

RUNNING RE-EDUCATION

A TREATMENT FOR EXERTIONAL LOWER LIMB PAIN

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Running-related lower limb pain is a commonly diagnosed overuse injury in runners both recreationally and in the military with an incidence of 27 to 33% of all lower leg pain presentations¹⁻³. Typically, the athlete presents with incremental pain with exercise, which is described as ‘tightness’, or ‘constricting pain’. Symptoms are usually related to the level of exertion such as running on an incline or at an increased speed, and tend to worsen to a crescendo so that continued running is impossible. The pain is alleviated by rest and occasionally presents with paraesthesia or foot slapping, however typically the individual is able to briefly recommence running prior to a recurrence of symptoms. Classically, the patient is pain-free when not exercising.

The pain can be localised to the anterior shin where it has been commonly described as anterior chronic exertional compartment syndrome, or to the medial shin where commonly, the terminology of medial tibial stress syndrome or ‘shin

splints’ has been used. Acute compartment syndrome is a surgical emergency, and usually following crush injury with muscle damage and bleeding causing increased intracompartmental pressure and ischaemic hypoxic cell damage to muscle, and requires urgent surgical decompression for tissue salvage. This differs from the chronic condition first described by Mavour in 1956⁴.

The author believes these conditions are better described as Biomechanical Overload Syndrome. The underlying pathophysiology was thought to be transient muscle ischaemia⁵ due to fascial non-compliance or muscle hypertrophy in the chronic compartment syndrome presentation, but to date, no conclusive proof of tissue necrosis or cell hypoxia has been demonstrated⁶.

The pathophysiology of medial tibial stress syndrome as a traction periostitis or that of a bony overload, actually supports the kinematic overload of the deep posterior structures arising from

the medial tibial border being unable to tolerate increased kinetic loading and hence fits the description well.

Biomechanical Overload Syndrome symptoms can be described in the anterior, peroneal and deep posterior compartments⁷ of the lower leg but the anterior is the most commonly detailed⁸. Intra-compartmental pressure measurement has been shown to be less reliable than assumed with the Pedowitz criteria. Also, there is substantial overlap of normative criteria and significant confounding variables of measurement technique and catheter placement, throwing doubt on the diagnostic process⁹. Increased pressures are likely to be clinically and diagnostically less relevant, given the doubt over their accuracy and elevated pressures are not seen in medial tibial stress syndrome despite the similarity in mechanism.

Muscle overuse syndromes are not new and should not be surprising. They are well-described in the literature, significantly in



musicians and office workers and there is a clear synergy with the exacerbating factors in repetitive overload: increasing frequency and the intensity or load of work and practice, and altered limb kinematics alongside limited interventions.

Exertional lower limb pain, to date, has proved difficult to treat conservatively with limited success of stretching, acupuncture, massage and activity modification^{10,11}. Rest and immobilisation take time and are poor options in the athletic population and for this reason many patients seek surgical decompression¹². Outcome data on operative intervention in chronic exertional compartment syndrome is good in the short-term but studies are limited on duration of follow-up and outcome measure along with much variation in operative technique^{13,14}. In medial tibial stress syndrome approaches include conservative¹⁵, interventional¹⁶ and there are promising studies in gait modification¹⁷.

THE GAIT CYCLE

Traditionally, distance runners and first-time joggers adopt a rearfoot strike, which

leads to a typical gait cycle. The heel makes the initial contact with the ground and then transitions to the flat foot mid-stance phase accompanied by a natural degree of pronation of the foot. This is controlled by the tibialis posterior and flexor digitorum muscles and ends when the rear foot leaves the ground in a supinated position and moves through the toe-off phase in part through momentum and in part via dorsiflexors.

Recent trends in footwear and running techniques have seen a widespread awareness of midfoot and forefoot running which has been driven in part by the adoption of newer shoe technologies purporting to offer a barefoot experience. In typical running shoes the midsole and outsole offer a graduated fall from heel to toe in a shoe, which commonly has been greater than 14 mm. In 'barefoot shoes' this can be 0 mm (representing a flat sole seen in Vibram FiveFingers) or more commonly in minimalistic shoes a 4 or 5 mm drop (seen in Nike Free)

These shoes in themselves do not cause a change in running technique but the runner

purchasing them is often keen to adapt their technique to suit the shoe! Minimalistic shoes promote a more midfoot landing but it is perfectly possible to run using either forefoot or rearfoot strike in any shoe and as such, much of the hype is manufacturer's promotion rather than true benefit.

