The *Human Locomotion Achilles Strap*: A Smarter Alternative to Static Stretching

By Tom Michaud, DC

For decades, injured athletes have spent countless hours aggressively stretching their Achilles tendons with the misguided belief that a more flexible calf is less prone to reinjury and more resilient when playing sports. Recent research shows that this is not the case. A growing body of literature is showing that following injury, our Achilles tendons actually become overly flexible as microscopic tears between tendon fibers produce a progressive loosening of the tendon, which researchers refer to as increased tendon compliance (Fig. 1).

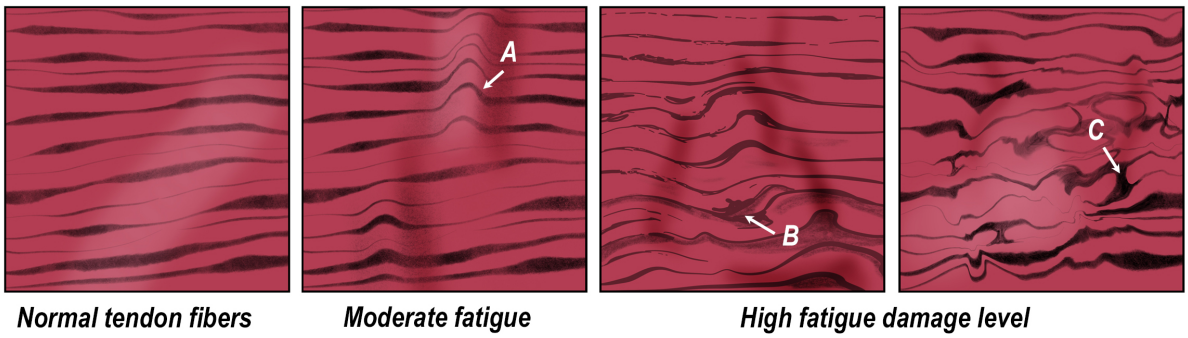

Fig. 1. Microstructural changes associated with increasing tensile loads in tendons stained with Fuchsin. Notice that at a moderate intensity of tendon strain, some fibers begin to kink (**A**). Microstructural changes at high fatigue damage level consists of dissociation among fibers (**B**), fiber discontinuities and eventual fiber rupture (**C**). Tendon compliance increases because the damaged and ruptured fibers are no longer able to resist tensile loads, which in turn causes the tendon to lengthen. *Redrawn from photographs in reference 13.*

Unfortunately, even a slight increase in tendon compliance can be problematic as it forces the gastrocnemius and soleus muscles to function in a shortened position, as they tighten to take up the slack associated with the overly flexible tendon. As is consistent with the length/tension relationship in muscles, muscles that are forced to operate in a shortened position become significantly weaker, as their muscle filaments overlap each other, reducing their ability to generate force (Fig. 2). Obviously, attempting to increase flexibility in an already overly compliant tendon with stretching would just worsen the strength deficits in gastrocnemius and soleus.

