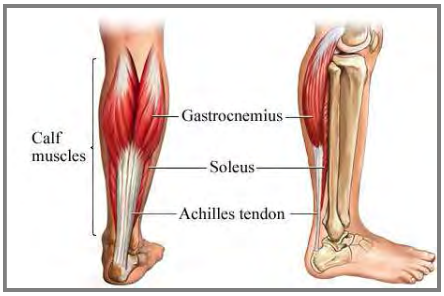
ACHILLES TENDINOSIS ('ACHILLES TENDINITIS')

DEFINITION

Achilles tendinosis, more commonly referred to as 'Achilles tendinitis', is an overuse injury to the Achilles tendon, the thickest and strongest tendon in the human body, which attaches the calf muscle (gastrocnemius and soleus) to the heel bone (calcaneus) (see image #1). Pain is typically experienced either at the attachment point (insertion) at the back of the heel, or in the mid-portion of the tendon (approximately 1.5 inches above the heel). The Achilles tendon does not have good blood supply, so the injury can be slow to heal (Ahmed et al, 1998).



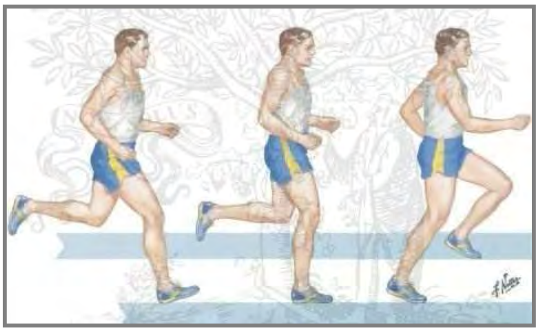
1. Source: How to Run Free

The term 'tendinosis' more accurately describes this injury, because it has been demonstrated that tendon degeneration exists without clinical or histological signs of an inflammatory response (Astrom and Rausing, 1995). Khan et al (1999) stated that inflammation has been shown to be infrequent, and when found, is almost always associated with partial tendon ruptures, but not in overuse tendinopathies. This finding has important implications for the treatment of overuse tendon injuries, as common treatment modalities for inflammatory conditions will not apply (e.g. non-steroidal anti-inflammatory drugs (NSAIDs) or corticosteroids), and could even have deleterious consequences. For example, the analgesic effect of NSAIDs could result in patients ignoring early symptoms, which could result in further tendon damage, and a delay in healing, while corticosteroid injection into tendon tissue can lead to cell death and tendon atrophy (Khan et al, 1999).

Achilles tendinosis usually develops after sudden changes in weight-bearing activity or training level, use of inappropriate footwear (e.g. inadequate heel cushioning), or training on uneven or hard surfaces, especially if other risk factors such as tight calf muscles or over-pronation are present. As people age, tendons become less flexible, and therefore more susceptible to injury. Therefore, middle-age recreational athletes are most susceptible to Achilles tendinosis.

FUNCTION

In addition to its role in transmitting forces from the calf muscles to the foot during propulsion, the Achilles also functions eccentrically (i.e. lengthens under tension), to decelerate, or brake, the downward movement of the body between foot strike and mid-stance (see image #2). The load on the Achilles tendon during eccentric contractions can be considerably higher than that which occurs during concentric contractions, as a result of this braking mechanism, especially with activities that require jumping and rapid change of direction. Barr and Harrast (2005) reported that ground reaction forces between 3 and 4 times body weight have been measured during distance running, while the force on the Achilles tendon can be close to twice that value (Maffulli et al, 2003), due to the biomechanics of the joint forces involved. The elastic nature of the Achilles tendon allows for storage of mechanical energy during the eccentric contraction, with subsequent release of this energy during the concentric propulsive phase, thereby improving



2. Source: Netter images

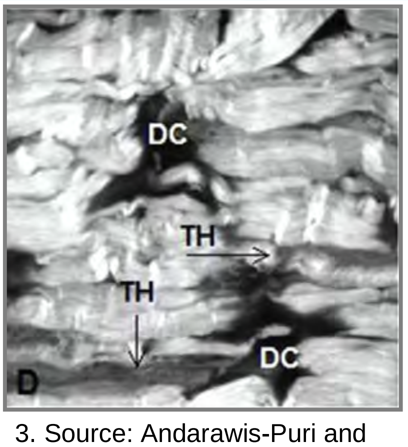
mechanical efficiency (Fukashiro et al., 1995; Komi, 2000). Tendon stiffness has been shown to increase in response to prolonged eccentric loading (i.e. additional resistance placed on the muscle/tendon unit during the eccentric contraction, in a controlled manner, that increases in magnitude in a progressive fashion over time), which results in an improved ability of the tendon to absorb energy during the eccentric lengthening contraction (Reich et al, 2000; Lindstedt et al, 2001), thereby enhancing efficiency and performance.