How this changes the forces on ground contact has been the subject of a plethora of recent research, all endeavouring to qualify the success of a particular style of shoe. Recent work has re-emphasised that the athlete can run in a variety of landing patterns regardless of whether wearing a shoe or not and this dismisses much of the lesser research.

However, this only relates to the foot. Much of the research currently ignores the force dynamics at the knee, hip and pelvis and as such is limited significantly as these cannot be ignored.

Running requires the absorption of the ground reaction force (GRF) which can be up to 3× body weight, but the muscle forces are substantially higher¹⁸ and so we need to look higher up the chain. Dr Irene Davis' work has looked at the angle of tibia in relation to the

absorption of GRF reduction by up to 30% but this GRF must be absorbed somewhere, most likely the hip flexor/extensor or knee flexors, assuming a degree of joint stiffness is provided by muscle.

RUNNING RE-EDUCATION

Trends have changed already and recent reports suggest that manufacturers of barefoot technology are already on the wane and replaced by ultra cushioned shoes such as Hoka One One. If we look at a sample of representative runners at marathon level, at least 75% of runners make initial foot contact with the heel. It is therefore good to question whether it is possible or indeed useful to be able to alter running kinematics. A heel strike causes a sudden impact force to the heel which Davis¹⁹ has demonstrated can be significantly reduced by changing to a midfoot or forefoot initial contact by up to 30%. In addition the tibial deceleration forces can be reduced by up to 50% which should reduce the tibial stress and also alter the muscle adaptation required to slow the tibia and move the foot through the gait cycle. However, more recent studies have suggested that midfoot landing can increase the overall ground reaction force. Certainly, more work is needed on this.

We have focused not on trying to identify an ideal running method, but more to identify kinematic variables which are common to patterns of injury presentation of biomechanical overload. Symptomatic resolution in making kinematic changes has been very successful and we have made extraordinarily successful changes with video-based interventions on a daily basis in a large cohort of runners. Many of these changes relate to the spring-mass model which makes the assumption of the runner as a mass acting to compress two spring-like legs²⁰. When the leg-spring is compressed, it resists this compression with a force that is proportional to the distance of compression. This gives a measure of leg stiffness. The leg-spring is compressed from foot strike to mid stance then released to provide forward propulsion. Increased leg stiffness therefore results in improved hip extension and propulsion.

We are not alone however, recent work on running technique and kinematic and kinetic changes of gait may provide the underlying mechanism behind the propagation of muscle overload. Reduction in the stride length, ground contact time, vertical oscillation and lower extremity angle all contribute to improved running economy²¹, reduced ground reaction force and movement efficiency^{22,23}. Cheung²⁴ has shown in a small case series that 90% of runners with patellofemoral pain were able to maintain a midfoot landing, following a re-training programme of eight sessions over 2 weeks, focused on moving from a rearfoot to midfoot strike to maintain a midfoot strike and similarly showed a reduction in peak ground reaction force between 10 and 35%, along with a reduction of pain scores and improved running performance. This is important as many runners question their ability not only to change the way they run but also to maintain it. The reduction in ground reaction force is clearly important but also the recruitment of the hip stabilisers, the gluteals, which can more-effectively engage to produce drive.

Previously, case series have been successfully described treating two athletes

with symptoms of chronic exertional compartment syndrome with footwear modification²⁵. Using video analysis the authors observed that at foot strike there was substantially less dorsiflexion in subjects using thinly soled shoes. Using these shoes lead to resolution of symptoms in the anterolateral compartment region. Despite not being pressure tested these subjects were successfully treated without surgery for the diagnosis of anterior compartment syndrome. Our view on this is that it is unlikely to provide lasting resolution without more substantial changes.