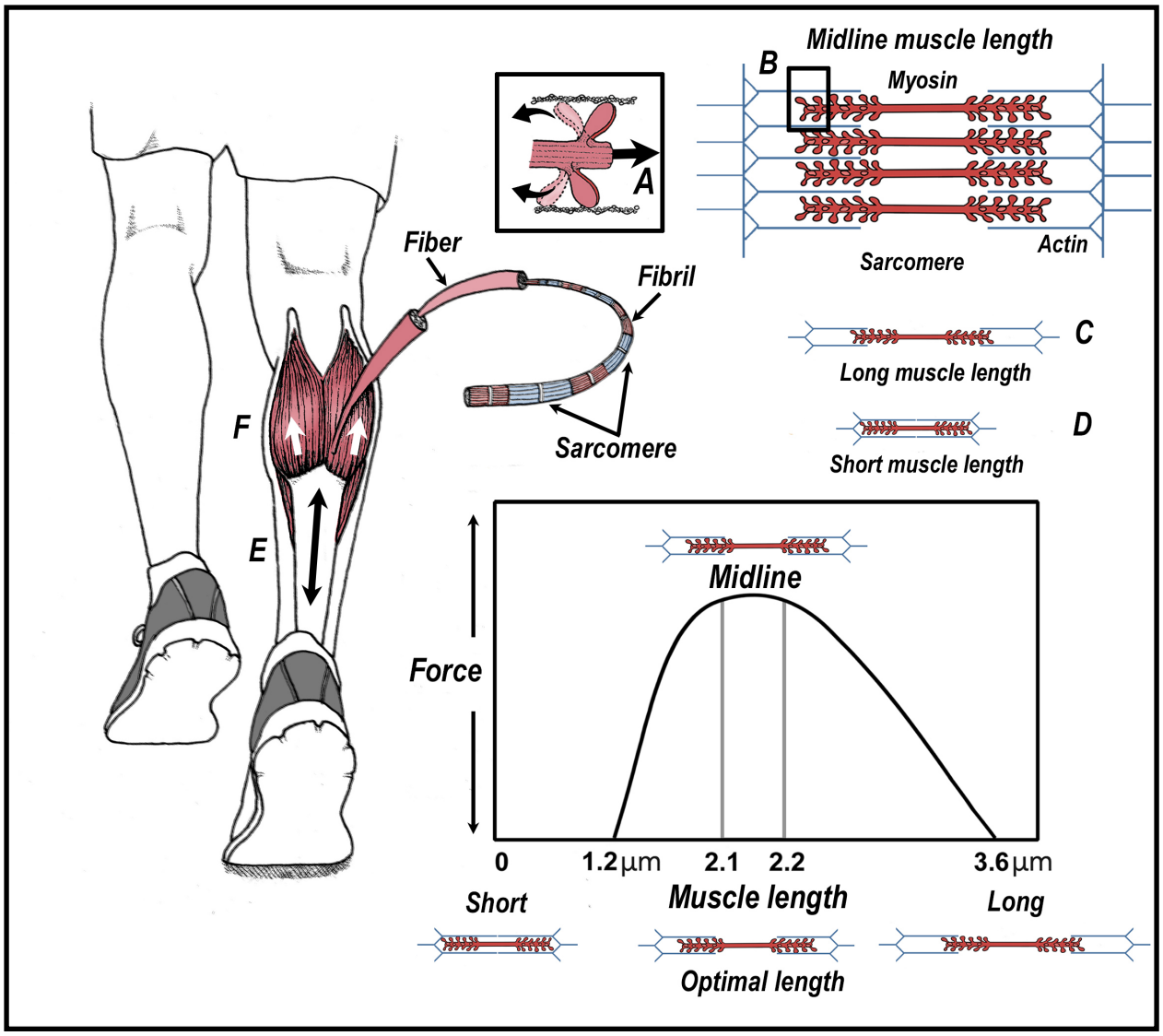

Fig. 2. The length/tension relationship in muscles. The basic contractile component of a muscle is called the sarcomere, and it is comprised of actin and myosin subunits that glide upon each other when stimulated by a nerve (**A** in top box). When a muscle is in a midline position, the majority of actin and myosin filaments overlap perfectly, allowing the muscle to create the greatest amount of contractile force as the maximum number of actin and myosin filaments are in full contact (**B**). Conversely, when a muscle is fully stretched (**C**) or shortened (**D**), there is reduced contact between the actin and myosin filaments, which greatly limits the amount of force a muscle can generate (**graph**). When a tendon is abnormally compliant (**E**), the calf muscles are placed in a shortened position (**F**), which significantly limits force output from the calf muscles.

In addition to injury, a major factor that causes a gradual loosening of the Achilles tendon is age. As we get older, our Achilles tendon fibers become smaller, and the Achilles tendon becomes gradually looser. By the time we are in our 30s and 40s, the age-related loosening of the Achilles tendon results in a significant reduction in force output from the calf muscles that decreases our ability to run fast. Paquette et al. (1) recently compared force output in all joints of young and middle-aged runners and determined that the older runners slow down not because of decreased

force output in their hips or knees, which remained unchanged, but because of isolated weakness in the calf muscles. This isolated weakness can only be explained by the fact that overly compliant Achilles tendons force the calf muscles to work in their shortened positions, making it impossible for them to generate adequate force output. The compliance-related decreased force output from the calf muscles gets worse as we get older. According to Gray et al. (2), people over the age of 70 have 44% less Achilles tendon stiffness than younger adults, which causes a 17% higher net metabolic power while walking. The authors state that in order to prevent age-related decreases in walking and running performance, research is needed to determine which interventions effectively tighten overly compliant Achilles tendons. The same is true following tendon injury: rather than focusing on increasing calf flexibility, which would just worsen the problems associated with exaggerated tendon compliance, exercise interventions should be performed that increase tendon stiffness.

