Best foot forward

HOW TO HONE YOUR RUNNING FORM

Dr Thomas Michaud discusses how a few simple changes to your running form can improve speed and efficiency – and may even reduce your risk of injury.

Given the popularity of running, it's surprising how much controversy exists over which style of running is best for improving performance. Some coaches advocate that all you need to do to achieve the ideal running form is to run with a cadence of 180 foot strikes per minute. In theory, this ideal cadence not only improves your running form but also reduces your overall risk of injury. The problem with this belief is that a universal cadence is achieved by altering stride length. More than 30 years ago, the renowned exercise physiologist Tim Anderson demonstrated that any adjustment in the length of the runner's self-selected running stride produces an immediate decrease in running efficiency[1]. On top of that, the world's best runners have huge fluctuations in cadence, with some runners averaging 145 foot strikes per minute and others averaging 210. Clearly, if cadence was an important factor in running economy, there wouldn't be so much variation in cadence among elites.

Perhaps the most pervasive belief regarding options to improve running form is whether runners should universally avoid heel striking by making initial ground contact with the mid or forefoot. Proponents of the more forward contact point suggest that a midfoot strike pattern is "more natural" because experienced lifelong barefoot runners immediately switch from heel to midfoot strike patterns when transitioning from walking to running. The switch to a more forward contact point is theorised to improve shock absorption (lessening our potential for injury) and enhance the storage and return of energy in our tendons (making us faster and more efficient). Advocates of Chi and Pose Running have gone so far as to say that runners who continue to strike the ground with their heels are reducing running efficiency and increasing their potential for injury.

> "Simply positioning your leg in a near vertical position at initial touchdown could improve both economy and performance"

In a recent literature review evaluating the pros and cons of the various foot contact points, Joe Hamill and Allison Gruber[2] looked at every published paper addressing the controversy and came to the adamant conclusion that "changing to a mid- or forefoot strike pattern does not improve running economy, does not eliminate an impact at the foot-ground contact, and does not reduce the risk of running-related injuries."

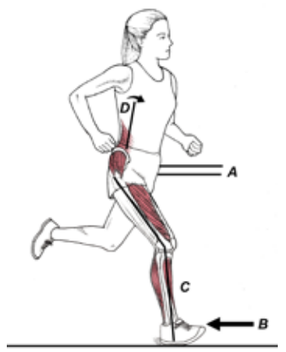
In my opinion, the controversy regarding ideal running form was finally resolved in 2017 when researchers from the United Kingdom evaluated 97 experienced distance runners (47 females) to determine exactly which biomechanical factors are associated with improved running economy and which factors relate to performance[3]. To evaluate economy, the authors analysed a range of respiratory gases and the velocity of lactate turn point (a marker of fatigue). The correlation between running performance and running form was determined by measuring three-dimensional motion of the spine, pelvis and lower extremities during all phases of gait and analysing which specific movement patterns correlated with each runner's season's best running time. The authors looked at stride length normalised to height, cadence, vertical oscillation of the pelvis, braking forces, posture and the position of the hip, knee and foot during different phases of the running cycle.

Surprisingly, even though all participants were experienced distance runners, including 29 elite runners, there was huge variation in all aspects of running form. For example, vertical oscillation of the pelvis varied two-fold and braking forces differed by 280%. Cadence ranged from 144-222 foot strikes per minute, while stride length was between 1.04 and 1.49 times the runner's height. Runners also showed significant differences in the positions of their feet, legs and hips at touchdown. Some runners made initial ground contact with their foot pointing down 11°, while others hit the ground with their foot pointing up 24°. The position of their lower legs varied from 1° to 16° relative to vertical, and the forward lean of the trunk varied by 20°.

