptation to significant new stresses. Don't be afraid to take things slowly in order to run faster.

Even a sensible training progression will not guarantee your protection from the small variations you may face however. By now you should be able to draw your own conclusions about how you may achieve this. Subtle variation and exposure to a slightly wider range of stresses will allow broader adaptation.

For example, based on changes in GrF and required leg stiffness, making an absolute transition from purely grass running to running only on the road is probably unwise.

‘The volume, intensity, gradient and terrain of any training should be consistent with your capacity to cope with the stress. And here lies the inherent risk of running; in order to adapt and improve our performance, we have to expose ourselves to progressive new stresses’

However, a well-balanced programme incorporating components of each may provide safe but challenging exposure to a range of stresses.

On the same basis, manipulating your running form for short periods in a controlled and skilful way could subtly broaden tissue exposure and coordination challenges. For instance, in addition to running drills, practice over or under striding, exaggerating your pelvis and hip rotation or running without any arm swing. Make measured, sensible adaptations to your training plan but within that plan train with a degree of variability.

A final word

Developing robustness requires resources, including energy and time. Going to the gym, developing a broad conditioning base and performing coordination drills may leave you less fragile, but it may also detract from the time and energy you have for running. Sacrificing too much of your running time at the expense of less specific training may leave you less adapted to the demands of running itself. And in terms of performance, it is probably your specific robustness that is most relevant. You can never remove the risk of injury completely (genetics probably has a say in this⁽¹⁴⁾), but planning and performing your training well may reduce the risk.

Australian-born Matt Lancaster relocated to the United Kingdom in 2000 and is currently employed by the English Institute of Sport as lead physiotherapist for the London region

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Masai barefoot trainers

Paul Brice weighs up the evidence for a shoe that would have us walk like warriors

Masai Barefoot Technology trainers (MBTs) have been around for 10 years, but lately are showing signs of becoming high-fashion must-have items. The makers claim that the shoe:

- activates neglected foot muscles
- improves posture
- tones and shapes the body
- improves performance
- helps with back, hip, leg and foot problems
- helps with joint, muscle, ligament and tendon injuries
- reduces stress on the knee and hip joints.

The international media hype around MBTs has even gone so far as to suggest that the shoes can help banish cellulite and promote weight loss – claims not far short of alchemy.

MBT is based on a simple concept: that the human foot is designed for barefoot walking on soft ground, yet most of us in developed countries spend our lives in supportive and restrictive footwear and walk on hard, flat surfaces. The shoe design is the brainchild of Karl Muller, a Swiss engineer, who derived his inspiration from the low injury rates of the African continent.

Leaving aside the obvious differences between the functional requirements of a Masai tribal member and the average innercity office worker/amateur athlete, does this shoe design add up to anything more than a gimmick in terms of injury prevention? Ordinary shoes do little to correct poor gait (walking style). Most of us prioritise comfort or fashion over our specific functional or anatomical needs, with the result that

we adopt a passive gait, in which the foot, ankle and leg muscles become under-worked and develop weaknesses.

Strong intrinsic foot musculature is what allows the tissues of the foot and ankle to tolerate the stresses of instability effectively and without damage or injury. It is therefore not unreasonable to suggest that areas of weakness can also be prime sites of potential injury.

The MBT was designed as a medical shoe. It is a slightly unsightly, bulky shoe, with a substantial thick sole that is curved from front to back, forcing a pronounced heel-to-toe walk. The unstable rocking action is thought to simulate the natural instability of walking over undulating ground and thereby encourage beneficial muscle strengthening.

To date there appear to have been three main scientific studies on the MBT trainer and its effect on how we walk. The first research came from the Human Performance Laboratory in Calgary, Canada. The MBT was shown to:

- increase rotational ankle movement, notably plantar flexion (where foot points downwards) and foot inversion (inward rolling)
- decrease ankle joint impulses for the knee joint, which means that the knee has to withstand fewer repetitive rotational stresses (down by 27%)
- increase the wearer's oxygen consumption by 2.5%
- increase movement of the 'centre of pressure' (COP) during standing, which allows force to be spread across a greater area of the foot. High forces going through small areas of the foot are strongly linked to an increase in injury levels with repetitive foot strikes over prolonged periods.

Based on these findings, the researchers report that the MBT strengthens the muscles of the foot and ankle complex, while reducing loading through the ankle joint. But this study had small numbers (eight people) and conducted its analysis at relatively low walking speeds, which limits its value.

The second relevant piece of research was a gait evaluation study from Sheffield Hallam University. The researchers found:

‘Most of us prioritise comfort or fashion over our specific functional or anatomical needs, with the result that we adopt a passive gait, in which the foot, ankle and leg muscles become under-worked and develop weaknesses’

- less forward lean: MBT promotes a more upright posture, which may affect the position of the centre of mass at foot strike. The further the distance of the foot when making contact with the ground the greater the braking forces that occur on the body. The authors imply that the MBT reduces braking forces, which does make mechanical sense, as anything that promotes a more upright posture tends to lead to a more efficient system and reduced load through the body
- higher dorsiflexion ankle angle: The shoe's rocker system forces the foot into a greater flexed position throughout the walking cycle. This would promote a rolling of the foot, which would distribute forces evenly through the feet, allowing the body to absorb force quickly, without injury
- reduced 'transient peaks' with MBTs: momentary forces sent through the skeleton as a result of impacts during normal walking and running are a primary factor in the development of many musculoskeletal disorders
- MBTs allowed increased muscle activity in the calf, hamstring and buttock muscles, but a decrease in the small postural muscles of the spine, perhaps because of the more upright posture and production of greater propulsive forces.

A third research group, from Edinburgh, compared foot pressures during gait among 22 subjects wearing MBTs and normal trainers. For the MBTs, it found:

- reduced foot pressure in the heel (probably the result of the MBT design in which there is no cut-away on the heel section)
- reduced peak pressure in the mid foot (21% lower) and heel (11% lower)
- average pressure was greater in the toes and forefoot and less in the mid foot and heel
- a shift in the pattern of the centre of pressure, allowing force to be spread over a greater area of the foot.

People suffering with conditions such as osteoarthritis or other degenerative joint disease may benefit from the reduced joint

“the shoe is primarily designed for ‘single plane’ activities such as walking or linear jogging. And the large and bulky sole unit may add to the shoe’s unsuitability for multidirectional sports (eg, squash, tennis or team sports) where shoe feel, lightness, durability etc are important”

loading of the MBT's heel-to-toe rocker. But because the rocker sole runs front to back, the shoe is primarily designed for 'single plane' activities such as walking or linear jogging. And the large and bulky sole unit may add to the shoe's unsuitability for multidirectional sports (eg, squash, tennis or team sports) where shoe feel, lightness, durability *etc* are important.

While there are manufacturer's claims for the MBT's efficacy in relation to jogging, there is no evidence to support them. Athletes using a more pronounced mid foot or even forefoot strike with the ground will find this kind of sole design irrelevant.

The bottom line? No single piece of technology can substitute for a well-structured and balanced conditioning programme that includes foot musculature strengthening. As things stand, it would be playing safe not to throw out all your other trainers/shoes for a life in MBTs.

Paul Brice *is a biomechanist with the English Institute of Sport West Midlands*

Evaluation of the kinetic chain & underlying muscle imbalances – getting to the core of your injury

Follow the kinetic chain to discover the source of repeated injuries to a limb, Cameron Reid advises

There have been several articles in issues of *SIB* (see issues 54-57) on the importance of core stability. It can, however, be difficult at times for the therapist to see the link between an injury and poor core stability as the ultimate cause. This is often particularly well illustrated in clients who have suffered a range of different injuries or who regularly injure one side of their body. This series of events is often due to poor functioning of the kinetic chain and the lumbo-pelvic-hip complex (the core area). So 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.

The kinetic chain

The kinetic chain is defined as the interdependent operation of the soft tissue system (muscle, tendon, ligament, fascia), the nervous system and the articular system (joints). These three major body systems together enable proper movement patterns to occur. If they are not working together (muscles, nerves, joints), you will place increased demands and strains on the tissues in the body, leading to fatigue and injury. One way of describing the coordination and strength of the kinetic chain is

“The tight iliopsoas will make gluteus maximus less efficient and weak, which in turn will adversely affect the function of the kinetic chain, in this case increasing strain on the lower extremity”

neuromuscular efficiency. This is the ability of all the muscles in the kinetic chain to work together to produce force, help decelerate, and maintain stability at all times. Good core stability and neuromuscular efficiency protect the body by allowing optimal shock absorption and the body to decelerate against gravity without injury.

Reciprocal inhibition

One of the most common reasons for poor neuromuscular efficiency in the core area is ‘reciprocal inhibition’ ^(1, 2). The principle is that a tight muscle will cause decreased neural input to its functional antagonist (opposing muscle); from a mechanical perspective a tight muscle will limit the range of motion through which its functional antagonist can move. For instance, in the case of gluteus maximus a tight iliopsoas mechanically will cause decreased hip extension and neurologically will decrease neural drive to the gluteus maximus. In other words, the tight iliopsoas will make gluteus maximus less efficient and weak, which in turn will adversely affect the function of the kinetic chain, in this case increasing strain on the lower extremity.

The footballer’s leg

I had a patient recently who played semiprofessional football. Plagued by various injuries to the right lower extremity (leg), he first came to see me after he’d had a sore right knee 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. Full examination of the knee was unremarkable, showing full pain-free passive movement (where the therapist moves the joint without resistance). The Thomas test (iliopsoas length test) was positive on the right, and showed the muscle to be tighter than the left. There was a large amount of tenderness at the patella tendon, mostly medially. The client told me he’d had this tenderness before on several occasions, 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. He also had

a sore Achilles tendon and transverse arch on the right foot, which he put down to old age (he's 31 years old).

All the usual treatments of ice, stretching and rest worked only temporarily, with knee soreness always returning. Standing examination showed a lordotic (hollow back) lumbar spine, 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 (*see box below*). If the neuromuscular system is not efficient it will be unable to respond to the demands placed on it during functional activities, leading to poor posture during these activities. This in turn causes excessive mechanical loading on the tissues.

When performing the overhead squat test, my client's feet started to collapse inwards and he felt much more comfortable with the feet turned out; his right knee buckled inwards during the squat and his lower back arched inwards even more, with erector spinae being very tight. His neck also arched backwards. The flattening of the client's feet during the squat is attributable to tight calves or a weak, inhibited gluteus maximus; the arched lower back and tight erector spinae are often linked to a tight hip flexor (iliopsoas); the knees buckling inwards can also be down to weak gluteus maximus and medius. In this player's case, a shortened psoas causes an inhibitory effect on gluteus maximus, which can affect the whole kinetic chain. Among the potential resultant problems are increased strain on the knee (because of the inhibited gluteus maximus) and quadriceps

Overhead squat test

Client stands with bare feet shoulder-width apart and arms straight over their head, elbows extended (it helps if they hold a wooden pole shoulder-width apart). Ask the client to squat down slowly as though sitting in a chair, to a comfortable level. Ask them to repeat the movement three to four times while you observe and note everything that is going on. In particular, note what happens to feet, knees, thighs, lower back, arms and shoulders.

overloaded to decelerate knee flexion and internal rotation, increasing the stress on the knee. The weak gluteus maximus may cause a similar strain on the tibialis posterior and calf muscles by increasing their eccentric load, which can cause a sore arch and plantar fasciitis or an Achilles tendinitis.

The footballer's rehab

The aim of rehabilitation in this case was to help the patient improve his neuromuscular efficiency, learn to engage his glut max, and keep psoas and the lumbar erector spinae well stretched. Glut max must have the strength to decelerate hip flexion eccentrically during running and help stabilise the lumbopelvic hip complex. In building a clear picture of the patient's neuromuscular control, as well as the overhead squat test, it is helpful to have an analysis of hip extension and abduction.

If there is altered firing patterns in the assessment of hip extension and abduction (your physio or sports therapist will be able to check this for you) good rehabilitation (or training) should be able to put this right. Some patients haven't a clue where gluteus maximus is and how to use it/recruit its fibres.

I get patients to stand upright and draw in abdominals and then contract their glut max while thinking 'bum'! It helps them find it and use it. Getting them to do everyday activities (walking, getting up from a chair *etc*) while thinking 'bum' reinforces awareness. Another useful awareness exercise is for the patient to go on to all fours and flex one hip and knee, drawing the knee forward into the chest, then slowly extend the hip and knee as far back as possible without also extending the lower spine, keeping the abdominals drawn in at the same time.

