Pronation and the Kinetic Chain

By Cameron Reid

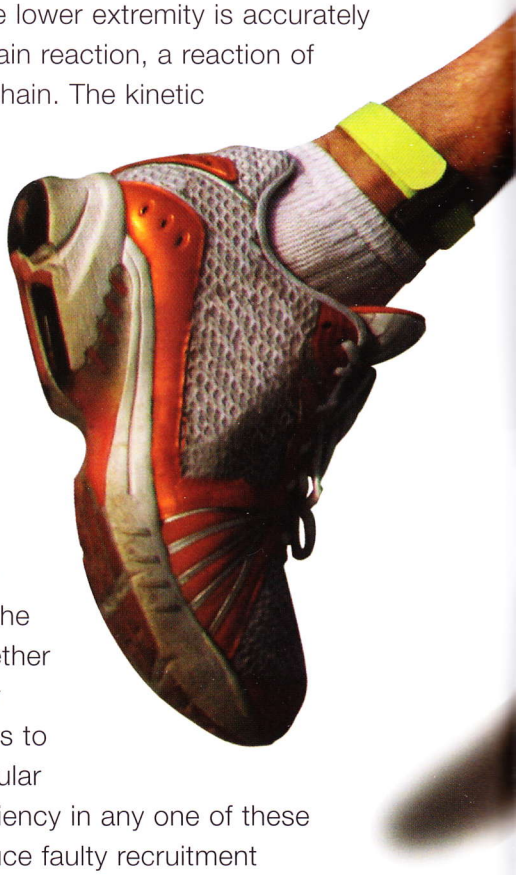
Probably the most written about subject in biomechanics has got to be pronation, supination and their effects.

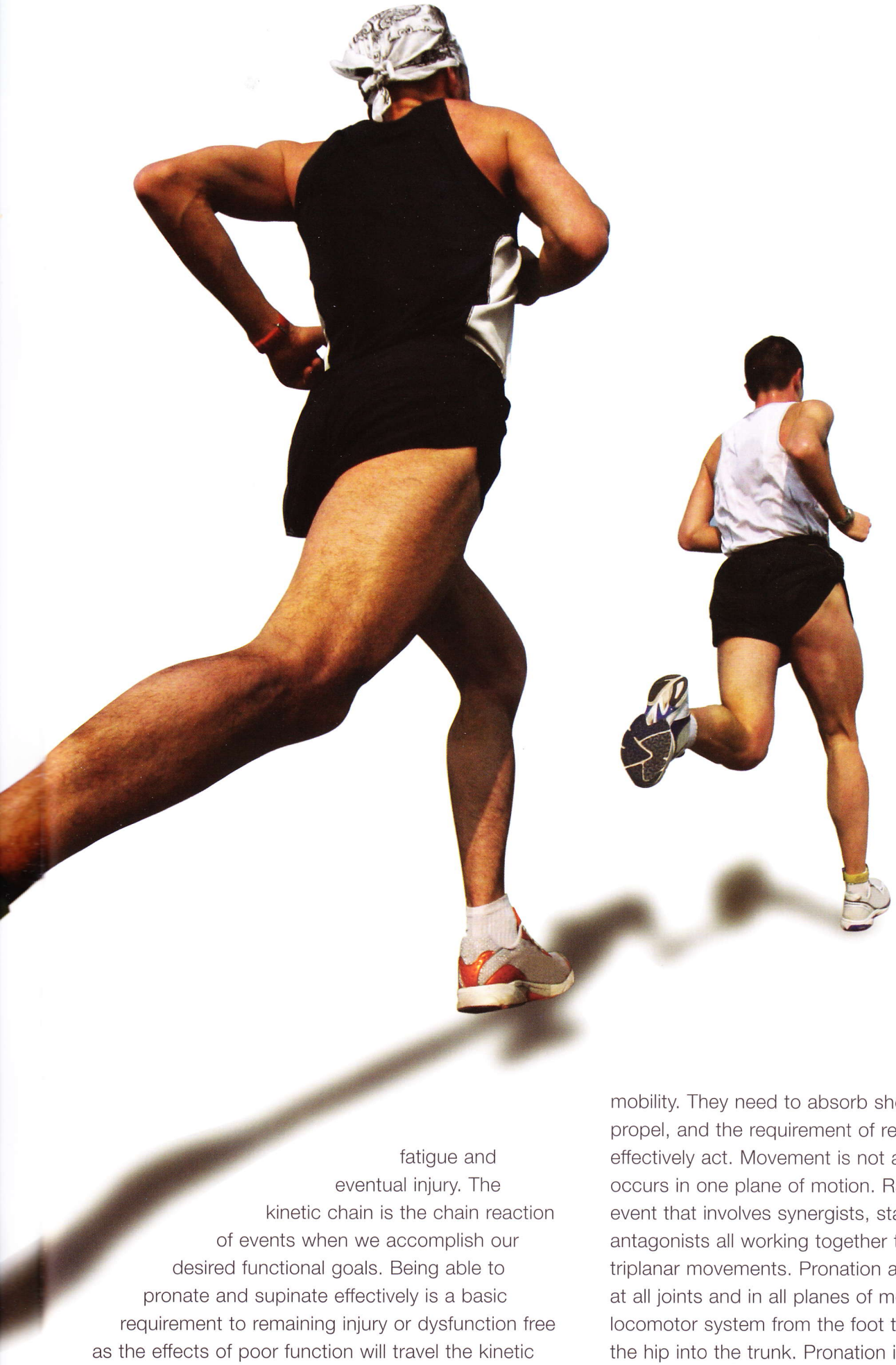
Traditionally we relate these anatomical terms to movements seen at the elbow/wrist and at the foot. In the elbow and wrist pronation is when the lower end of the radius rotates around the head of the ulna, carrying the hand with it. In the anatomical position the forearm is supinated (palm facing anteriorly) and the radius is lateral to and roughly parallel to the ulna. In the distal end, the radius comes to lie on the medial side of the ulna moving the dorsum of the hand to face anteriorly. This is termed pronation and the opposite movement will be supination.