INCIDENCE OF INJURY

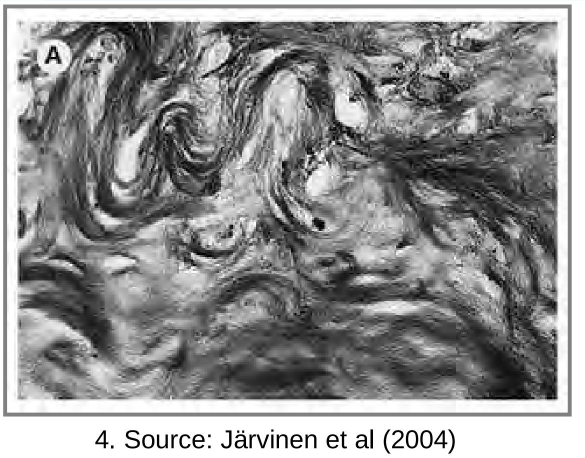
Achilles tendinosis is common in “weekend warriors” (i.e. those who are less conditioned and participate in athletics only on weekends or infrequently). Sports that require a lot of running, jumping and change of direction, such as long-distance running, football, basketball and tennis, have the greatest prevalence of Achilles injuries. The majority of Achilles tendon overuse injuries occur in men, and they occur at a higher rate in middle-aged athletes than do most other overuse injuries (Alfredson et al, 1998). It is estimated that Achilles tendinosis accounts for approximately 11% of all running injuries, and undue strain results in over 230,000 Achilles tendon injuries per year in the U.S. alone (Noto, 2011).

MECHANISM OF INJURY

LaStayo et al (2003) reported that chronic tendon disorders often result from intensive repetitive activities, which are predominantly eccentric in nature, due to their role in deceleration (braking). Due to higher-than-normal eccentric muscle forces transmitted via the tendon, the ability of the tendon to repair itself becomes impaired and the tendon deteriorates. If the magnitude and frequency of the loading is high enough, fatigue can manifest in the tendon, causing a reduction in the failure force threshold to a level below that which it is exposed to, resulting in micro-tears and fiber degeneration within the tendon (see image #3) (Andarawis-Puri and Flatow, 2011). Micro-tears within the tendon can weaken the structural integrity of the tissue and increase the chance of further injury. As part of the healing process, new collagen fibers are laid down to repair the damaged fibers. If the tissue is stressed during this repair process (e.g. a person resumes the same activity before full recovery), the new collagen fibers become damaged, causing the new collagen to grow in a disorganized, random fashion (see image #4), effectively forming scar tissue (Davies, 2011).



3. Source: Andarawis-Puri and Flatow (2011)



4. Source: Järvinen et al (2004)

A consequence of scar tissue is inflexibility. As a result, whenever tension is placed on the scar tissue, such as during walking or running, there is very little stretching of the tissue that can take place, resulting in restricted range of motion and pain. There is also a greater risk of tearing, due to the increased stress that is placed on the tendon injury site. Uncontrolled eccentric exercise (e.g. running, climbing) can do more damage (i.e. tearing), which causes more disordered collagen (i.e. scar tissue) to build up, magnifying the problem (Davies, 2011).

CONTRIBUTORY RISK FACTORS

- Sudden increases in training volume or intensity (which may include an intense return to training after an absence or a layoff) (Kvist, 1991; Kvist, 1994; Järvinen et al., 2001; Järvinen et al., 2005);
- Overuse (Jozsa, et al. 1997);
- Lack of stretching prior to activity (Note: warm-up activities have been found to have no effect on Achilles tendon compliance, but are beneficial for performance-enhancing effects) (Rosenbaum and Hennig, 1995);
- Decreased calf muscle flexibility, strength, and muscular endurance (Lorentzon, 1998);
- Over-pronation (Clement et al, 1984; Nigg, 2001; Ryan et al, 2009);
- Decreased intrinsic foot (toe flexor) muscle strength or muscular endurance, which can help to reduce or prevent over-pronation (Headlee et al, 2008);
- Decreased ankle dorsiflexion range of motion (Kaufman et al, 1999);
- Increased hamstring tightness (Pribut, 2012);
- Flat feet or high-arched feet (Kaufman et al, 1999);
- Leg-length discrepancy (Kannus, 1997);
- Running on hard, slippery, or uneven training surfaces (James, et al. 1978);
- Sudden addition of hill training and speed work (Pribut, 2012);
- Excessive hill running (Pribut, 2012);
- Inadequate heel cushioning in shoes (Maclellan and Vyvyan, 1981);
- Excessive heel cushioning (e.g. air-cushioned heels) (Pribut, 2012);
- Inflexible shoes (Pribut, 2012);
- Prolonged walking in high-heeled shoes (heels that are 2” in height or greater), which can result in shortening of the calf muscle and increased tightness in the Achilles tendon (Csapo et al, 2010).