Once they can feel and use glut max properly, I use the following exercises ⁽³⁾:

Prone hip extension

Lie prone. Draw in abdominals, relax neck and shoulders and tighten gluteals. Hold for 5 to 10 sec. Progress this to drawing one leg off floor as high as gluteal contraction will allow without extending lower back or tilting the pelvis.

Bridge on stability ball

Lie supine with shoulders and head centrally on the ball. Feet point forwards, knees are over second toe and flexed to about 90 degrees. Draw in abdominals and squeeze glut max hard to raise hips upwards into a bridge. Do not extend lumbar spine.

Lunge

Stand upright, palms facing chest. Draw in abdominals. Lunge forward, maintaining good knee alignment (knee above 2nd toe). Keep upright posture. Progress to sideways lunge and then backwards lunge (harder, and needs good balance).

Step-ups

Face a 12in (30cm) step. Place one foot on step, draw in abdominals, raise body on to step and return slowly under control (eccentrically contracting opposite glut max). Progress a) to sideways step-up; b) to using dumbbells with palms facing chest.

Conclusion

The significance of core stability can be seen to extend well beyond issues of pain or dysfunction in the core region 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. What your patient does when they are not with you, in many ways, is equally important. Static muscular overstrain encourages the development of muscular imbalances⁽⁴⁾, and hence a weaker core. It is very important to enquire about your patient's working, sleeping and leisure habits. Poor postural habits in these areas of life will lessen the effect of all that hard work done in training and rehab.

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A pain in the side – why stitch can turn a sporting demigod into a ‘DNF’

When Haile Gebrselassie dropped out of the 2007 London Marathon, no one was more shocked than the man himself. But why should an athlete of his ability and experience be struck down by something as mundane as a side ‘stitch’? Alison McConnell explains

The sight of Haile Gebrselassie pulling out of the 2007 London Marathon was almost as shocking to onlookers as Paula Radcliffe’s untimely exit from the Olympic Marathon in Athens. The double Olympic 10,000m champion dropped out of the lead group shortly after the 30km mark, clutching his ribs. ‘I had a stitch here in my chest and could not continue. I’m not injured I just couldn’t breathe,’ he told BBC Sport, with more than a tinge of exasperated disbelief in his voice.

The manner of Gebrselassie’s exit is almost as surprising as his failure to finish; surely succumbing to stitch is not something that we associate with one of the greatest distance runners who has ever lived? Stitch is what ‘fun runners’ get – a ‘rite of passage’ for those en route to being ‘real runners’ isn’t it? However, as Gebrselassie’s exit from the London Marathon demonstrates, this is clearly not the case!

The lack of a definitive scientific explanation for stitch shouldn’t really surprise us since it’s a very difficult phenomenon to study using normal experimental methods. Experimental scientists generally study a phenomenon by inducing it, or manipulating it, and in doing so they derive a better understanding of its characteristics and the mechanisms that control it.

However, stitch is notoriously unpredictable in its onset, so studying stitch is very much like trying to study a condition such as acute mountain sickness (AMS); we know AMS occurs in some people when they ascend to altitude, but the symptoms vary between people, AMS doesn't always affect the same person in the same way, and it doesn't affect everyone at the same altitude.

This means that the only way you can study AMS is to observe a huge number of people, wait for AMS to develop in some of them, and then record the circumstances under which it occurred. This 'observational', or epidemiological research generates information that is analysed by crossreferencing many factors in order to tease out the common denominators within the symptomology and physiology. Associations between these factors then provide pointers to the underlying cause(s).

But even when these links are identified, the best that can be achieved with epidemiological research methods is circumstantial evidence of underlying mechanisms. So it is for stitch. Until 2000, there had been no data published on the phenomenon in the medical literature since 1951. Even those data that now exist are primarily epidemiological, and have originated from just one research group in Australia.

For example, in one study these researchers administered a questionnaire to 848 people who took part in a 14km run⁽²⁾. Twenty seven per cent experienced stitch and it was twice as common in those who ran in the event than in those who walked. This tells us that stitch arises frequently, but what are the common denominators in terms of its occurrence?

Causal factors in stitch

Studies have also used epidemiological techniques in an attempt to identify causal factors, as well as its prevalence. For example, a survey of almost 1,000 regular sports participants in Australia⁽³⁾ found that the prevalence of stitch declined with increasing age, and that neither gender, nor training experience appeared to influence stitch. In addition, they noted that stitch was often associated with shoulder tip pain; the shoulder tip is a site for

referred diaphragm pain (in much the same way that people get pain in their left arm when they are having a heart attack, pain in the right shoulder is linked to a problem relating to the diaphragm). In another survey from the same research group⁽⁴⁾, 1,000 participants in running, swimming, cycling, aerobics, basketball and horse riding were compared. The authors found that stitch was most common in sports that involve repetitive movement of the torso, either vertically (eg running and horse riding), or in longitudinal rotation (eg swimming).

- Current theories on the causes of stitch are outlined and evidence for these are presented;
- The importance of the diaphragm in stitch and its role as core a stabiliser is discussed;
- Strategies for coping with stitch and training techniques for its prevention are given.

‘The lack of a definitive scientific explanation for stitch shouldn’t really surprise us since it’s a very difficult phenomenon to study using normal experimental methods’

At a Glance

- Current theories on the causes of stitch are outlined and evidence for these are presented;
- The importance of the diaphragm in stitch and its role as a core stabiliser is discussed;
- Strategies for coping with stitch and training techniques for its prevention are given.

What is a ‘stitch’?

One theory is that stitch is caused by the movements of the stomach and liver, which places strain on the diaphragm ligaments and/or the ligaments supporting the abdominal organs. Another theory is that stitch is just plain old diaphragm ischaemia (insufficient blood flow for the metabolic demand), and/or a diaphragm spasm (cramp)⁽¹⁾. A more recent theory is that stitch is a symptom of an irritation of the lining of the abdominal cavity (peritoneum) caused by friction between the abdominal wall and the abdominal organs⁽¹⁾.

However, the jury is still out and there is, as yet, no unequivocal scientific evidence to implicate any one of these potential mechanisms.

‘Drinking fruit juice appeared to be more provocative than the other conditions, but there was no statistical difference between taking no fluid and taking flavoured water, or a sports drink’

There have been only two interventional studies of stitch, ie studies where the experimenters tried to induce stitch deliberately. In the first of these the experimenters administered a range of different drinks in an attempt to differentiate the influence upon stitch of fluid per se, as well as the effect of the composition of the fluid upon blood flow to the stomach and intestines⁽⁵⁾. After ingesting the fluid (14mls per kg body mass) the subjects were required to perform repeated bouts of hard running on a treadmill. They found that the composition of the fluid had little or no effect upon the development of ‘stitch’. In a separate part of the study the subjects performed a number of manoeuvres after the onset of stitch in an attempt to alleviate its intensity. The most effective of these were:

- bending forwards while contracting the abdominal muscles, or tightening a belt around the waist;
- breathing through pursed lips with an increased breathing volume.

The second study that attempted to deliberately induce stitch also examined the influence of the composition of different drinks upon the severity and subjective experience of the stitch⁽⁶⁾. The researchers selected 40 subjects who were susceptible to stitch, and compared their responses to four treadmill running trials (one control and three test drinks). Drinking fruit juice appeared to be more provocative than the other conditions, but there was no statistical difference between taking no fluid and taking flavoured water, or a sports drink. However, the difference between the sports drink and the other two conditions (water or no drink) was nearly statistically significant and the authors concluded that susceptible individuals should avoid fruit juice and other high carbohydrate drinks before, or during exercise. So what does all this tell us about the causes of stitch? The fact that it occurs more often in sports that involve jarring and/or twisting of the torso suggests it’s linked to the movement of the body’s internal organs, and that factors that are involved in maintaining postural stability may be involved. The shoulder tip pain indicates that the diaphragm muscle may be involved,

while the fact that having food or fluid in the stomach increases the prevalence of stitch points to the involvement of organs that are in close proximity to the diaphragm (stomach and liver). Finally, the clincher is the fact that stitch makes it very, very uncomfortable to breathe. All in all, the evidence adds up to the pain originating from the diaphragm muscle.

The role of the diaphragm

It's pretty well understood by most people that the diaphragm is the main muscle of inhalation, but what is less widely appreciated is that the diaphragm is also a vital part of the group of muscles known as the core stabilisers. The core stabilisers include superficial muscles that form a muscular 'corset', which encapsulates the abdominal compartment of the body, as well as deep muscles that stabilise the spine and pelvis. These muscles are responsible for keeping the body upright during activities that perturb the centre of gravity, such as bending, jumping, running, riding a horse, *etc.* They also help to provide a stable 'base' from which other torso muscles can twist the trunk during actions such as throwing, hitting a ball, or even front crawl and backstroke swimming. Perhaps the most important role for the core stabilisers is to protect the spine and pelvis from damage during lifting and any actions that load or impose stress upon these parts of the skeleton.

In its role as a core stabiliser, the diaphragm is activated subconsciously during the preparatory phase of most limb movements⁽⁷⁾. In doing so it raises the pressure inside the abdomen, which acts to increase spinal stability⁽⁸⁾. This function presents no problem when standing still, but when exercising, there's an additional demand placed on the diaphragm that comes from the requirement to breathe more vigorously. Put these two demands together, as occurs during running, and it easy to see how the diaphragm can become 'overloaded'⁽⁹⁾.

In other words, the diaphragm is subjected to competing demands in its roles as a vital core stabiliser and the principal muscle of breathing. In addition, because it is surrounded by large, heavy organs (specifically the stomach and the liver below

‘The fact that it occurs more often in sports that involve jarring and/or twisting of the torso suggests it’s linked to the movement of the body’s internal organs, and that factors that are involved in maintaining postural stability may be involved’

it), there are some situations that make life even more difficult for the diaphragm. If breathing and stride cadence aren't synchronised, the diaphragm can be 'buffeted' by the movements of these large organs as they move up and down under the force of gravity and in synchrony with the foot strike.

Not only does this stretch the diaphragm, but it also means that it must work against the buffeting, which adds considerably to the amount of work it must do. This can be a particular problem on uneven terrain when it's hard to get into a rhythm, and the postural role of the diaphragm and other trunk muscles is also being challenged. Ever had rib ache the day after a cross-country run? That's because your ribcage and diaphragm muscles have been fighting hard to keep you from landing on your face in the mud!

Facts about stitch

Only a few studies have been conducted into the causes of stitch, but here's what we know so far:

1. Stitch is most common during running (almost 10 times more common than in cycling)⁽³⁾;
2. The site of stitch varies, but is most commonly the mid/lateral abdomen⁽¹⁾;
3. Stitch decreases with increasing age⁽³⁾;
4. Stitch may be more common in people who train less regularly⁽³⁾;
5. Stitch is sometimes linked to food or fluid intake^(5,6);
6. Stitch is sometimes also associated with shoulder tip pain^(3,4);
7. Stitch can lead to difficulty in breathing;
8. Stitch also occurs frequently in horse riding and other sports in which the torso is subjected to movement (team sports and swimming)⁽³⁾.

Diaphragm discomfort

As a scientist, I must resist the temptation to apply my personal experience of a phenomenon to its interpretation. However, I have observed a consistent response across a large number of people, and over many years. These observations (combined

with the circumstantial evidence that exists within the literature) suggests, to me at least, that stitch is almost certainly diaphragm discomfort arising because of an inability to cope with the demands that are being placed upon it. Most people are inherently poor and inefficient breathers; they just let it happen automatically, and pay no attention to the muscles that are used to do it. Of the many muscles involved in breathing, the diaphragm is by far the largest, strongest and most resistant to fatigue. Accordingly, the diaphragm is the muscle that should be employed to undertake the lion's share of the work of breathing, not the rib cage muscles.

Sadly, in my experience, few people use their diaphragm as effectively as they could. In order to do so, they have to re-educate themselves into a way of breathing that was second nature to them as infants. This re-education is possible through a conscious process of focusing inspiratory effort upon the diaphragm, and is best practiced in the first instance while not exercising. (For a detailed account of how to enhance diaphragm breathing efficiency, see *Getting in touch with your diaphragm*, which can be found online at: www.powerbreathe.com/pdf/articles/Ironman_article_4.pdf).