Forefoot running has been demonstrated to lower intra-compartmental pressures and resolve clinical symptoms improved when adopted by patients with symptomatic running²⁶.

If we look at how easily the forces affecting muscle in the shin can be changed by adapting running kinematics, it is logical to apply the principle of overload to the smaller muscles of the leg which are simply being asked to do too much work or indeed adapt to a higher workload too quickly. There is little in the way of a pathological process at work here, unless the work rate is maintained despite warning and the

**tibial deceleration
forces can be reduced
by up to 50%**

ABOS



Figure 1: Common kinematics of ABOS. ABOS=anterior biomechanical overload syndrome.

development of stress response in the underlying bone leads to a stress response and then fracture. The muscles of the lower limb are designed to absorb the force applied by landing, jumping and running and stress response can be seen as a failure to load these sequentially. It is the imbalance in loading that results in the muscle fatigue failure – the proximal muscles should be taking the greater share of the load. It should be a case of the ‘big muscles doing the big jobs’, but too often we have seen that this is not in fact the case. It’s no wonder – the typical runner receives little to no coaching on their technique and as such tends to display many common variables which we have attempted to address in coaching cues in response to common patterns of overload.

Anterior biomechanical overload

Patients presenting with anterior progressive shin pain are typically overusing the foot flexors and tibialis anterior to both prepare the foot for heel strike and pick up the toes, but also to control its descent concentrically then eccentrically. Rather than measuring pressures or prescribing shoes or orthotics, it is possible to reduce the load on these muscles and hence symptoms by altering running kinematics.

The first coaching point relates to the position of the pelvis and the body. We

focus on an upright body over the centre of mass with a neutral pelvis. An anterior tilted pelvis makes the active hip extension movement very difficult and as such, the neutral position of the anterior superior iliac spine to posterior superior iliac spine makes this easier to achieve. This also keeps the centre of mass over the stance phase and reduces the eccentric load on the shank when in midstance, unlike ChiRunning® which exacerbates this. ChiRunning® is a style of running which describes itself as evidence-based to reduce injury but on which there is no research-based evidence, just anecdotal. Based on Tai Chi, with a focus on forward lean and minimal effort, the proponents claim a significant reduction in injury but this is yet to be shown and does not make biomechanical sense. The Pose Method®, another proprietary method of running claiming significant evidence, focuses on a forefoot running technique with high cadence and flexed knee. In the published scientific press there is only one study referencing this method.

Secondly, we need to focus on stride length and step cadence. Shorter strides are familiar to those aware of both barefoot running and the ‘Pose Method’, this does not help in the concentric/eccentric load of tibialis anterior and as such, we aim to increase cadence 5% above what the patient

presents with, rather than a prescribed rate. In order to achieve this, we utilise one component of the spring-mass model and increase leg stiffness, assisting in the spring compression. Additionally this assists in achieving a midfoot strike and more vertical tibia orientation. Although the ideal cadence has been discussed at length, we feel it is more the foot position, tibial angle and decreased ground contact time that offload the anterior compartment muscles here. Although there may well be a resultant increase in GRF at the ankle, focusing on hip flexion allows greater hip extension and possible secondary absorption of the GRF.

This also allows us to reduce the progression of tibial stress response by decreasing the angle of the tibia and reducing the force impulse.

Thirdly, we focus on a midfoot strike to complement the tibial angle and, assuming Newton’s second law, the force must be distributed higher in the ‘spring’ to the knee extensors, hip flexors or hip extensors²⁷.

Finally we focus on coaching an increase in hip flexion, this is aimed at obtaining more effective hip extension as a result and focussing on the downward and backward movement of the leg and allows the large proximal muscles to provide the propelling force rather than the smaller muscles of the shank.

PBOS

Marked knee flexion



dorsiflexion ankle



Anterior torso tip

ITBS

Hip drop



Xover gait



Knee flexion

Figure 2: Common kinematics of PBOS. PBOS=posterior biomechanical overload syndrome.**Figure 3:** Common faults seen in iliotibial band compression syndrome. ITBS=iliotibial band syndrome.**Posterior biomechanical overload**

Posterior biomechanical overload is a very common presentation of lower limb pain, typically referred to as 'shin splints'. There has been much focus in the literature on the periostitis (or lack of) and whether this is traction bone injury. There is certainly traction from the extensor muscles, tibialis posterior and flexor hallucis and flexor digitorum longus, all of which run in the deep posterior compartment.