It turns out there has been a significant amount of research showing that the easiest way to tighten injured and/or aging tendons is to perform heavy-resistance prolonged isometric contractions (3,4). Isometric contractions can even improve metabolic efficiency while running. Albrecht et al. (5) recently had 17 runners perform a simple intervention in which they sat with their hips flexed 40°, their knees extended, and their ankle positioned in 5° of dorsiflexion. In this position, the runners were told to do five sets of four near full effort isometric calf contractions, in which they spent three seconds building to peak force and then three seconds relaxing after each contraction. This exercise was done on both legs, four times per week, for 14 weeks (Fig. 3). At the end of the study, compared to a control group, the group performing isometric contractions had a remarkable 16% increase in Achilles tendon stiffness, which resulted in a 4% reduction in the rate of oxygen consumption while running.

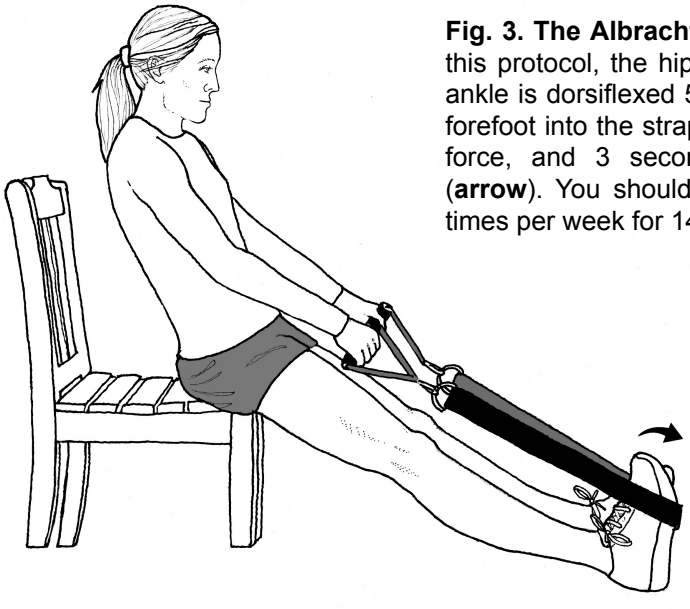

Fig. 3. The Albracht protocol to increase tendon strength. In this protocol, the hip is flexed 40°, the knee is straight, and the ankle is dorsiflexed 5°. While holding the strap firmly, push your forefoot into the strap, spending 3 seconds building to near peak force, and 3 seconds gradually decreasing from this force (**arrow**). You should do 5 sets of 4 repetitions on each leg, 4 times per week for 14 weeks.

Note that this 4% improvement in running economy is equal to or greater than the improved running economy associated with wearing the new carbon-plated running super shoes, which can take 4-6 minutes off of a 3-hour marathon (6). Albrecht et al. (5) relate the improved metabolic efficiency directly to the fact that the isometric contractions stiffen the Achilles tendon, which allow the calf muscles to work in their metabolically efficient midline positions. While this study evaluated the effect on younger athletes, this exercise routine is also a very effective way to improve tendon health and walking efficiency in older adults. Several studies have shown that prolonged isometric contractions, especially when performed with the tendon in a lengthened position, can increase tendon stiffness by as much as 50% (7).

In addition to using the exercise strap for performing isometric contractions, the *Achilles Strap* can also be used as a warm-up prior to sports participation. Anthony Kay et al. (8) describe an effective protocol in which you place the strap around your forefoot and perform a 5-second isometric contraction by pushing into the strap with light force while your ankle is kept in a midline position. This is immediately followed by a 10-second end-range stretch. The contraction followed by a stretch is repeated three more times (Fig. 4).