Unfortunately, the conscious shifting of effort towards the diaphragm during running can have an initial downside, and many people find that they experience the most frequent and severe stitch pains they've ever had. However, in my experience, with perseverance over a two- to three-week period, most people also find that the pains gradually reduce in frequency and severity. My interpretation of this phenomenon is that during the initial phase, the diaphragm is subjected to an increased demand to do more of the work of breathing, leading to overload and ultimately, stitch. However, over a two- to three-week period, the diaphragm does what every other muscle in the body does when you ask it to do more than it's used to – it adapts. This adaptation means that the diaphragm becomes better able to cope with the increased demand and the result is that the stitch no longer occurs. But is this the only way to reduce the risk of 'stitch'?

‘some also reported that if they trained their inspiratory muscles within an hour or so of going for a run, they often got a stitch. In other words, they went for a run with the diaphragm in a pre-fatigued state’

In the course of my academic research, I have studied the ways in which breathing limits exercise tolerance and performance for over 15 years. This research led to the development of a device that trains the diaphragm (an inspiratory muscle trainer) by imposing a resistance to inhalation that is akin to lifting a dumbbell.

The reason this type of training is relevant to stitch is that one of the anecdotal observations of many people who train their inspiratory muscles using such devices is that they no longer experience stitch pain. In addition, some also reported that if they trained their inspiratory muscles within an hour or so of going for a run, they often got a stitch. In other words, they went for a run with the diaphragm in a pre-fatigued state, which predisposed them to getting a stitch. These observations are strongly indicative that stitch is a response of the diaphragm to a situation it can no longer cope with.

Inspiratory muscle training (IMT)

IMT requires a specific training device, such as a POWERbreathe. A typical IMT session consists of inhaling against a moderate training load (around 50% of the maximal voluntary contraction force of the inspiratory muscles) for around 30 repetitions (breaths). This magnitude of load corresponds to the 30-repetition maximum (RM) for the inspiratory muscles, *ie* the maximum load that can be sustained for 30 repetitions. This is identified by trial and error (just as you would when identifying the 12-RM for a bench press). This ‘foundation training’ is undertaken in the standing position twice daily for 4-6 weeks, and a typical session requires just 2-3 minutes.

After completing this foundation block, you can move to a more sport-specific training routine. This is achieved by introducing posture specificity to the session in order to challenge both the breathing and postural roles of your inspiratory muscles – *eg* cyclists performing IMT in a position that simulates their position on the cycle, rowers in a rowing position, *etc.* If ‘eliminating stitch’ is the main goal, then specificity can be achieved by challenging the postural stabilising role of the

‘These observations are strongly indicative that stitch is a response of the diaphragm to a situation it can no longer cope with’

diaphragm while undertaking IMT – eg by standing on a wobble board, air pillow, or Bosu ball while performing IMT.

Coping with stitch

So, what should you do if you suffer a stitch during a race? One option is to drop out, which is unfortunately what Gebrselassie felt forced to do, but stitch doesn't have to spell the end of the race. Stitch pain will subside if you allow the diaphragm to rest, so you can either slow the pace right down, or even walk for a while. Alternatively, you can give your diaphragm a 'breather' by consciously shifting the work of breathing away from your diaphragm for a few minutes (see the online article cited above – 'Getting in touch with your diaphragm'), or until the stitch subsides. This tactic has to be a last resort, because your ribcage muscles will also fatigue if you rely on them too heavily. Other techniques that are supported by the evidence of one study⁽⁵⁾ are to:

1. Bend forwards while contracting the abdominal muscles, or to tighten a belt around the waist;
2. Breathe deeply through pursed lips. A technique that appears effective for some athletes I've worked with is to bend forwards, tighten the abdominal muscles (especially transversus abdominis) and press inwards and upwards (hard!) on the site of the pain with your palm for 10-15 seconds.

Prevention is much better than cure, so let's consider what can be done to minimise the risk of developing a stitch in the first place. The research suggests that ingesting large volumes of food or drink, especially if it's high in carbohydrate, should be avoided immediately before, or during exercise. However, perhaps the best advice is to train your diaphragm so that it's never faced with a situation that it can't cope with (*see box on page 10*).

As we've seen, no amount of ordinary training can do this; if it did, then the likes of Gebrselassie would surely be immune to 'stitch', and he patently isn't. If you don't want to

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experience the same fate, then a little heavy breathing will help ensure that your diaphragm can cope with anything you care to throw at it!

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How to heal a serious ankle sprain

Ulrik Larsen offers guidance on how to spot and treat the kind of lateral ankle damage that can ruin an athletic career

What is the most common sporting injury? Chances are that anyone who has done any kind of weight-bearing sport has had it happen: a sprained ankle. But there is a vast difference between mild sprains and moderate to severe lateral ankle sprains which actually damage the ankle. Incorrect management can easily turn a recovery time from 3-4 months into a 12-18 month epic. I've seen it happen and made the mistakes myself as a younger clinician!

To establish an accurate diagnosis and treatment schedule you need to know where a sprain fits into the spectrum. The key question is this: what are the signs and symptoms that distinguish a sprained ankle that is damaged? Only by identifying these features can we undertake the crucial early management, and predict which sprains will require longer time frames for recovery. I am not talking here about mild ankle sprains that will always get better regardless of what is done to them – most athletes will 'walk them off' because there is no real damage to the ankle. Nor will I discuss medial ankle sprains, or acute forefoot/mid-foot injuries. And finally, I will not be looking at the obviously severe injuries that need orthopaedic referral: fractures of tibia and/or fibula, talar dome and ankle dislocations. Usually these will be picked up in the emergency department of the local hospital. If the injury happens on the field, the severity of pain would be enough to convince anyone to summon an ambulance and have immediate X-rays!

“The most common mistake that clinicians, coaches and athletes make is to underrate the severity of damage and return to activity too early.”

So what does that leave? Precisely the tricky sprains in which damage to the ankle is unlikely to show up positive on X-ray. Commonly these injuries have a history of having occurred with some heavy weight-bearing and rotary force; they present with significant swelling, pain, lack of normal range of movement; and the client will be unable to walk and/or run without pain and aggravation. An athlete in this situation is certainly going to be frustrated, because they will probably present after a few weeks have gone by and things are not resolving, having been given the all-important all-clear on X-ray. So their expectations will have been skewed towards thinking that they will be back on the field within two to four weeks. The most common mistake that clinicians, coaches and athletes make is to underrate the severity of damage and return to activity too early. The fatal assumption is that when the X-ray is negative, then the damage can't be too bad...

Wrong! The best result will often be had by overrating the damage in the first month, and being extra cautious, rather than pushing for progress. Let's paint a couple of painful pictures to help us understand how a damaged ankle sprain happens.

Scenario 1

You're running at speed with the ball and step heavily off your left foot to move quickly to your right. But the ground doesn't feel quite like you thought it would. In a split second your foot has rolled underneath your leg, resulting in a feeling of more than one 'crack' followed shortly afterwards by a searing pain that envelops your whole foot and leaves you writhing in agony on the ground.

Scenario 2

While contesting the ball among a few other players you jump as high as you can to reach it. You land while you are twisting around, catching the edge of another player's shoe, and causing your foot to land on the ground on its outside edge. The crunch that you feel is nauseating and soon so is the pain.

Both these situations will very likely result in damage to bone, joint, ligament, tendon or nerve that will require profound rest for complete healing to take place. How long and to what degree the rest needs to be enforced (and many athletes will not be happy to hear that they need to be on crutches for two to four weeks if normal weight-bearing is preventing good healing) depends on the all-important diagnosis.

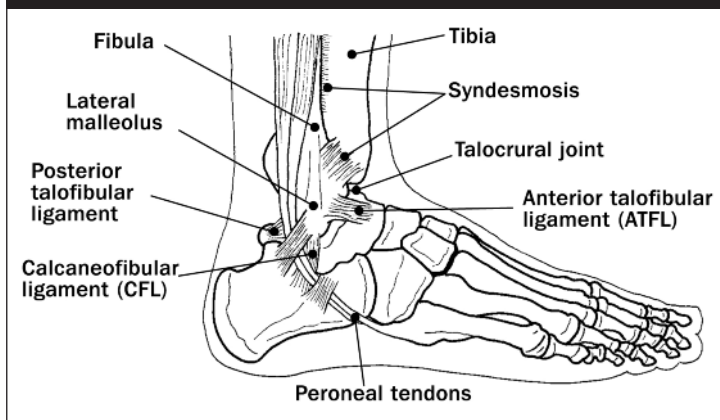
The first few days is the critical phase for diagnosis because it immediately determines the management and time frames for full recovery:

- Are further investigations warranted?
- Do you need to refer the client to a specialist?
- Do they need a cast or crutches?
- Roughly how long will their rehabilitation take?

If you don't have a good working diagnosis, none of these questions can be answered.

‘The first few days is the critical phase for diagnosis because it immediately determines the management and time frames for full recovery’

The lateral ankle: key injury sites



The crucial first week

While there isn't any hard evidence to back this up, the issue of whether the athlete can reasonably weight-bear during the first week seems to be critical in establishing whether any of the four

‘if it is painful to weight-bear on the foot in the first week, significant damage has occurred’

‘nasties’ discussed below has occurred. This is because for the foot not to be able to stand simple weight-bearing, implies that the weight-bearing surface and/or the stability mechanisms of the ankle must have been severely compromised.

This, therefore, is your first key diagnostic and management judgement: if it is painful to weight-bear on the foot in the first week, significant damage has occurred. The athlete needs to be non-weight bearing, on crutches, to the level that ensures there is no pain. The option of soft-casting the ankle to hold it still will often need to be considered to achieve complete immobilisation. Any negative secondary effects of non-weight bearing for a week will be far outweighed by further damage caused by painful weight bearing.

From non-weight bearing, you will need to take the client conservatively through each new progression:

- partial weight bearing to...
- full weight bearing to...
- walking to
- transitional drills to ...
- running.

Delay each new step rather than reaggravate the symptoms. Put the client in the water to practise each successive stage to reduce body weight and rehearse technique. A good idea is to use weight scales to objectify the graduated weight-bearing increases: stand them next to the scales and get them to load to 10kg and listen to how their ankle feels; that may be all they do for the first few days: holding that same level of pressure for 10 seconds, and repeating for 5-10 reps. The action must be pain-free.

There are four main types of primary damage that may in isolation or in combination prevent reasonable weight bearing in the first week.

1. Osteochondral defect (OCD)

This is damage to the surface chondral layer of the bone; the damage may be simple bruising, through to a displaced segment of cartilage. It may occur on the talar dome, the inferior tibial

surface ('tibial plafond') or the medial fibular surface in the lateral gutter of the ankle.

The damage to various parts of the bony surfaces is commonly the result of the twisting force of landing, which causes the talus to invert (to turn the sole of the foot inwards) and medially rotate in the tight angular ankle joint.

Signs

- usually there is no obvious sign on initial X-ray, but closer inspection or re-X-ray may reveal disruption to the joint margins
- significant pain on weight bearing
- the medial and lateral anterior talar dome, anterior tip of tibia or fibula will be very tender on palpation
- swelling all around joint
- CT or MRI should tell all
- if sufficiently disrupted, this may require surgical referral.

Recovery time-frame: three to six months.

2. Bone stress short of fracture

Signs

- not visible on X-ray; bone scan will confirm but is not really necessary
- extreme tenderness on palpation, on medial/lateral malleolus or along shaft of tibia or fibula will confirm diagnosis
- may be positive to squeeze or stress tests (where the bone is gently stressed as if you were trying to bend a stick).

Recovery time-frame: will heal by itself with sufficient rest over two to six weeks, depending on severity.

3. Lateral ankle ligament tear leading to gross instability

This is significant tearing (Grade II), through to complete rupture (Grade III) of the anterior talo-fibular (ATFL) and/or calcaneo-fibular (CFL) ligaments. Complete rupture of the

lateral ligament complex requires immediate orthopaedic referral for stabilisation surgery.