After analysing all the data, the authors determined that the most economical runners had less up and down motion of the pelvis, lower braking force, stiffer knees, shorter stride lengths and a more vertical leg during initial ground contact. Running performance was predicted by lower braking forces, a more vertical leg during contact, reduced spinal motion and reduced ground contact times. The best part of this study was the conclusion that simply positioning your leg in a near vertical position at initial touchdown could improve both economy and performance. In fact, having a nearly vertical leg at touchdown explained 10% of a runner's performance and it is one of the easiest changes in running form you can make. Figure 1 summarises the various joint interactions associated with improved performance and efficiency. The authors point out that their study provides "novel and robust evidence" that running form strongly influences running economy and performance.

Figure 1:

Biomechanical measurements associated with improved performance and efficiency



Folland et al[3] prove the most economical runners presented with reduced vertical oscillation of the pelvis **(A),** lower braking forces **(B),** shorter stride lengths, and a more vertical leg during initial ground contact **(C).** Runners with the fastest running times presented with decreased braking forces, shorter ground contact times, a more vertical leg at initial contact **(C)** and a reduced range of spinal motion **(D).** Excessive vertical oscillation of the pelvis and a more vertical leg at touchdown most strongly correlated with both improved economy and faster running times.

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> Jump rope training allowed the runners to spend less time on the ground, as the tendons of their legs and arches learned to more effectively store and return energy

The best drills and exercises for improved performance

While you can easily adjust the position of your leg and reduce motion of your pelvis with minimal practice, the ability to reduce ground contact time is a little more complicated and can typically only be achieved by performing plyometric running drills. These drills improve the storage and return of energy in your tendons, which in turn allows you to spend less time on the ground as you more effectively propel forward. My favourite plyometric drills are illustrated in Figure 2. One study showed a 5% improvement in VO^2max and a 3% improvement in 3km race performance after just six weeks of training[4].

An alternative but more complicated method for reducing ground contact times in improving efficiency is to perform a series of six, 10-second strides while wearing a weighted vest (fitted with 20% of the runner's bodyweight). Researchers from New Zealand[5] showed that, compared to a control group, runners who performed the drills while wearing the weighted vests had huge improvements in peak running speed and economy. Apparently, the weighted vests allowed for faster running times and improved efficiency because the vests forced the runners to stiffen their knees and hips in order to absorb forces associated with carrying the added weight, which in turn reduced the amount of time they spent on the ground. The improved form persisted even after the weights were no longer worn. I really like this study, as the added weight allows your central nervous system to analyse impact forces at the point of contact and modify limb position and stiffness accordingly. For example, if you had excessive up and down oscillation of the centre of mass and/or were overstriding, you might not notice this if you're strong and healthy but the amplified impact force associated with wearing the weighted vest would make it more obvious. My only concern is that the weighted vests used in this study were pretty heavy, which could increase the risk of injury. Less fit or inexperienced runners should definitely start out with lighter weights and gradually increase the load based on comfort.

Runners who don't want to play around with weighted vests can also increase efficiency by adding a jump rope routine to their weekly workouts. One recent paper showed that swapping out a conventional warm-up routine with five minutes of jump rope training a few times per week resulted in significant improvements in 3km time-trial performance[6]. The jump rope training more than likely allowed the runners to spend less time on the ground, as the tendons of their legs and arches learned to more effectively store and return energy.

Lastly, because isometric contractions performed with muscles maintained in their lengthened positions have been proven to improve tendon resiliency[7], I've outlined a few simple exercises that you can do in five minutes or fewer to keep your muscles and tendons strong and supple (Figure 3). Whether you run a marathon in two or six hours, these exercises can help improve performance and can also serve to reduce your risk of injury.

Figure 2: Dynamic stretching drills

Gluteals	While walking, lift knee toward chest, raising the body on the toes of the opposite leg.	
Hamstrings	Walk while swinging your leg forward until a stretch is felt in your hamstrings. Keep your toes pointing towards your knee.	
Abductors	While moving forward, raise the trail leg by abducting the hip 90º, while keeping the knee flexed. Move as though you were stepping over an object just below waist height.	
Gastrocnemius	Tip-toe walking. Move forward while alternating walking on tiptoes. The aim is to raise your body as high as possible with each step.	
Quadriceps	Rapidly kick heels towards buttocks while moving forward.	
Abductors	Quickly move sidewards alternating one leg in front of the other. Go 15 yards and repeat in opposite direction.	