PREVENTION

Increase running distance and speed gradually. Ensure that increments in distance or speed are no greater than 10% per week.

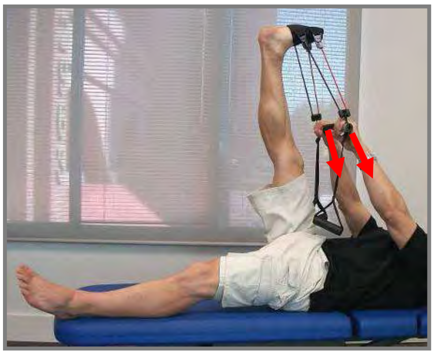
Reduce intensity of exercise after a lay-off. If the athlete is returning to training after a lay-off, start at a lower intensity level and gradually increase to allow their muscles and tendons a chance to adapt.

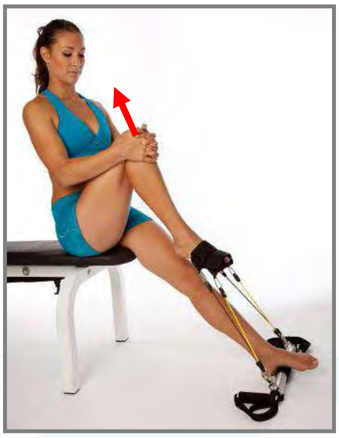
Ensure adequate rest and recovery. After an intense exercise session involving the lower leg muscles, allow at least 48 hours recovery.

Warm up before stretching or exercising. Spend a minimum of ten minutes using a dynamic or sports-specific warm-up.

Stretch between warming up and exercising, and then again after exercising. Stretch the calf and toe flexor muscles (see image #4), hamstrings (see image #5), and ankle dorsiflexors (see image #6). Tightness in the hamstring can lead to increased stress on the Achilles tendon. Stretch gently and slowly. Hold each stretch for a minimum of 15 to 30 seconds, until a sense of muscle relaxation occurs.


4. Calf and toe flexor muscle stretch


5. Hamstrings stretch


6. Dorsiflexor stretch

Strengthen the calf muscles, the intrinsic muscles of the feet, and the ankle inverter muscles (see images #7 to #8). Include full range of motion exercise and eccentric loading, and increase the resistance consistently and gradually to optimally strengthen these muscles. Also strengthen the dorsiflexor muscles (see image #9) on the front of the shin so that the athlete has balanced strength between the plantar flexors and dorsiflexors.


7. Calf & intrinsic muscle strengthening


8. Ankle Inversion


9. Dorsiflexor strengthening

Reduce amount of training on uneven, sloped, or hard training surfaces. If the sport or activity is performed on an uneven, sloped, or hard surface, avoid training on these types of surfaces for extended periods of time to minimize the risk of muscle fatigue and potential injury.

Cross-train. Alternate high-impact activities, such as running and jumping, with low-impact activities, such as cycling and swimming, on a daily basis.

If the athlete is performing aerobic and strengthening exercises on the same day, do the aerobic exercises first. If leg strengthening exercises are done before aerobic activity, the Achilles tendons may end up taking up more of the load during the aerobic activity due to leg muscle fatigue, which will increase the risk of Achilles injury.

Wear appropriate dress shoes and sports shoes. Avoid wearing high-heeled shoes (heel height equal to or greater than 2 inches) and ensure that training shoes have a well-cushioned heel (avoid air cushioning) and good flexibility. In cases where flat feet or over-pronation cannot be corrected with foot and ankle strengthening, arch supports/orthotics or anti-pronation shoes may be required to reduce stress on the Achilles tendon. For those who run long-distance barefoot or in minimalist footwear, avoid landing on the forefoot on hard surfaces (e.g. concrete), as this will result in a significant impact force and large rotary force (torque) around the ankle joint, which must be resisted by the Achilles. This may result in early fatigue of the Achilles, and increased risk for injury. A mid-foot strike is recommended for these individuals, as the impact force will be more evenly distributed over the foot, and the torque around the ankle joint will be significantly reduced.