Signs

- the most common result of a plantar- flexion/inversion sprain, rarely occurs in isolation from bony injury
- talocrural joint demonstrates instability, leading to overloading of capsular and/or ligamentous structures and later possibly synovitis (thickened and inflamed capsule)
- client is unlikely to be able to weightbear for initial period because of likely involvement of bony structure damage
- trial taping for diagnostic purposes: stirrups and heel locks can artificially stabilise the lateral ankle complex and help to diagnose a pure instability problem
- physio/sports therapist to perform anterior drawer (ATFL) and possible medial glide of talus/calcaneum to gauge the end-feel of ligaments.

Recovery time-frame: three to six months, depending on other damage.

4. Tibio-fibular ligament / syndesmosis damage leading to instability

Also known as ‘high ankle sprain’. Can be very nasty, requiring orthopaedic referral to prevent long-term arthritic changes. The fibula will usually fracture laterally as well, preventing further damage along the line of the syndesmosis (a fibrous joint that allows little movement).

Signs

- landing with twisting is very likely to stress and drive the tibia and fibula apart, causing a tear of the ligament and syndesmosis (in addition to damage to other structures above)
- palpation of the anterior shin between tibia and fibula will show tenderness; medial/lateral stress test holding the calcaneum will reveal gapping and laxity between tibia and fibula.

- with significant instability, separation of tibio-fibular articulation is likely to be seen on a weight-bearing (heel pressure) X-ray, compared with other side
- it may be useful at a later stage to re-Xray in weight bearing at end-of-range dorsiflexion (if that was not possible at the outset because of pain) to detect any ongoing instability of the tibio-fibular complex compared with other ankle. With luck it may show up negative at the three-month stage with fibrosing and scar tissue doing a sufficient job of holding it together
- tibio-fibular compression taping may help with stabilising in the early weightbearing phases.

Recovery time-frame: absolutely critical to prevent weight bearing on foot for up to three or four weeks with a more conservative progression through partial to full weight bearing. In total, allow six to eight months to return to sport.

Continued pain at 4 to 8 weeks

If things are not going well, or you are noticing new symptoms, there may be secondary damage issues. These may not clearly manifest until the worst of the pain, swelling and disability has receded, but they need to be addressed in their own right as part of the mid- to late stage rehabilitation process. A physio or sports therapist will be able to help the athlete identify these.

Conclusion

Once there is clarity about the nature and severity of damage to structures, the physio or sports therapist will be able to develop time frames for recovery and then tackle the challenge of restricting the athlete to crutches and prescribing safe exercise for the ankle. More often than generally acknowledged, a period on crutches can be critical for the initial phase of healing, and to prevent side effects such as ongoing instability, long-term swelling and ankle thickening, and even reflex sympathetic dystrophy. If you manage the rest and the healing phases thoroughly, you will help your client minimise their time out of action from the sport and they will have long-term reason to be thankful for your patient care.

Meniscal damage to the knee

An update by Sam Oussedik and Fares Haddad

The menisci are two crescent-shaped pieces of cartilage present in both knees, one in the medial tibiofemoral compartment – the medial meniscus – and the other in the lateral tibiofemoral compartment – the lateral meniscus. Together these structures act in four different ways to improve knee function:

- They transmit load across the joint. In extension, this is up to 50% of axial load; in flexion it increases to 90%
- They improve joint congruency or stability
- They increase the contact surface area of tibia and femur, helping to spread axial load across a greater area of articular cartilage
- They help to circulate synovial fluid around the knee⁽¹⁾.

To carry out these functions, the menisci have a complex structure. They are composed of a specialised type of fibrocartilage the high water content of which allows them to resist the forces they must withstand. They have a limited healing potential. Their blood supply only reaches the outermost 10% to 30% of each meniscus; within this region tears may heal. More centrally placed tears have very little chance of healing.

Meniscal injuries are relatively common, with the medial meniscus most often injured. The posterior part of the medial meniscus also supplements the anterior cruciate ligament (ACL) in helping to stop the tibia from sliding forwards against the femur. This puts the meniscus at risk from injury in any

‘Meniscal injuries are relatively common, with the medial meniscus most often injured’

trauma that disrupts the ACL. It also means that ACL deficiency can lead to tears in the meniscus. More commonly, the menisci are damaged from a twisting injury to the knee, with the foot usually anchored on the ground.

These traumatic injuries should be differentiated from degenerative tears, which occur in an older age group, although sometimes in patients as young as their late 20s, often in association with early degenerative changes in the knee. Typically a client with a traumatic meniscal tear will have a history of recent trauma, swelling of the knee, and a restricted range of motion. If there is a ‘bucket-handle’ tear, where a mobile segment of torn meniscus can lodge in the joint, the client may feel frequent locking of the knee, or the inability to fully extend. More frequently symptoms may simply be of discomfort over one side of the knee, particularly in deep flexion. The client may not be able to kneel or squat, and may not ‘trust’ that knee. Joint line tenderness is a common feature and restricted range of motion may be the result of effusion or mechanical block by a mobile segment of meniscus. Pain is elicited on deep squatting.

McMurray’s test is diagnostic: the knee is placed into full flexion and the tibia is internally and externally rotated as the knee is brought into extension. This test is positive if pain is found in the presence of a palpable or audible clicking.

Management - Non-operative

While a relatively asymptomatic client (where no noticeable symptoms are experienced) with low functional demands may do very well with non-operative management; where the tear is symptomatic or the patient has a high functional demand, an orthopaedic surgeon should assess the case for a possible operation. Symptomatic tears may result in further damage to the articular surfaces of the femur and tibia. The added stress on the torn meniscus associated with greater sporting activity may also result in degeneration of the torn segment, such that meniscal repair may not be possible. Early assessment is therefore required, before secondary damage is caused.

Non-operative management is usually reserved for those patients with few or no symptoms who are able to carry out a full range of physical activities. This group is usually made up of older patients with degenerative tears in the presence of significant degenerate changes in the knee. Physiotherapy helps to regain range of motion and strengthen muscle groups. This is also an important part of postoperative management.

Operative

Patients with recurrent mechanical symptoms and/or significant pain require operative management. Nowadays this means an arthroscopy. Depending on the location of the tear, several options are available. Partial meniscectomy is indicated for those tears which are degenerate, or outside the vascularised zone (where blood vessels can form).

During this procedure, specialised instruments are introduced through an arthroscopy portal 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 behind the largest amount of healthy, stable tissue to continue protecting the articular cartilage from increased stress. In those tears that lie within the vascularised zone, repair can be attempted by fixing the damaged part to the meniscus behind it and the joint capsule. Tears repaired at the time of cruciate ligament reconstruction have a better prognosis. We believe this is related to the fact that these are traumatic tears in healthy menisci with good healing potential rather than degenerate ‘predetermined’ tears, which have poor healing potential.

Results for meniscal repair are very good, especially when carried out during ACL reconstruction. Boyd and Myers⁽²⁾ estimate a re-tear rate of less than 10%. 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 patients will recover all but the final⁽³⁾ degrees of flexion, which is inconsequential for most sporting needs. It is important that the patient is prewarned about this likelihood. Shelbourne *et al*⁽⁴⁾ looked at

‘The added stress on the torn meniscus associated with greater sporting activity may also result in degeneration of the torn segment, such that meniscal repair may not be possible. Early assessment is therefore required, before secondary damage is caused’

rehabilitation following isolated meniscal repair. They found that an accelerated programme, allowing a full range of motion and weight bearing as tolerated, had similar results in terms of meniscal healing to a more conventional restrictive regime.

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A different angle on chronic lower limb strains

Mark Alexander *proposes a novel approach to the diagnosis and treatment of lower limb strains*

Most sports therapists have at some time come across patients suffering from injuries that appear to be chronic calf or hamstring muscle strains, yet there is no evidence of tears or strains on MRI or ultrasound scans^(1,2,3). These conditions are commonly explained or diagnosed as lumbar (central nervous system) and/or neural (peripheral nervous system) in origin. But frustratingly these muscle injuries are chronically recurrent, especially in the older athlete, despite our best efforts. So is there something we are missing in our assessment and treatment of these recurrent muscle conditions to ensure optimal injury prevention and management?

Here we explore a new neural interface concept involving the smaller nerves perforating through the fascia (a sheet or band of fibrous connective tissue) that surrounds muscle tissue, creating a potential neural entrapment. The focus will be on the calf/lower leg, although this phenomenon may not be exclusive to this area, with the hamstring potentially being involved as well. These chronic muscle injuries have been explained as being either intraneural, which involves the nerve-conducting or nerve connective tissue; or extraneural, which is external to the nerve tissue.

One interface that hasn't previously been described in the sports injury literature, however, is where specific nerves perforate or pass through fascia supplying muscles and skin with innervation (nerve distribution)⁽⁴⁾.

This is one example of an ignored interface that may lead to nerve entrapment, which I believe to be a common source of symptoms with chronic calf strains and tightness. This neural interface is a likely point of irritation based on the amount of translational movement of lower limb nerves during movement. In one study the tibial nerve glided 10mm with hip motion and 2 mm with knee motion; the sciatic nerve glided 24mm with hip motion and 7 mm with knee motion⁽⁵⁾. This joint movement occurs during running and so may produce some gliding of the cutaneous branch (branch affecting the skin) of the tibial nerve (medial sural nerve) through the deep fascia.

How to test

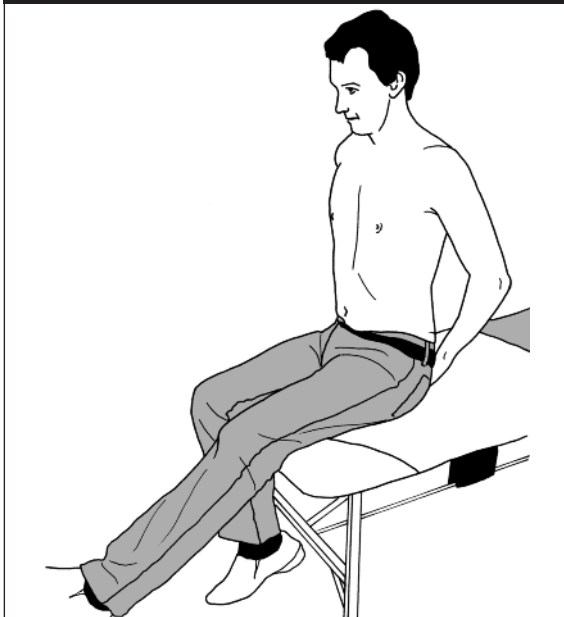
Palpation is the most accurate form of assessment for this condition and can be done with the patient lying supine, knees bent and feet flat, so the muscle, nerve and fascia are off-stretch. This enables more accurate palpation of the nerves and adhesions within the muscle, and of any increased muscle tone. In symptomatic people, there are obvious adhesions in the mid-calf, deep between the two gastrocnemius heads, where the nerve perforates the fascia. Palpation usually reproduces both their site and type of pain.

Treatment

The treatment is performed in the same assessment position using transverse frictions across the line of the nerve where it perforates the deep fascia. Treatment time should only be 2 to 3 minutes as the technique is quite painful. It is wise to teach patients to friction themselves at home for 2 to 3 minutes daily, to maintain treatment effectiveness. I would reassess their modified lordotic slump test and then reassess a functional task such as running or hopping to determine if any improvement has occurred. Anecdotal results occur quite rapidly within two to three treatments.

Mr J's calf strain

Mr J is a 43-year-old keen runner who had completed five marathons and had a long

Slump test with lordosis

history of calf strains and tightness deep in the mid-belly of his right calf. He felt vulnerable to calf strains during most runs especially after 10km. Massage and stretching had never alleviated the symptoms. He also had numerous treatments on his back with spinal mobilisations and also neural mobilisations in the slump and straight-leg raise positions with little benefit as the problem continued to recur. On assessment his slump and straight leg raise tests were symmetrical and only slightly restricted. The modified slump test in lumbar lordosis was symmetrical in range but he had a sensation of tightness and shearing at end of range in the area of his calf tightness. His lumbar spine assessment revealed nothing significant. His ankle range of motion and biomechanics were symmetrical and similarly not remarkable.

During hopping and calf raises, after 5-6 reps he had a vague feeling of burning and tightness on the right side. On palpation the right calf had noticeably more tone, and deep in the calf

between the two gastroc heads there was a palpable adhesion about the size of a pea. When this adhesion was frictioned it reproduced the exact site of his symptoms and was extremely painful. The patient described it as like a knife being poked into his leg. On palpation there was nothing similar felt on the left side.