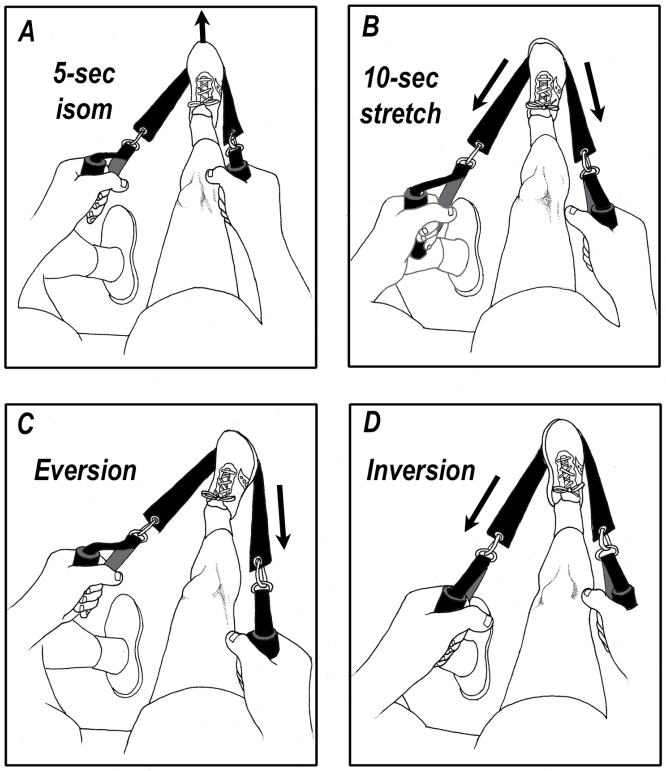

Fig. 4. Neutral position stretching. Place your ankle at a 90° angle to your leg and isometrically tense your calf with light resistance for 5 seconds (**A**). Follow the 5-second contraction with a 10-second stretch by pulling with your hands (**B**). Repeat this 2 times and do your next 5-second isometric contraction with the foot slightly everted (**C**). Follow the contraction with a 10-second stretch keeping the foot everted (**arrow**). Lastly, perform a 5-second isometric contraction with the ankle inverted and finish by stretching in this position for an additional 10 seconds (**D**). According to Bojsen-Moeller, inverting/everting the foot increases tensile strain on different portions of the Achilles tendon by as much as 15% (14). This entire warm-up takes about 60 seconds on each leg.

Kay et al. (8) prove that this simple routine produces an immediate increase in elastic potential energy storage of up to 24%, which has the potential to both improve performance and reduce injuries to the muscle-tendon junction. The authors note that compared to standard muscle energy stretches, isometrically contracting a muscle while it is in a midline position is safer, produces less discomfort, and represents a "practical stretching paradigm to support athletic and clinical exercise prescription."

Warming up with the *Achilles Strap* is particularly important when treating someone with a painful Achilles tendon. As demonstrated by Rio et al. (9), a painful tendon causes the central nervous system to decrease motor drive to the tendon, causing muscle weakness and impaired performance during sport. These authors demonstrate that performing 5, 45-second isometric contractions at 70% full effort results in an immediate and significant reduction in pain that lasts for a minimum of 45 minutes. When compared to a general warm up with isotonic contractions, the isometric contractions produced a 6.8/10 reduction in pain scores compared to a 2.6/10 reduction in pain following conventional isotonic exercises. The isometric exercises also improved neural drive to the muscles, resulting in a nearly 19% increase in muscle strength. Rio et al. (9) emphasize that in addition to the improved performance associated with increased force output, the repeat isometric contractions can allow athletes to manage their pain before and after sports participation, decreasing the need for pharmacological interventions for pain management, which can have significant side effects.

Because the strap is small and lightweight, you can carry it in your gym bag and do a few isometric contractions and/or neutral position stretches immediately before your sport. The handgrips on the strap are reinforced and can tolerate over 100 pounds of force in each hand, making them perfect for high-effort isometric contractions. The Achilles strap is particularly effective when done in conjunction with the advanced ToePro workout, which in addition to strengthening the Achilles tendon, also strengthens important synergists to the Achilles tendon, such as flexor hallucis longus and peroneus longus. Several studies have shown that these powerful muscles can distribute stress away from the Achilles tendon and improve agility and overall athletic performance (10-12). It is possible to measure improved performance associated with these treatment interventions by simply measuring 50 meter sprint times, 5K running times, and/or horizontal jump performance. Most people notice measurable improvement within the first 6-8 weeks of treatment.

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