Runners we have worked with share common features in running kinematics. Very often there is a prolonged ground contact time. This allows a significant dorsiflexion under load and maintained eccentric loading of the muscle in each stance phase. This contributes to the overload and one can see how the traction will develop over time.

By coaching a stiffer leg on ground contact and less knee flexion alongside

a more forceful down 'dabbing' ground contact, we engage the hip extensors rather than the ankle flexors and reduce the load and subsequent traction¹⁷.

Iliotibial band compression pain

Iliotibial band compression pain is an incredibly common condition which again has little success with conservative measures. Recurrent local anaesthetic injections to the Kager's fat pad underneath



The focus here is on changing muscle sequence and load



Kaplan's fibres leave little ongoing room for resolution. The current vogue for foam-rolling the fascia makes little sense physiologically and the mechanics of the anatomy explain the underlying pathology well.

We see two common features in almost all who suffer iliotibial band compression pain:

1. Crossover feet in the running pattern. From the coronal view on the running treadmill we see that the legs cross over the midline at initial contact. This allows a more oblique pull of the tensor fasciae latae on the distal fascial insertions increasing the compression of the fat pad. The angulation and obliquity of the leg and hip increases as the stance phase takes over.
2. Gluteus medius control of the stance leg and therefore allowing a contralateral lateral tip of the pelvis (Trendelenberg), the load on the distal lateral knee will be further exacerbated.

The coaching cues here are straightforward and often asking the patient to run with their feet separated a little more will achieve much on its own. In fact it is often prudent to reassess things at this stage as any apparent rapid pronation of the forefoot or indeed lateral loading at initial contact may well be addressed with this cue. We therefore always reassess at this stage.

This condition does require some off-treadmill exercises to improve the single leg femoral rotation control by the gluteal muscles. The sequential activation of gluteus maximus and gluteus medius

through the gait cycle are important to train and this cannot always be achieved just on the treadmill. The stability of the pelvis in stance phase, however, needs both cueing with running drills such as hip hitching and arm extensions alongside the off-treadmill sequencing.

THE ANSWER FOR ALL PROBLEMS?

We now have clinical experience of over 500 patients making kinematic changes to address the common running-related overuse problems and have adapted both the coaching cues we use over this period, but also widened our inclusion of other conditions.

It would be foolish to think that changing kinematics can address all problems. We have certainly failed in a fraction of patients, particularly those with patellofemoral joint chondrosis who often, although they are compliant in trying to achieve femoral rotation control, cannot due to pain inhibition or anatomical deficiency. A common question from multi-directional athletes is how making straight line changes can help them adapt when changing pace and direction. There is no straightforward answer to this. We have found significant cross over from straight line training – clearly when a soccer player is sprinting, he is not thinking of how he is running, but the baseline changes are held over from training and easier pace work.

Although one or two patients have struggled to maintain the kinematic changes, significantly, most have found after two or three interventions that the changes became more natural and lasting.

We use video feedback as a critical cueing process and all review sessions involve live video.

The focus here is on changing the sequence of muscle loading, by altering the rate of force development of the posterior chain. Even if a small degree of carry over is maintained, this is often enough to alleviate symptoms.

We have not, however, resorted to measuring intracompartmental pressures or surgical intervention in any of these patients and have just published a successful case series of our interventions.

We have not mentioned orthotics in this discussion at all and it almost certainly is a separate discussion. The adaptation of running kinematics is like inflating the tyres of a car – if there is a role for orthotics then it would be the tracking of the wheels i.e. pointless unless the tyres are inflated.

We find running re-education an invaluable tool in the management of patients with exertional lower limb pain and continue to refine the process and coaching cues along with interventions at the Sports Surgery Clinic in Dublin and typically a patient with exertional lower limb pain would return to 30 minutes of pain free running within 4 to 6 weeks with two to three coaching sessions and a graduated walk to run programme.

References

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