Treatment involved four sessions over two weeks of deep frictions and daily self treatment at home, with one day off every three to four days to reduce the local bruising from treatment. The patient continued to run but reduced his mileage to 4-5km for two weeks.

Ice was applied after runs. He also performed three stretches that were aimed at the neural and fascial system, such as the low back rotational stretch, the hamstring straight-leg raise stretch and the calf stretch. On assessment after two weeks, the patient could run for 10km symptom-free, which he hadn't been able to achieve for 12 months. The muscle tone was symmetrical.

While there was still a small detectable adhesion on the right-hand side, it wasn't excruciatingly tender as it had been. The patient continued his self-treatment and stretches and he was able to complete his sixth marathon three months later.

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Pose running technique: a beginners guide

If running is natural, why do we keep on injuring ourselves? Australian physio Scott Smith takes a look at a controversial alternative style that claims to reduce the risk of damage

The popularity of running as a leisure pursuit has increased throughout the past 25 years, reflecting social trends away from organised team sports and towards less time consuming, more flexible and independent ways of keeping fit and active. Over the same time period there has been an explosion in sports science and sports injury research and therapeutic practice. Among other things, this has produced a wealth of advice on baseline fitness and training for running, and huge advances in footwear technology.

Yet runners keep on injuring themselves. They continue to seek treatment, typically, for Achilles tendinosis, patellofemoral pain, repetitive calf muscle strains, big toe pain and low back pain – and it seems to those of us who have been around the sports therapy world for a while that the incidence of running injuries has not reduced significantly. Is it time to return to the fundamentals of running to find out why so many people are still hurting themselves?

Coaches, trainers, therapists and athletes have no difficulty agreeing that technique has an important role to play in leisure pursuits such as rowing, golf, swimming and ballet, but when I ask my running patients about their technique – whether, for instance, they heel-strike or land with their knees straight – I receive blank expressions. In most sports, enthusiasts will expect to devote months and even years to working on

“Is there an optimal running technique that enables athletes to train without fear of injury, with a real reduction in their injury risk – and with the prospect of still being able to improve their performance?”

movement technique, whereas with running we tend only ever to focus on how to run faster and/or further, and how much fitter we can get as a result.

In other words, running is practised rather than taught. This leads to the question: is there an optimal running technique that enables athletes to train without fear of injury, with a real reduction in their injury risk – and with the prospect of still being able to improve their performance?

One recently developed technique, called ‘pose running’, lays claim to be able to do all three things.

Pose running was invented by Nicholas Romanov, a Russian scientist now based in Miami and consultant to the British, US and Mexican triathlon associations. During the 1970s and early 80s, Romanov was heavily involved with athlete training in Russia, where he observed that as his athletes turned up the workload, so they would start to break down physically. At that time there was little strength and conditioning training. With a heavy emphasis on improving mileage and speed, the athletes focused on increasing their cardiovascular and respiratory systems, and paid little heed to their underlying running technique.

“The concept is simple enough, but the practice is extremely hard to master”

The pose method

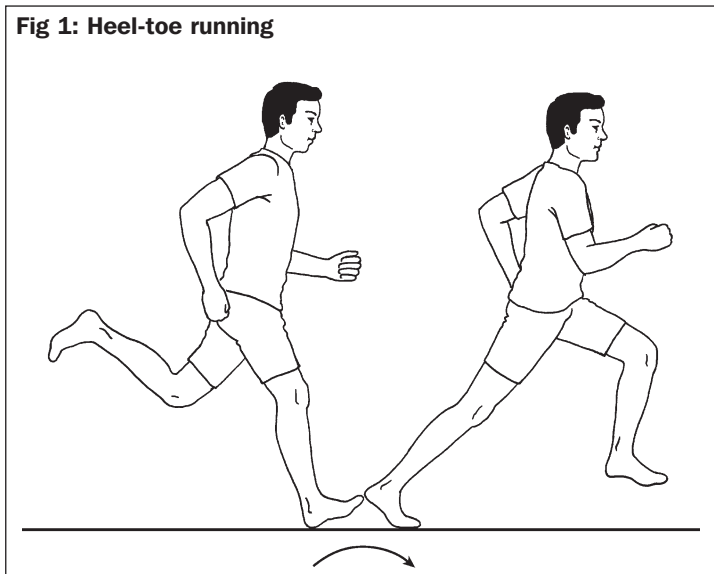
Romanov proposes one universal technique for all runners, regardless of speed or distance: a 100m sprinter runs with the same underlying technique as a 10km long-distance runner. The technique is designed to prevent undue strain on the joints and requires a great deal of muscular endurance and resilience.

The elite British triathletes Tim Don, Andrew Johns and Leanda Cave have all adopted the pose method under Romanov’s guidance. According to Romanov, the Ethiopian distance champion Haile Gebrselassie and the US sprint legend Michael Johnson are both examples of runners with a natural pose style – ‘born with perfect technique’.

The distinguishing characteristic of pose running is that the athlete lands on the midfoot, with the supporting joints flexed at impact, and then uses the hamstring muscles to withdraw the

foot from the ground, relying on gravity to propel the runner forward. This style is in clear contrast to the heelstrike method that most runners deploy and which is advocated by some health care professionals (*see Fig 1 below*).

Fig 1: Heel-toe running



The concept is simple enough, but the practice is extremely hard to master. It is only with expert tuition and dedicated training that the athlete can perfect the technique. Running in pose is physically demanding, so runners must undertake strengthening drills before starting the programme. Maybe it is this added balance and stability training that allows the athlete to remain injury free? As yet there is no body of research to help answer this question.

Principles

Running should be easy, effortless, smooth and flowing. We have all seen and heard the heavy runner who pounds away on a gym treadmill. Romanov says the runner is only as good as his change of support and that the runner should have a very high

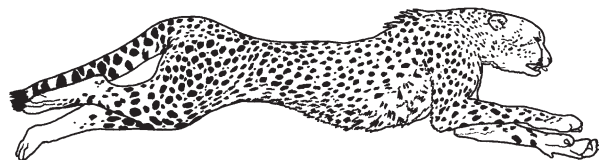
cadence – not a long, extended stride length. In pose running, the key is to maximise your effort in removing your support foot from the ground; good training is essential to ensure that you don't over-stride or create excessive vertical oscillation. The runner should fall forwards, changing support from one leg to the other by pulling the foot from the ground, allowing minimum effort and producing minimum braking to this body movement. The idea is to maximise the use of gravity to pull the runner forward. The pose method is centred on the idea that a runner maintains a single pose or position, moving continually forwards in this position.

Romanov uses two models to explain the rationale behind pose:

- the mechanical model – the centre of gravity, which is around the hip position, should move in a horizontal line, without vertical up and down displacement;
- the biological model – the rear leg maintains an 'S-like' form, and never straightens. This notion comes from animals such as the cheetah which do not land on their heels but run on the midfoot and deploy a pulling through action using their hamstrings rather than pushing the foot into the ground (*see Fig 2 below*).

Perhaps the most useful imagery to help with this technique is to imagine a vertical line coming from the runner's head straight down to the ground. The raised front leg should never breach this line, but remain behind it. This focuses the effort

Fig 2: The cheetah



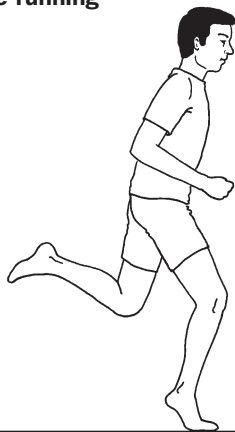
firmly on pulling the ankle up vertically under your hip rather than extending forward with your quads and hip flexors (front of thighs).

The power behind the pose

Pose is by no means universally accepted by the running fraternity. While top athletes have sought Romanov's help because of injuries, the method does require good scientific research to back it up. It is quite possible that many of the benefits experienced by pose athletes are the result of the rigorous strengthening programmes they undertake.

The training regime's focus on proprioception (joint stability and balance), together with the strong imagery of the technique, changes the physical placement of the limbs and reduces the downward displacement force of the foot on to the ground.

Fig 3: Toe running



‘It is only with expert tuition and dedicated training that the athlete can perfect the technique’

That said, I know of people who have tried to run in pose and have sustained injuries such as calf strains and lower back problems, because they did not get their pose stance right and did not have sufficient hip control. You need to be committed to learning the new technique: once you have decided to learn to run in pose, you cannot expect to chop and change between

running styles at will. The technical drills outlined below can be very strenuous and may be harmful if attempted, for instance, at the wrong point in an injured runner's rehabilitation phase.

Runners and coaches alike should adopt these drills with proper caution.

‘Drills should be practised for at least a week before attempting to run in pose, and should be performed before a run’

How to do it: pose drills

If you are embarking on a serious transition to pose, you should practise the drills (building up the level of difficulty) once or twice daily, three sets of 10 to 15 reps per drill. Drills should be practised for at least a week before attempting to run in pose, and should be performed before a run. All drills should be performed barefoot for added awareness of the movements, on a forgiving surface such as grass or a running track.

The drills fall into three sections:

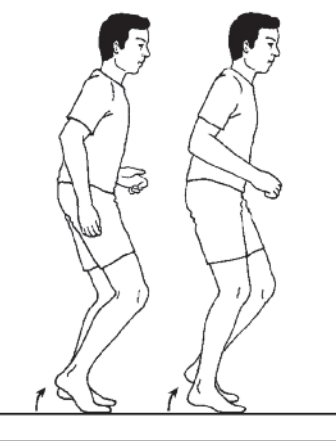
- a) Basic drills to reinforce the pose position, the use of the hamstring in pulling the foot from the ground and the feeling of falling forward under the effect of gravity (drills 1-7);
- b) Intermediate drills to reinforce these feelings (drills 8 and 9);
- c) Advanced drills to aid speed, balance, strength and reflexiveness (none shown here).

Drill 1 (Fig 4):

Pose stance

This to be practised as a static pose, held for up to 30 seconds. It requires good postural control; no support is allowed. The idea is to challenge the mechanoreceptors in the joints and soft tissues to provide feedback to the brain regarding joint position and muscle tone.

- It is the basic position to hold and to practise balance
- The use of a mirror is recommended
- Shoulder, hip and ankle should always be vertically aligned
- Point of contact with the ground is always the midfoot
- Hip is always held over the support point, which is the midfoot.

Fig 4: Pose stance**Fig 5: Pony****Drill 2:**

Change of support without moving

- Shift centre of gravity sideways from one leg to the other, maintaining support on the midfoot
- You must feel the weight shift from one leg to the other before pulling up
- It is important to feel the weight shift and then the acceleration of this movement by the pulling up of the hamstring
- Pull the ankle up vertically under the hip using the hamstring only, not hip flexors or quadriceps
- Allow the leg to drop to the ground – do not drive it down
- Mental focus is on the pulling-up action, not the leg drop.

Drill 3 (Fig 5):**Pony**

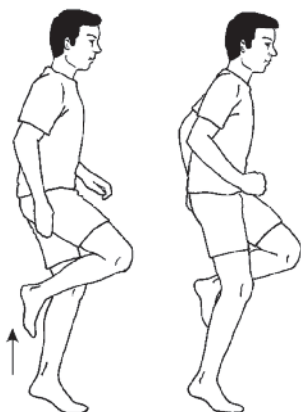
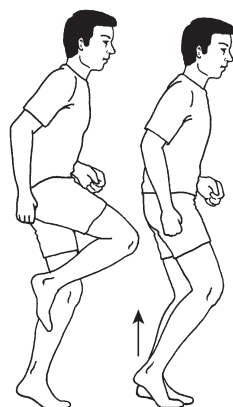
- This practises changing support using minimum effort and minimal range of movement
- Simultaneously lift the ankle of the support leg while allowing your body weight to shift to the other leg
- Use only the hamstring. Keep in mind your support point on the midfoot (toes will also be in contact).

Drill 4 (Fig 6):**Forward change of support**

- This puts the pony into action; practise slowly at first
- Lean slightly forward and simultaneously pull the ankle up under the hip using the hamstring and allow the non-support leg to drop to the ground under the force of gravity
- Make sure the weight transfer is effortless and that the foot is allowed to fall.