When applied to the foot, pronation is the combination of the three movements of eversion, abduction and dorsiflexion. Supination is the opposite set of movements, namely the combined motion of inversion, adduction, and plantarflexion. These combined movements occur at the subtalar joint. In walking or running when the weight bearing foot interacts with the ground it will 'collapse inwards' and pronate. When it is about to come off the ground it stiffens up or 'supinates'. Those of you who regularly treat runners will be very aware of these terms. But these terms give us the impression that is all that happens. But in reality this is not all that happens, and many of the musculoskeletal problems we see in clinic are related to these simple movements.

The Kinetic Chain

The function of the lower extremities in gait is to enable the body to do what it wants to do. Most of what the lower extremities do is at a subconscious level constantly interacting with the environment in order to walk, run, jump, twist, climb and balance etc. The function of the lower extremity is accurately described as a chain reaction, a reaction of the entire kinetic chain. The kinetic chain is simply defined as the interdependent operation of the soft tissue system (muscle, tendon, ligament and fascia), the nervous system, and the articular system. In other words these three major systems in the body operate together to allow for proper movement patterns to occur (neuromuscular efficiency). A deficiency in any one of these systems will produce faulty recruitment patterns and place increased demand on tissues in the body. This can lead to early tissue





fatigue and eventual injury. The kinetic chain is the chain reaction of events when we accomplish our desired functional goals. Being able to pronate and supinate effectively is a basic requirement to remaining injury or dysfunction free as the effects of poor function will travel the kinetic chain and cause pain somewhere along it. The lower extremities require stability in order to demonstrate mobility. They need to absorb shock in order to propel, and the requirement of reaction in order to effectively act. Movement is not an isolated event that occurs in one plane of motion. Rather, it is a complex event that involves synergists, stabilizes, and antagonists all working together to reproduce efficient triplanar movements. Pronation and supination occur at all joints and in all planes of motions within the locomotor system from the foot through the knee to the hip into the trunk. Pronation is dominated by deceleration muscle function. Supination is dominated by acceleration muscle function.

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Deceleration of muscle function as seen in pronation is termed eccentric muscle function, a lengthening muscle contraction. Acceleration muscle function that is seen during supination is concentric muscle function, this is a shortening of the muscle length to produce power. At some point there has to be a situation where both are occurring at the same time or a transformation. You may have deceleration occurring at one joint or joints e.g. when your foot hits the ground in running, and at the same time a joint or joints will exhibit acceleration of movement, or supination, to create a solid base on which to propel you forward. Imagine watching a runner, when his leading foot hits the ground, there is a general crumpling up of that side in order to shock absorb and control deceleration. Once he gets to pushing off on his other leg to complete his stride, the propulsive leg needs to stiffens up to accelerate leg and body movement to keep propelling him forwards. This chain of events does not just occur at the foot or just the knee but as a chain of events reaching right up to the upper body.

Movements

Movements and their effects like pronation/supination must be viewed more as whole body movements, which occur through the body. They are also triplanar i.e. occur in all three planes of movement. Triplanar movements are in the, sagittal (forward/backwards), frontal (sideways), transverse (rotation) planes. All our joints demonstrate triplanar movement. Some joints demonstrate better movement than others in certain planes e.g. the knee is great in the sagittal plane (flexion/extension) but will have a small amount of frontal plane movement (sidebending) and a bit more transverse plane movement (rotation). The hip moves well in all three planes, it has good flex/ext, good rotation (transverse plane) and good frontal plane movement in its range of abduction/adduction. To avoid injury to the hip and surrounding tissues it has to work efficiently in all three lanes of movement. Failure to do this will cause muscle imbalances leading to injury. Muscle imbalances develop due to:

Force Reduction – Pronation	Force Production – Supination
Eccentric	Concentric
Deceleration	Acceleration
Reacting	Acting

Associated Common Injuries

What common injuries are caused by poorly controlled pronation? An example is Achilles Tendinitis. This injury is often associated with the athlete suddenly increasing his training load, or with over pronating feet and associated poor footwear. This is certainly so and can influence the Achilles on their own. What about the cases that do not respond to treatment? The poor runner is still suffering, something must be wrong in the kinetic chain of events. Take a close look at Gluteus Maximus, its isolated function is to extend the hip and externally rotate the hip (femur). However its integrated function when actually involved in movement is to:

- Decelerate hip flexion and internal rotation (acts like a break controlling pronation)
- Decelerates tibial internal rotation via its insertion into the ITB
- Concentrically accelerates hip extension and external rotation to extend the hip, knee, and ankle.