Do not ignore pain. If the athlete reports Achilles tendon pain while training, do not ignore it. The pain is an indication that damage has occurred, and appropriate treatment including rest is essential. Continued training and stress on the Achilles tendon could lead to further injury and, in some cases, may cause the tendon to rupture.

Eccentric Loading and Rehabilitation

Controlled and targeted eccentric exercise has been shown to be very effective in alleviating symptoms of tendinosis, restoring full functionality, and reducing risk of further injury (Jensen and Di Fabio, 1989; Alfredson et al, 1998; Cannell et al, 2001; Croisier et al, 2001, Silbernagel et al, 2001; Roos et al, 2004). In most cases, subjects who underwent eccentric loading recovered completely from their injuries, with little or no recurrence of injury.

According to Davies (2011), the physiological repair process is as follows:

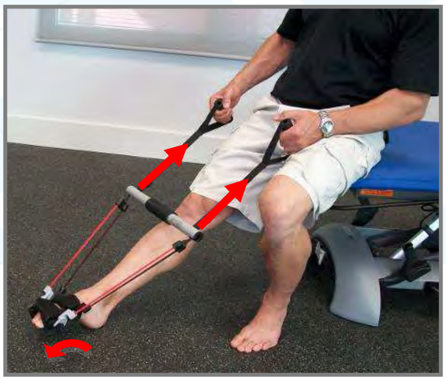
- A moderate amount of eccentric exercise (into moderate pain zone) breaks down the disordered collagen at the injury site;
- The body responds by increasing collagen synthesis and producing new fibers;
- If the new collagen fibers are laid down in the proper direction (i.e. in line with the original, healthy fibers), they will not break down when exposed to additional controlled eccentric exercise;
- Over time, as the controlled and targeted eccentric load increases, more and more disordered fibers are broken down and replaced with properly-ordered fibers, which regain their original parallel wavy pattern;
- Eventually, the tissue has been repaired enough to handle a return to high-level training;
- The failure force threshold of the tissue increases due to structural changes in the collagen fibers (e.g. increased density) (LaStayo, 2003), which can help to reduce the recurrence of injury.

Treatment Protocol – Eccentric Loading

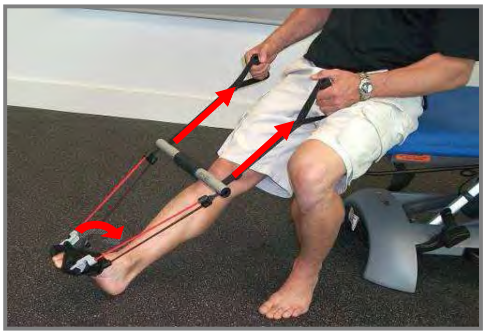
It is recommended that the initial stages of the treatment protocol be performed with user-controlled eccentric loading of the Achilles tendon without the addition of body weight, such as with the AFX, to prevent excessive loading and further damage to the tendon, which could occur in some individuals. The following exercise incorporates eccentric loading of the Achilles tendon and strengthening of the toe flexor muscles.

1. Choose a resistance level that will allow the athlete to perform the following exercise (see image #11) for at least 10 repetitions;
2. Stretch the calf muscle and Achilles tendon for a minimum of 15 to 30 seconds by pulling back on the handles and relaxing the muscles of the foot and lower leg (see image #10);
3. Perform full range of motion plantar flexion and toe flexion while pulling back slightly on the handles (see image #11);
4. Eccentrically load the Achilles tendon – have the athlete pull back more on the handles of the AFX as they dorsiflex at the ankle joint (i.e. move the foot back toward the shin), attempting to resist the movement with their foot (image #12);
5. Continue to resist the movement until the ankle is in full dorsiflexion (image #13);
6. Return to step 3 and continue with this cycle (steps 3 to 5) until the athlete has completed the prescribed number of repetitions (see Training Schedule below);
7. At the end of each set, have the athlete stretch the calf muscle and Achilles tendon for a minimum of 15 to 30 seconds by pulling back on the handles and relaxing the muscles of the foot and lower leg (see image #10).