Drill 5 (Fig 7):**Foot tapping**

- Single-leg drill, 10-15 taps per set
- This emphasises the vertical leg action and use of hamstrings rather than driving the knees up and forward using your hip flexors and quads
- It prevents your foot from being too far out in front of the body, which would cause you to land on your heel and create a braking action
- Aim for rapid firing of the hamstring, lifting the foot from the ground as soon as it touches down

Fig 6: Forward change of support**Fig 7: Foot tapping**

- You must feel the muscles fire and then relax. Avoid a forceful pull all the way up. If you are doing it correctly the lower leg will decelerate after the initial firing and accelerate as gravity returns it to the ground.

Drill 6 (Fig 8):

Hopping

This movement progresses the tapping drill. The momentum for the hopping support leg should come from the hamstring action on the nonhopping leg. Take care: this is an advanced movement which will place unhealthy stress on structures such as the Achilles/calf muscles if not performed correctly.

- Start by pulling up the non-hopping leg with your hamstring and use the reaction force of the ground to aid this recoil effect
- Do not push with the calf but just lift the ankle with the hamstring and make sure the ankle is relaxed between hops.

Fig 8: Hopping



Drill 7:

Front lunge

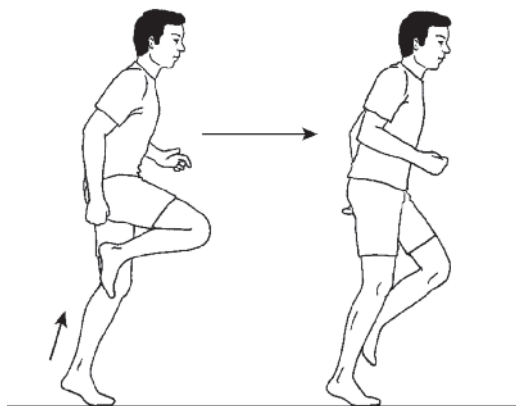
- Single-leg drill which increases the range of movement of the hopping drill
- This truly forces you to isolate the hamstring muscles
- Practise initially on the spot until you are stable enough to allow forward movement
- Keep weight on front leg; the back leg drags behind
- Pull ankle vertically up under the hip, using the hamstring
- Keep contact time with the ground as short as possible
- Allow rear leg to follow loosely
- Remember to land on the ball of your foot
- Forward movement is created not by pushing off but by leaning forward from the hips. You drag the rear leg behind you for balance.

Drill 8 (Fig 9):**Switch**

- Both ankles are being picked up
- This time you are picking the rear leg up as well with the hamstring
- Transfer weight from one leg to the other as you alternate support
- Keep contact time with the ground to a minimum, only as necessary to change support
- Keep heels off the ground and land on the balls of your feet
- Always think of the pose stance: good vertical alignment of shoulder, hip and foot.

Drill 9:**Running lunge**

- This is pose running, but with a deliberate emphasis on the speed of the hamstring pull-up
- The aim is to teach the working leg to react as quickly as possible, minimising support time on the ground
- The runner pulls the heel up vertically from the ground but allows it to fall easily to the ground.

Fig 9: Switch

Pose principles in summary

1. Raise your ankle straight up under your hip, using the hamstrings;
2. Keep your support time short;
3. Your support is always on the balls of your feet;
4. Do not touch the ground with your heels;
5. Avoid shifting weight over your toes: raise your ankle when the weight is on the ball of your foot;
6. Keep your ankle fixed at the same angle;
7. Keep knees bent at all times;
8. Feet remain behind the vertical line going through your knees;
9. Keep stride length short;
10. Keep knees and thighs down, close together, and relaxed;
11. Always focus on pulling the foot from the ground, not on landing;
12. Do not point or land on the toes (see Fig 3 on p2: Toe running);
13. Gravity, not muscle action, controls the landing of the legs;
14. Keep shoulder, hip and ankle in vertical alignment;
15. Arm movement is for balance, not for force production.

Scott Smith is an Australian physiotherapist. He works at Albany Creek Sports Injury Clinic in Brisbane, specialising in running and golf injuries

Further reading

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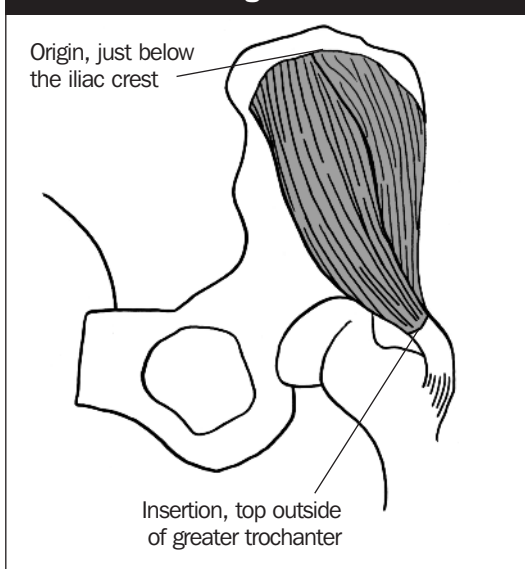
Weak buttocks ruin the runner

Gluteus medius weakness, Sean Fyfe says, is a likely culprit in many overuse injuries

The gluteus medius should be considered in every running injury. So many athletes with running overuse injuries of the lower limb present with 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 in the achievement of a biomechanically 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. All sports injury practitioners should, I believe, be able to assess and retrain gluteus medius function.

The gluteus medius muscle originates at the dorsal ilium below the iliac crest and inserts at the top outside surfaces of the greater trochanter. It is the major abductor of the thigh. The anterior fibres rotate the hip internally and the posterior fibres rotate externally. The muscle is innervated by the superior gluteal nerve (L4, L5, S1) and gains its blood supply via the superior gluteal artery.

During closed kinetic chain actions, 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, the muscle contracts to slow the downward motion of the left side of the pelvis so that the pelvis doesn't tilt more than seven to eight 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, but not always, you may see the

Gluteus medius: origin and insertion

same weakness in walking (producing a waddling motion or, in extremis, a limp), and the dysfunction will then be more marked when they run.

The therapist should analyse the function of gluteus medius dynamically and manually. This is not easy. The assessor must be properly alert to the adaptations to running technique that an athlete can adopt to offload a weak or fatigued gluteus medius muscle. To scrutinise the dynamic function accurately, you will need to use video analysis.

Table 1 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 ipsilateral (same-sided) trunk shift. In my experience, runners with poor dynamic pelvis stability, for which gluteus medius is vital, 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’

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

- the femur to adduct and internally rotate excessively
- the knee to fall into a valgus position
- the tibia to rotate internally relative to the foot
- an increase in weight transfer to the medial aspect 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. As it is not often seen in the clinic or documented in the literature, many sports injury practitioners may not be aware of it. It occurs when the athlete is running in excessive anterior tilt and forward trunk 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. Shock absorption through the lower limb is affected.

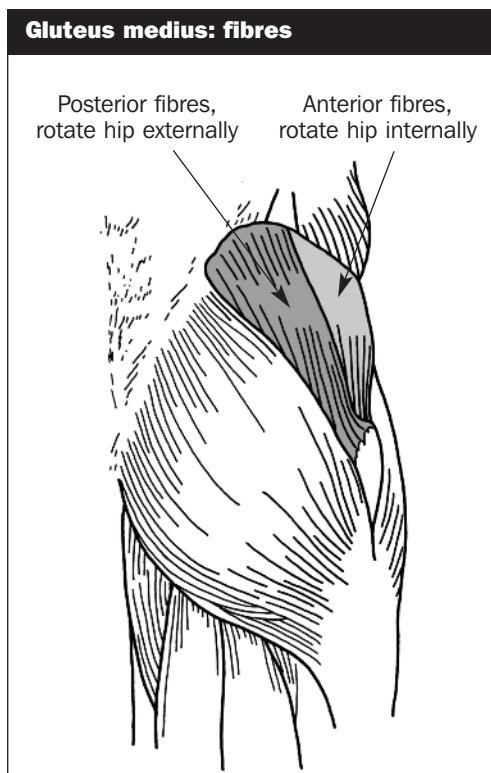
Table 1: Adaptations to weak gluteus medius in stance phase

Adaptations	Areas at risk of structural overload
1. Trendelenburg	Lumbar spine, sacroiliac joint (SIJ), greater trochanter bursa, insertion of muscle on greater trochanter, overactivity of piriformis and tensor fascia lata (TFL)
2. Medial knee drift (valgus position of tibiofemoral joint)	Lateral tibiofemoral compartment (via compression), patellofemoral joint, patella tendon and fat pad, pes anserinus, iliotibial band (ITB)
3. Lateral knee drift (varus position of tibiofemoral joint)	Medial tibiofemoral compartment (via compression), ITB, posterolateral compartment, popliteus
4. Same-sided shift of trunk (lateral flexion of trunk)	Lumbar spine (increased disc and facet joint compression), SIJ (increased shear)

Testing the muscle strength

As always with muscle testing, it can be difficult to be completely objective in the clinic without lab equipment. But it is quite easy to gain valuable information to complement your dynamic assessment. My approach is threefold. Let's imagine we are testing the right gluteus medius. First, I ask the athlete to perform the 'clam' exercise. In left side-lying, 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. I palpate the gluteus medius for activation. If the pelvis moves despite education on positioning, it means the athlete is unable to isolate the muscle and is trying to recruit 'cheating' muscles such as TFL.

‘In my experience, runners with poor dynamic pelvis stability, for which gluteus medius is vital, 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’



The second test is side-lying hip abduction, performed in the same position, but with the right leg straight and in slight hip extension (*ie* just behind the line of the trunk). The athlete must abduct the leg without hitching the right side of the pelvis (hip hitching would mean they were concentrically recruiting quadratus lumborum and obliques), without falling into anterior pelvic tilt and without letting the pelvis tip back. You can further test the strength of the muscle by getting the athlete to resist your attempts to push the abducted leg downwards. Check for any compensatory or cheating recruitment. To assess muscular endurance, ask the athlete to hold the abducted leg steady 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 lowerlimb-to-pelvis chain. All this should be compared to the uninjured side.

A highly informative study by Fredericson *et al* (2000) upholds the idea that gluteus medius weakness is a contributing factor in ITB friction syndrome; confirms that injured and uninjured sides can be compared to determine weakness; and endorses retraining for strength gains as an effective treatment.

Fredericson measured hip abductor strength in a group of injured male and female subjects, and found an average deficit of 2% in gluteus medius strength on the injured side compared to the uninjured. After a six-week retraining programme, average hip abductor torque 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.

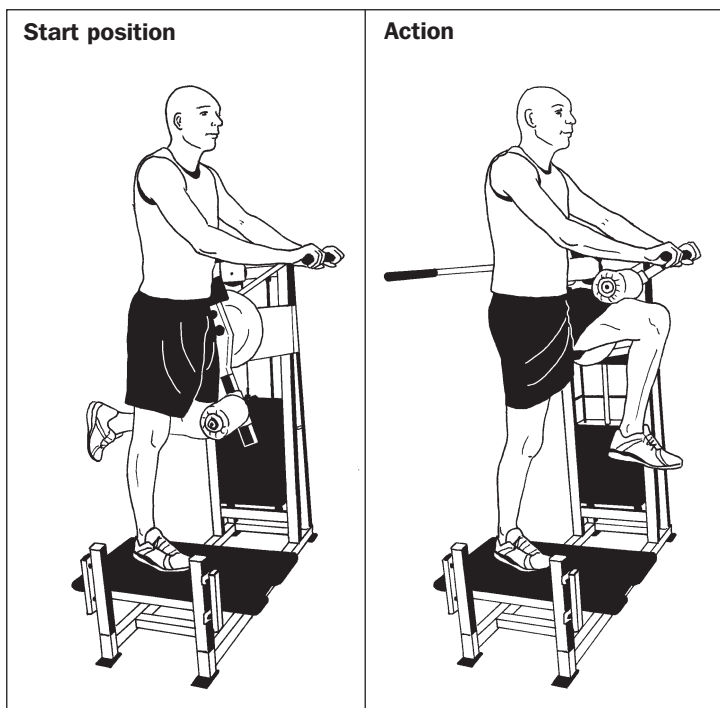
Reference

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Hip flexor exercise



Muscles involved: Front of hip and upper leg (iliopsoas and rectus femoris);

Joint motion: Hip flexion;

Sports applicability: All, but especially related to running-based sports, specifically the 'pull through' phase of the running action.