If gluteus maximus is weak, as often seen in office workers and drivers, it can't control lower extremity pronation effectively. This puts increased strain on the calf muscles. The gastrocnemius and soleus both eccentrically control pronation at the tibia (knee joint) and ankle joint. The calf becomes overloaded and can no longer control this motion. This causes the

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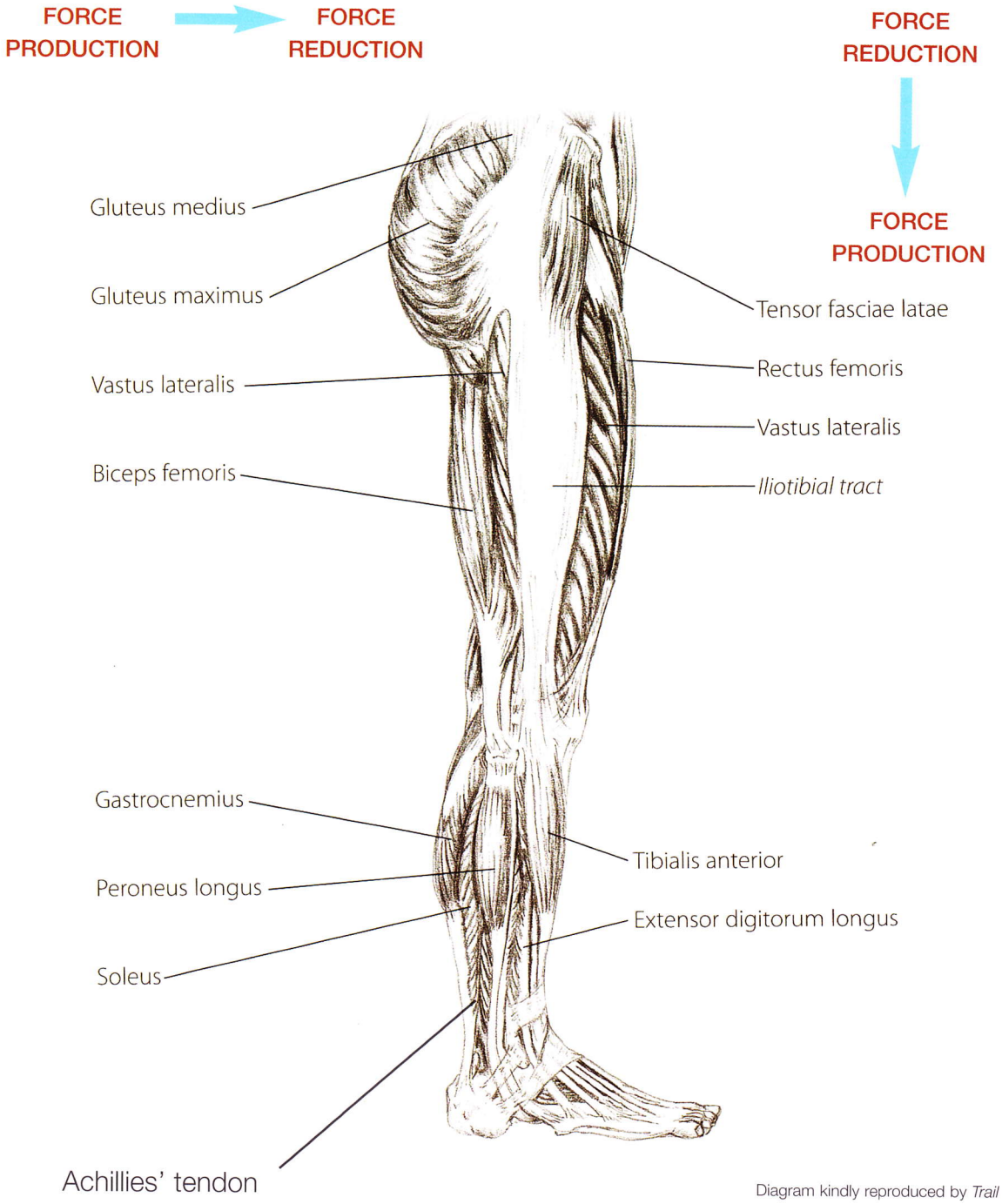
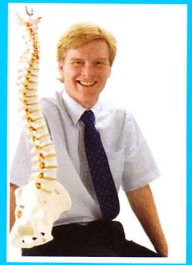


Diagram kindly reproduced by *Trail Guide to the Body*

lower leg to remain in a pronated state for a fraction of a second too long, causing stress to the Achilles tendon leading to tissue overload and a tendinitis. When you next see a patient with Achilles tendinitis and they have had it for ages or it keeps coming back, then consider this as a possible aetiology.



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