10. Calf and Achilles tendon stretching



11. Plantar flexion and toe flexion



12. Pull back on the handles and resist the movement with your foot

13. Continue to resist movement until the ankle is in full dorsiflexion

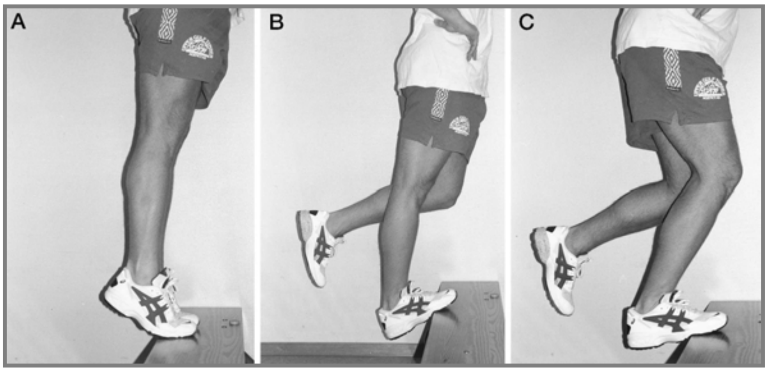
Guidelines and Precautions

- Perform eccentric loading slowly (4 to 6 seconds for each repetition);
- Initial increases in eccentric tension should be approximately 10 to 20% greater than concentric tension, followed by a gradual increase over time;
- Each session, attempt to increase eccentric resistance as tolerance to pain will allow;
- If excessive pain is experienced the day following exercise, reduce the intensity of eccentric resistance;
- Increase the resistance band level when 3 sets of 15 reps can be performed without pain;
- Avoid any repetitive or excessive loading of the Achilles tendon such as running, jumping, or climbing during this recovery program.

Training Schedule

Week 1	Week 2 and Onward
Day 1: one set of 10 reps for each foot that is affected	Day 1: 3 sets of 12 to 15 reps
Day 2: rest	Day 2: rest
Day 3: two sets of 10 reps	Day 3: 3 sets of 12 to 15 reps
Day 4: rest	Day 4: rest
Day 5: three sets of 10 reps	Day 5: 3 sets of 12 to 15 reps
Day 6: rest	Day 6: rest
Day 7: rest	Day 7: rest

Continue the program following the regimen listed for “week 2 and onward” until full rehabilitation has occurred (Note: research has shown that full rehabilitation of tendinosis injuries typically occurs within 6 to 12 weeks). If the patient is able to tolerate increased frequency of exercise without excessive pain the day following exercise therapy, daily training of 3 sets of 12 to 15 reps can be implemented. It is recommended that daily training does not occur until week 3 of the program. After progressing through the training program with the AFX, and it is felt that additional resistance is required, one-legged eccentric heel drops can be performed as illustrated in the images below (see image #14). This technique requires that the heel raise be performed using both feet (see image ‘A’), and then eccentric loading of one leg during the heel drop can be performed by placing the opposite leg free in the air (see image ‘B’). By flexing the knee of the exercising leg (see image ‘C’), the soleus muscle can be maximally activated, thereby increasing the tension on the Achilles tendon. To further increase the load on the Achilles tendon, a dumbbell can be held in one hand, or a weighted backpack can be used. Alternatively, a weight machine could be used to increase the load (see image #15).



14. Source: Alfredson et al (1998)

15. Source: Alfredson et al (1998)

How AFX Helps

- Very effective and easy-to-use stretching device - can help improve range of motion;
- Helps improve calf muscle flexibility, strength, and muscular endurance;
- Increases intrinsic foot (toe flexor) and ankle inverter muscle strength and muscular endurance, which can help to reduce or prevent over-pronation and improve arch support for individuals with flat feet;
- Increases ankle evertor muscle strength to reduce hindfoot inversion and associated high-arched feet;
- Helps increase ankle dorsiflexion range of motion;
- Helps decrease hamstring tightness;
- Eccentric loading can easily be performed for each movement of the foot and ankle, to optimize strength gains for injury prevention and performance enhancement, and to treat tendinosis injuries.

~ Rick Hall, M.Sc.

Rick is the Principal Scientist for Progressive Health Innovations, and co-inventor of the AFX. Rick has a M.Sc. in Biomechanics, and has conducted research in athletic performance enhancement, exercise physiology, and injury prevention for over 20 years. He is a member of the International Foot and Ankle Biomechanics Community, and is also a reviewer for the Journal of Biomechanics.

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IMAGES

1. Achilles tendon. Available from: http://howtorunfree.com/category/injury-prevention

2. Running phases. Available from: http://www.netterimages.com/image/12790.htm