Conditioning benefits

- **General.** The majority of athletes will benefit from strong hip flexor muscles. As well as lifting the thighs these

‘The hip flexor muscles have been identified as the most important for generating running speed (above that of the calf muscles and thigh muscles)’

muscles can contribute to trunk stability. However, it is important to maintain flexibility in the hip flexor muscles, as shortening (due to regular sprinting, high knee drills and the use of this exercise, *etc*) can place strain on the back.

- **Sport-specific.** As noted, the exercise is closely related to the running action – specifically the pull through of the non-grounded leg once it has completed the drive phase. Everything else being equal, the more vigorous this action and the stronger/more powerful the athlete is in this range of motion, the faster he or she will be. Indeed the hip flexor muscles have been identified as the most important for generating running speed (above that of the calf muscles and thigh muscles).

Start position

Stand upright on the machine, taking hold of the stabilising bar, with straight arms. Keep the back in a neutral position (neither overly rounded or hyper-extended). Maintain a slight bend in the supporting leg. Adjust the machine so that the pad rests across the thigh, just above the knee.

Action

‘Pull’ the leg through from the hip, until the upper thigh is approximately parallel to the floor. Return the leg back to the start position under control, keeping the pad in contact with the thigh. The limit to this range of movement is determined by the need to remain upright while performing the exercise.

Training tips

Maintain a balanced and elevated chest position throughout the exercise and do not allow the hips to internally or externally rotate. Start with 3 x 12 repetitions using a light to moderate weight.

Alternatives

- **Standing machine hip extension:** This variation targets the gluteus maximus of the buttocks and hamstrings of the rear

thigh. The exercise is performed very similarly to machine hip flexion except that the pad of the machine is placed under the thigh, close to the knee and the action is reversed – *ie* the exercise is performed by sweeping the leg backwards.

Do: 3 x 12 repetitions. Combining both these hip exercises into a workout will have a highly running-specific conditioning effect.

- **Harness runs:** The two hip machine exercises can be translated into very running-specific field exercises by the use of a harness and a training partner/coach. The harness is attached around the waste of the athlete, while the partner takes firm hold of its ends, standing approximately 1m behind the athlete. The athlete runs forward, against the light to moderate resistance offered by their partner. This will enable the athlete to drive back (equivalent to the machine hip extension exercise) and pull the leg through as dynamically as possible into the next stride (equivalent to the machine hip flexion exercise). This drill is ideal for developing accelerative ability. The athlete should pump their arms backward and forward as vigorously as possible to assist their speed.

Do: 6 x 30m efforts with full recovery in between after a suitable, dynamic warm-up.

Warning

The author and PP take no responsibility for injuries caused by attempting this exercise. PP recommends that you always learn new exercises under the guidance of a professional.

John Shepherd MA

Dynamic flexibility for injury prevention & rehab

Static stretching is out. Nick Grantham examines the case for the new pretender

Flexibility components are often included in training programmes as a key aspect of preparation for physical activity, with the goals of decreased injury risk and improved performance^(1, 2). Exercises and drills to improve flexibility have traditionally been classified as either static or ballistic (*see Table 1, overleaf*).

Ballistic stretching, with its focus on end-of-range movement, has long been the black sheep of the flexibility family. This stretch technique uses momentum to get the body or limb to forcibly increase its range of movement, an approach that can cause soreness and injury. Critics also say that ballistic stretching fails to provide adequate time for tissue adaptation to the stretch, and that it increases muscular tension, which makes it more difficult to stretch connective tissue.

By contrast, the inclusion of static stretching within warm-ups or training programmes has long been accepted without any scientific proof of its effectiveness. Of late, however, it seems that static stretching has also fallen out of favour, with critics arguing that it does not prepare the body for the movements employed later in training or in sports performance⁽³⁾.

Much of this recent backlash can be attributed to a growing body of research suggesting that static stretching has a detrimental effect on the subsequent performance of speed, power and strength work⁽⁴⁾. Studies have shown that static stretching can negatively affect the performance of a skill that demands high power outputs such as sprinting and jumping, even when preceded by a dynamic warm-up protocol⁽⁴⁾.

While the underlying mechanisms for this adverse effect are still not fully understood, the negative effects reported in the literature have left coaches and athletes looking for an alternative.

So, new ‘dynamic stretching’ protocols have been gaining a lot of attention (see summary box, opposite) as an apparently effective alternative way to enhance athletic performance, provide a safe warm-up and prevent injury^(5, 6,7, 8, 9).

Table 1: Stretching classifications	
Static	The application of a constant lengthening force to a muscle held still, to increase range of movement at a joint. The stretch may be achieved either by a static muscle contraction (active) or assisted by gravity, a partner or apparatus (passive) ⁽³⁾ .
Ballistic	The use of repeated rhythmic movements – ‘bounces’, ‘bobbing’, ‘rebounding’, ‘pulsing’ – at a joint’s end of range to try to produce an extension to that range. Ballistic stretching imposes passive momentum that exceeds static ROM on either relaxed or contracted muscles ⁽³⁾ .

“The athlete progresses from an environment of control to activity simulation, from slow-velocity methodical activity to high-velocity functional activity”

Haven’t we been here before?

If you spend long enough working in the sports, exercise or rehabilitation industries, you will start to realise that everything is cyclical. Training techniques that you used 10 years ago will reappear under a new name to become the latest performance-boosting or rehab sensation. That, I believe, is what is happening with the current trend favouring dynamic flexibility work.

It seems to me that dynamic stretching is nothing more or less than a more ‘friendly’ version of ballistic stretching: it requires muscles to be moved through a range into some tension and then back out again. The main difference is that with dynamic flexibility, actions are supposedly controlled through a full range of movement, unlike the emphasis on small movements at the end of range used in ballistic work. Dynamic stretching can be

performed slowly or quickly; actively (as in swinging an arm or leg under its own control); or passively, by someone else⁽¹⁰⁾. Research has demonstrated that both ballistic and dynamic stretching enhance flexibility; however, dynamic stretching develops optimum dynamic flexibility, essential for all sports.

Why are we only just starting to appreciate the benefits of dynamic stretching? In 1990 Zachazewski recommended a 'progressive velocity flexibility programme' (PVFP). This programme involved a series of dynamic (ballistic) stretches preceded by a warm-up. The speed and range of lengthening was combined and controlled on a progressive basis^(3,11), as follows:

- After static-stretching, slow short end range (SSER) ballistic stretching is initiated.
- The athlete then progresses to slow full range stretching (SFR), fast short end range (FSER) and fast full range (FFR) stretching.
- Control and range are the responsibility of the athlete. No outside force is exerted by anyone else.

While no controlled clinical studies or research have been published on PVFP, the principle of progressively moving from static to a more dynamic programme of stretching seems sensible.'

Dynamic stretching in rehab

While the literature would seem to support the benefits of dynamic flexibility warm-ups over static stretching in performance terms, at the moment there is no comparable evidence base for its use in rehab or for longer term flexibility gains.

But, backed by research or not, the good practitioner will always consider the requirements of each individual when deciding on the most appropriate rehab tools. As a coach working with athletes and clients every day of the week, I'm amazed that people still seem to think there is a single right or wrong way to stretch. The right way will always be the approach that works best to meet the specific client and their rehab goals. You can't fix everything with a hammer: sometimes you need to use a screwdriver.

‘I’m amazed that people still seem to think there is a single right or wrong way to stretch. The right way will always be the approach that works best to meet the specific client and their rehab goals’

Dynamic Stretching – What the Research has found

- Warm-ups using dynamic stretching resulted in an increase in countermovement jump (CMJ) height and rate of force development (RFD) when compared to a traditional general warm-up protocol⁽⁹⁾
- A dynamic warm-up improved drop jump (DJ) height, CMJ contact time, RFD and peak force when compared to static stretching⁽⁹⁾
- Dynamic warm-ups improved sprint performances in rugby players compared to traditional warm up activities⁽⁶⁾
- Dynamic stretching routines in warm-up protocols enhance power performance⁽¹⁵⁾
- Dynamic stretching was found to improve leg extension power when compared to a static stretching protocol⁽¹⁶⁾
- Dynamic stretch protocols produced significantly faster 10m sprint times compared to static stretching and the researchers concluded that dynamic stretching is probably the most effective method of preparation for the high speed performances required in sports such as soccer⁽²⁾
- When investigating the effect of static v dynamic stretch warm-ups on power and agility performance among army cadets, the results suggested that a dynamic warm-up offers benefits not found with static stretching⁽¹⁷⁾

Both methods of stretching have their place. Dynamic stretches may well be more appropriate for a warm-up. Static stretches, on the other hand, may be more appropriate at the end of a workout to help relax the muscles and facilitate an improvement over time in maximum range of motion⁽¹²⁾ (*ie* developmental stretching).

Whilst evidence increasingly suggests that static stretching may indeed adversely affect subsequent power- and strength-based activities such as maximal lifts, sprinting and jumping⁽⁴⁾, this effect may be limited simply by reducing the length of hold for each static stretch (*ie* 10 to 20 seconds is fine; it is from 30 seconds and longer that you are going to experience a drop in performance)⁽¹³⁾.

It will not surprise you to learn that I like to take an approach that combines these different techniques to suit the circumstances. If a client is found to have poor hamstring flexibility and this is a limiting factor for their training, my main focus will be on developing the hamstring range of movement. To improve

ROM we will include a greater proportion of static stretches, we will probably even prescribe specific stretching sessions. We will then follow with some dynamic movements to prepare the body for sporting or training activity. If the client doesn't present any limiting flexibility issues, we will skip the static stretches and simply include a range of dynamic stretches in preparation for the subsequent training session.

Warm-up moves

Here are my top five dynamic stretches that can be used as part of a typical dynamic warm-up (*adapted from Boyle, 2004*)⁽¹⁴⁾.

High knee walk

A great way to start the warm-up, it hits all the key muscles of the posterior chain (most importantly, the glutes):

- Step forward and grasp the shin of the opposite leg, pulling the knee in towards the chest.
- Concentrate on extending the stepping leg to get up onto the toes. This takes the body through triple extension (ankle, knee, hip), which is important for all running and jumping sports.
- Progress this movement into a high knee skip and then a high knee run.

Straight-leg deadlift walk

Gives a great active hamstring stretch plus a proprioceptive and balance workout:

- Reach both arms out to the side while attempting to lift one leg straight back and up to waist height.
- The stretch is felt through the hamstrings of the supporting leg, simultaneously activating the hamstrings of the moving leg, which will be working as a hip extensor.

Forward lunge walks

Works the anterior hip and warms up all of the leg and hip extensors. A tough drill which should only be included once the client has completed at least one week of single-leg strength work:

- Use a basic lunge pattern incorporating a step forward after each lunge (walking lunge).
- For an extra challenge, do the stepping lunges backwards.

Caterpillars

A total body warm-up drill. Tough but well worth the effort:

- Begin in a push up position.
- Drop the hips to stretch the abdominal area and then walk feet up as close as possible to the hands, keeping the legs straight (take baby steps and keep legs straight).
- Walk forward to take the hands away from the stationary feet, finishing again with the hips down to stretch the abdominals. This portion of the drill works the upper body, particularly the scapulothoracic region.

Stationary spiderman

A great warm-up drill for any sport requiring lateral movement:

- Start in a push up position and step the right foot forward to just outside the right hand.
- Drop the right elbow to the ground.
- Return the foot to its original position and switch sides.
- Remember this is a dynamic stretch, so it should move from right to left leg in a rhythmical manner with no holds at the end position.

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How to teach a squat

Chris Mallac *cuts through the controversy and explains how to achieve safe and effective form*

One of the enduring debates in the worlds of strength and conditioning, fitness training and rehab, concerns the pros and cons of squats as an exercise. Advocates of the squat are keen on the ‘functionality’ and total body movement involved, and the potential to load the exercise for real strength gains. Critics say the price is too high: squats cause too many injuries for the benefits they confer, and better alternatives can be found. Every aspect of the squat movement, it seems, is contested: foot position, stance, depth of movement, position and extent of load, breathing, speed and so on.