This figure has been modified from Figure 4.5 in Turki O, Chaouachi D, Behm D *et al* (2012), The effect of warm-ups incorporating different volumes of dynamic stretching on 10- and 20m sprint performance in highly trained male athletes, *J Strength Cond.* 26: 63-71.

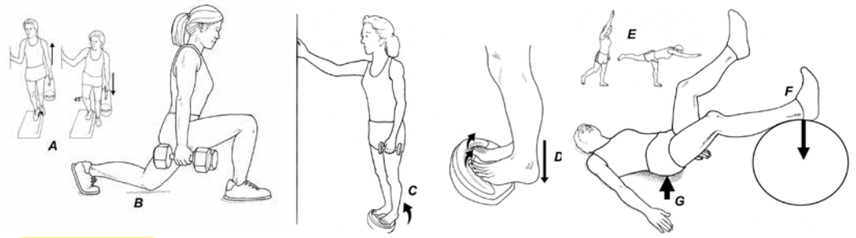

Figure 3: The best exercises to improve tendon resiliency

■ To improve resiliency in your glutes and quad tendons, warm up with 25 lateral step-ups (A). Next, move into a long-step forward lunge position and hold this position with your back knee held slightly off the ground (B). This exercise places less stress on your knee than conventional lunges (20) and, in addition to placing the glutes and quads in their lengthened positions in the forward leg, the rectus femoris is isometrically tensed in a lengthened position in the back leg. Maintain this position for 20 seconds and repeat four times. A resilient rectus femoris tendon is essential for fast running, as it snaps the trail leg forward to initiate the swing phase.

■ Your Achilles' and calf tendons can be made more resilient with the ToePro platform. Warm up by doing 25 repetitions (C) and then slowly lower your heels so they are 1cm from the ground (D). Hold this position isometrically for 20 seconds and repeat that routine four times. With each set, alternate between raising and lowering your arch to isolate different tendons: your peroneals are lengthened when your weight is on the outside of your foot, while your tibialis posterior tendon is lengthened when your foot is rolled inward. If you don't want to use a ToePro, you can do this exercise by leaning forward into a wall while standing on an AirEx balance pad. With all of these exercises, you need to be fatigued when you finish, so stronger runners may need to wear a weighted backpack or hold a dumbbell.

■ The most effective exercise to improve resilience in the glutes and hamstrings is the single-leg push down. Before performing this exercise, warm up with a standing windmill exercise (E). After you've warmed up, lie face up on the floor with your arms out for stability, then place your foot on a physio ball or workout bench and push down with your heel (F) with enough force to raise the pelvis off the ground (G). Try to duplicate the position your hip is in during initial contact, which is typically between 20 and 30° of flexion. Hold this position for 20 seconds and repeat four times on each leg. If this exercise is too difficult, bring the opposite knee towards the chest. Conversely, if you're not fatigued after 20 seconds, straighten the opposite leg so it is closer to the leg that is pushing down, which makes the exercise significantly more difficult. This exercise duplicates the position your foot is in just before initial ground contact and markedly strengthens the hamstring tendons, which are important for both shock absorption and storing and returning energy.

DR MICHAUD graduated from chiropractic college in the early 80s. In 1993, his first textbook, *Foot Orthoses and Other Forms of Conservative Foot Care*, was translated into four languages. *Human Locomotion* was published in 2012 and is used in physical therapy, chiropractic, pedorthic and podiatry schools around the world. He recently completed a second edition of *Injury-Free Running: Your Illustrated Guide to Biomechanics, Gait Analysis, and Injury Prevention*. This article was reprinted from a portion of this book.

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