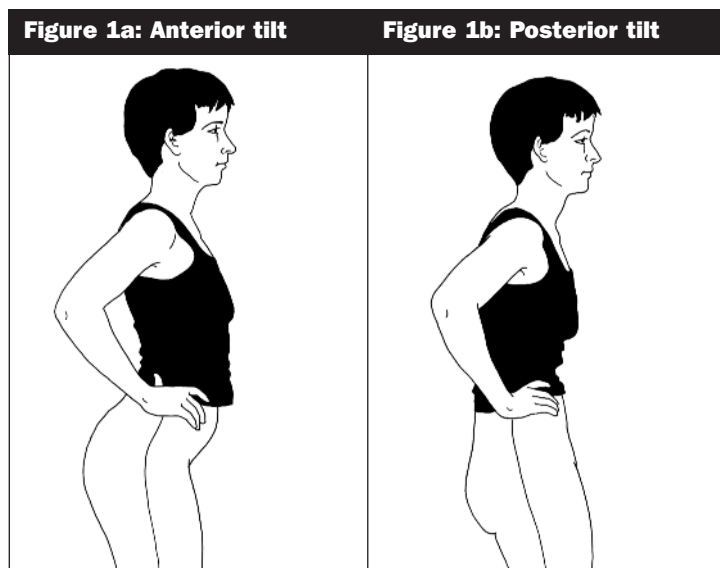
In this examination of squat performance we start from a different premise: there is no such thing as a bad exercise, only bad bodies, bad form and bad decision making. The exercise or rehab professional should be familiar enough with their client’s needs, goals, physical limitations and imbalances to prescribe the most beneficial form of training to meet that individual’s circumstances.

The focus of our squat analysis here is on pelvic tilt. This is because many of the variations come down to differences in the degree of pelvic tilt used to initiate the squatting movement. Using this analysis, the trainer will be better able to evaluate the risk-benefit decision for each client.

Direction of pelvic tilt

As all good squat techniques are initiated with some degree of pelvic tilt, the direction of tilt will completely change the dynamics of the squat movement. The pelvis can tilt along a

continuum from anterior to posterior (see SIB69, ‘The lost art of pelvic tilt’ for a fuller discussion on this). In summary pelvic tilt movements work as follows:



Anterior pelvic tilt

The anterior superior iliac spines (ASIS) are pushed forward (anteriorly) and downwards (inferiorly). For a full anterior tilt a good cue is to ‘stick the bum out’ (see *Figure 1a*, above left).

Key features:

- Ilium anteriorly rotates
- Lower lumbar spine moves into relative extension
- Facet joints engage so the spine is passively locked into a stable position
- Long dorsal sacroiliac ligament is taut so the sacroiliac joint (SIJ) is locked into a stable position.

Posterior pelvic tilt

The ASIS bones move backward (posteriorly) and upwards (superiorly). An appropriate cue for posterior tilt would be to ‘tuck the bum under’ (see *Figure 1b*, above right).

Key features:

- Ilium rotates posteriorly
- Lower lumbar spine moves into relative flexion
- Facet joints disengage so the spine has no bony support
- Long dorsal sacroiliac joint ligament is loose so the SIJ is unlocked into a relatively unstable ligamentous position (this does not mean that muscles are not supporting it).

A common error by inexperienced trainers is to teach an ineffective squat technique by getting their client to initiate the squat movement with knee flexion rather than pelvic tilt. This will produce a very upright body position, an uncontrolled descent phase and limited depth of squat.

What is a moment arm?

The distance from an axis of rotation (eg hip joint) to the line of action of a force (eg a squat bar weight). If the tendency of that line of action is to force the hip into flexion, it is referred to as a 'flexion moment'. To stay balanced the body must produce a force to counteract the moment arm, which will be an extension force, in this case the hip and back extensors.

Squat form 1: anterior tilt

When the pelvis is tilted anteriorly during the squat, the athlete can achieve a greater angle of hip flexion (*ie* their trunk can move closer to their thigh) as they squat down. This allows an increase in the flexion 'moment arm' (*see box, above*) over the hip. In other words, as Figures 3a and 3b show (*overleaf*), the distance from the hip to the vertical weight line increases, and as a consequence, the flexion moment over the knee decreases.

This relative shift in the moment arms allows more weight to be directed towards the hip so that the athlete can recruit the more powerful hip extensor muscles instead of relying on their quads. This is how powerlifters achieve a heavy squat. They also tend to hold the bar around the mid thoracic spine which reduces the flexion moment around the lower lumbar spine. This is safer on the spine and allows them to really shift the moment arm around the hip towards more flexion.

The kinetic benefit of this squat method is that the anterior tilt places the upper hamstrings and adductor magnus in a more favourable length-tension position to generate force, permitting a more powerful return phase.

Squat form 2: posterior tilt

In this position, the spine is forced to stay relatively straight, so less hip flexion is possible (*see Figures 4a and 4, below*). This causes the squatting athlete to keep their weight directly over the hip joint, eliminating any hip flexion moment, and instead producing greater ankle dorsiflexion, which in turn causes the knee to move well forward of the vertical weight line. This massively increases the knee flexion moment, leading to maximal activation of the quads. Indeed, this squat is often called a ‘quad-loading squat’. The resultant increase in quads activation causes an increase in patellofemoral joint compression and loading of the patellar tendon.

The kinetic benefit of this squat is that the posterior gluteus medius fibres and lower abdominals have to work very hard to maintain the posterior tilt, and the quads have to work extremely hard to cope with the massive knee flexion moment.

Squat form 3: neutral tilt

The athlete holds their pelvis in a neutral position, which means maintaining a slight anterior tilt, so as to preserve the natural lordosis (curve) of the lumbar spine. Mechanically this position

Figure 3a, 3b
Anterior tilt squat

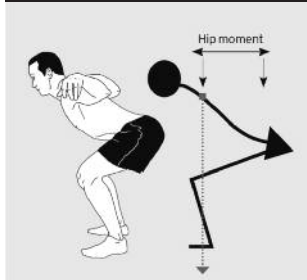


Figure 4a, 4b
Posterior tilt squat

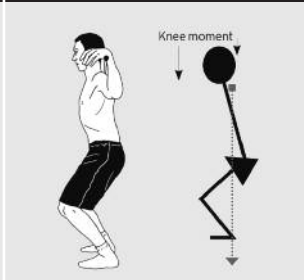
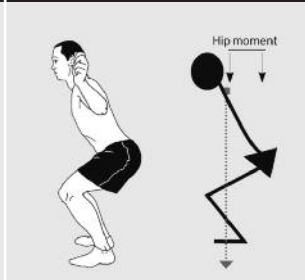


Figure 5a, 5b
Neutral pelvic tilt



is mid-way between a full anterior tilt squat and full posterior tilt squat. In this squat the exercise or rehab specialist would observe that the tibia and spine move together and stay parallel through the movement, as shown in Figures 5a and 5b (*opposite, below*). Compare this with the non-parallel relationship between the spine and tibia in Figures 3 and 4.

The kinetic effects of this squat will be a combination of the other two, but without the extreme effects of either position.

Pelvic tilt and injury risk

All squat variations carry specific injury risks. Although we will not go into any detail here, it is worth noting that factors other than pelvic tilt also contribute to injury risk. For example:

- **squat depth:** the deeper the squat, the greater the shear and compression force on the medial meniscus ;
- **foot turn-out:** can contribute to knee rotation force and posterior hip forces;
- **narrow v wide stance:** wide stance tends to favour an anterior pelvic tilt as it allows increased hip flexion. It is very difficult and inadvisable to posterior tilt squat with a wide stance.

In the full anterior tilt squat, the facet joints of the lumbar spine lock into a safe closed position, so that the low back is braced

Table 1: Biomechanical effects of the squat

Biomechanical effect	Increase (↑)	Decrease (↓)
	Anterior tilt	Posterior tilt
Hip flexion	↑	↓
Hip flexion moment	↑	↓
Dorsiflexion	↓	↑
Forward knee movement	↓	↑
Lumbar spine flexion moment	↑	↓
Quadriceps activation	↓	↑
Hip extensor activation	↑	↓

well by passive structures. However, this does not necessarily safeguard it: because of the more extreme hip flexion. The lumbar spine, which is already quite extended, is placed into an increasingly horizontal position, in which the vertebral discs are more perpendicular to the ground and therefore more vulnerable to the shearing (slipping) forces of gravity.

Lumbar spine discs dislike shear force more than any other kind (the lower back tolerates compression forces far better). Furthermore, the increase in the flexion moment around the lower lumbar spine caused by the forward lean, results in a greater contraction of the erector spinae muscles, in their effort to supply the counterbalancing extension moment. This intensified contraction of erector spinae has the secondary effect of greatly increasing lumbar disc pressure, as it basically squashes the discs and vertebrae together.

And what of the argument that the anterior tilt squat ‘saves knees’, because of the reduced knee flexion moment? It all depends. If your athlete is preferentially recruiting their upper hamstrings/adductor magnus by increasing their hip flexion moment, then they are in effect also under-utilising their quads. If this type of squat is the only lower-limb exercise they perform, you may well be setting them up for poor quad-to-hip-extensor strength, which over time may cause problems with knees in movements that require more balanced lower-limb strength.

The full posterior tilt squat has two main effects on the lumbar spine, relating to its position of relative flexion:

- poor passive support
- increased disc pressure.

As mentioned above, in posterior tilt the facet joints disengage, so the lumbar vertebrae lose that passive restraining structure. The low back now needs to hang off soft tissues and muscles far more for support. In addition, all flexion movements increase posterior pressure on the lumbar discs, making them more susceptible to injury.

We have already noted that the increased knee flexion moment in this position greatly increases forces through the

Table 2: Injury risks of pelvic variations in the squat

Squat variation	Injury risk	Rationale
Anterior tilt (powerlifter's squat)	Shoulder strain/instability Lumbar spine pathology Anterior hip impingement Piriformis syndromes Overdevelopment of upperhamstrings/ adductor magnus	Excessive shoulder external rotation required to hold the bar High loads and large spine flexion moments Increased hip flexion Generally need to hold hips externally rotated at bottom of squat to allow range of motion Large hip moments
Neutral tilt	Mild incidence of lumbar spine and knee problems	Where load is too great
Posterior tilt (Quad loading squat)	Lumbar spine pathology Patellofemoral compression; patellar tendon loading Ankle impingement	Relative instability caused by lack of facet joint locking and relative lumbar flexion loading posterior disc Increased knee flexion moment Increased dorsiflexion

quadriceps muscles. Is this a problem? Possibly: if done too often or with too much load, the patellofemoral joint is subjected to massive compressive forces, which may lead to all sorts of cartilage-related problems behind the kneecap and on the femoral condyles. And there is an increased long-term risk of patellar tendinopathy, too, from the compressive force on the posterior part of the patella.

The main injury effects of different pelvic positions in the squat are summarised in Table 2, above.

Conclusion

Common sense would suggest that the best way for a trainer or rehab specialist to avoid exposing their client to injury is to perform squats with a neutral pelvic tilt. This is most definitely true. But exercise prescription is very rarely about a single factor, especially if that sole factor is the avoidance of injury risk. Taught and performed carefully, logically and in safe

progressions, the full anterior tilt squat and posterior tilt squat both have their place.

If your client is a performance athlete and needs to squat heavy, the anterior tilt squat is likely to be the way to go. It has mechanical advantages and the lumbar spine is at least partially supported by the locking of the facet joints. If the goal is to achieve significant development of the lower back and hip extensors, the anterior tilt squat will do this – but so will deadlifts, back extensions and Romanian deadlifts.

If you are going to use squats to maximise your client's quadriceps development, the posterior tilt version will be your exercise of choice.

If 'functional' exercise is an important consideration for your client, squats certainly tick all the boxes: they are performed in weight bearing, involve natural compressions of the spine and SIJ, involve recruitment of the 'functional' myofascial slings and activate the triple extension mechanism of the lower limb in the concentric or lifting phase (ankle plantarflexion, knee extension, hip extension).

For sports and rehab professionals who tend to deal with sub-elite athletes or less highly trained people, the most logical starting point is to teach the client to become proficient at the neutral pelvic tilt squat. This allows the client to develop some pelvic control in a 'functional' movement, at the same time gaining a broad-brush approach to lower-limb strength development, as this style works the entire kinetic chain without intense targeting of particular muscle groups.

As the client becomes more advanced, decision making and judgement by the trainer or therapist can be more sophisticated. If, for example, the professional feels that the client could do with more direct quad loading, the squat can be progressed into a posterior tilt direction to emphasise the knee dominance of this variation.

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Notes

