# Tendon Injuries

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Tendon injury is a common affliction with resistance trainees, ranging from tendinosis to spontaneous rupture. Typical causes include cumulative microtrauma, and forces that exceed soft tissue integrity. This article will explore why these mishaps occur, and provide rehabilitative requirements for reinstating full functional capacity in such an event.

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### Anatomical Structure and Architecture

Tendons consist of fibrous connective tissue that connect muscle and bone, which transmit force generated by the muscle, thereby producing joint movement or torque. The contact area between muscle and tendon is called the myotendinous junction (MTJ). The contact area between tendon and bone is called the osteotendinous junction (OTJ). The OTJ is somewhat elastic to resist compressive and shear forces, yet rigid enough to provide tensile strength. The architecture of the MTJ resembles finger-like processes).

Folding of the tissues at the MTJ considerably increases the contact area between the muscle and tendon fibers, which essentially reduces the applied force per surface unit of the MTJ during muscle contraction. The contact surface of the MTJ is about 35% larger in the more powerful fast-twitch fibers, than in slow-twitch fibers. This arrangement permits more intense contractions generated by fast-twitch fibers, without increasing the force applied to the surface unit of the MTJ. When a healthy musculotendinous unit stretches, agitation seldom occurs in the midsubstance of the tendon but rather in the MTJ, the OTJ or in the muscle belly. Also, it is the MTJ that is the weakest zone in the muscle-tendon unit, making it vulnerable to injury

Tendon strength surpasses bone strength, with its capacity governed by its thickness and collagen content - not maximum tension its associated muscle can generate. The greater the cross-sectional contact area of muscle and tendon, the heavier the loads that can be applied prior to tissue failure; and the longer the tendon tissue fibers, the greater the fiber elongation before failure. A short tendon is not as strong as a long tendon, since it absorbs less total energy than a long tendon, although its energy-absorbing capacity per unit volume is higher than that of a long tendon.

At rest, tendon fibers exhibit a wavy formation. This formation disappears when under tension, resulting in straightened tissue. When tension abates, the tendon resumes a wavy appearance.

### Causes of Tendon Injury

Tendons are most at risk of injury when: 1) force is generated by the muscles as it is being stretched during eccentric movement - i.e., depth jumps; 2) when force is applied quickly and obliquely - i.e., dropping quickly to the bottom position of dumbbell pec flyes; 3) if the tendon tenses before injury, resulting in reduced elasticity - i.e., bracing yourself before a fall; 4) if the tendon is weak in comparison to its muscle - i.e., steroid use; 5) if the muscle group is violently stretched, or overstretched, by external stimuli or forces - i.e., ballistic stretching; 6) if the muscle contracts rapidly and powerfully against overload, and the degenerated tendon bears the damaging stretch - i.e., explosive style lifting from the bottom position of an exercise, 7) a limb and its parts (joint, soft tissues) moves violently and passively from a position of flexion, extension, adduction, or abduction against a strong muscle contraction, resulting in a forcible stretching of the unit - i.e., football tackle; or 8) insufficient healing or remodeling time passes before undergoing further strain - i.e., exercising too frequently.

### The Effect of Too Frequent Exercise

Intense exercise alters the quantitative properties of tendons, making them larger, stronger, and more resistant to injury. Tissues proceed through a period of transient weakness as it adapts to exercise, yet the tissue's mechanical strength will diminish at some point during remodeling. This situation is reflective of both muscle and tendons. First, there is a degradation; second, there is a compensation; third, there is an overcompensation or supercompensation. Most importantly, since tendon tissue breaks down structurally before remodeling, the tendon will be weaker than normal, and susceptible to injury during this period of transition. Without adequate recovery, exercise-induced inflammation and fiber damage may occur. If a tendon ruptures during movement that would normally not cause a rupture, it is the result of a weakened or degenerated state prior to the rupture. This is often the result of cumulative microtrauma (constant wear and tear without adequate healing). However, even a healthy tendon can tear if the forces are extreme. Compared to muscle tissue, the metabolic turnover (repair and regeneration) of tendon tissue is several times slower due to poorer circulation and vascularity. Consequently, adaptive responses of tendons to training are likewise slower than those of muscles.

### Tension Under Stretch

Elastic fibers are barely existent in human tendons, making up about 2% of a tendon's dry mass, and being mostly elastin. Elastin contributes primarily to the recovery of the wavy collagen fiber configuration after muscle contraction and tendon stretch. However, if elongation exceeds approximately 4% of its original length, minor damage to the tendon tissue could occur. Moreover, acute stress resulting in an 8%+ elongation may cause tendon rupture. Injury to a tendon results in inflammation, edema, and pain. The consequence is tendinitis, tendinous bursitis, insertitis, peritendinitis, or any combination. If the damage progresses, without adequate recovery and proper rehabilitation, tendinosis, partial tears, and complete ruptures may ensue.

### Impact Forces

Impact forces, from low to extreme, are often responsible for tendon degradation and injury. When running, the forces placed on the lower leg and heel can exceed two times body weight, producing a shock wave with every step. For instance, a 160 pound runner at 1500 steps per mile absorbs about 150,000 tons of force each foot per mile. Patellar tendon ruptures in skilled weight lifters often undergo a force of approximately 15-17 times that of body weight.

### Cumulative Microtrauma

It is estimated that as much as half of sports injuries are due to overuse, with musculotendinous units being the most commonly affected. The cause of overuse injury is repetitive strain of the affected tendon so that the tendon is unable to remodel during recovery. Consequently, the tendon is unable to endure further stress, and its structure begins to fail, resulting in inflammation, edema, and pain. With resistance trainees, tendinitis is most noticeable in the forearm near the elbow, and in the shoulder. Shoulder tendinitis is more debilitating, resulting from impingement of the rotator cuff due to repetitive use, and impact forces resulting from internal rotation (i.e., bench presses). The supraspinatus tendon is often the most affected muscle in the rotator cuff group.

### Tendon Strains

A strain injury occurs when a tendon has been stretched and microscopically damaged, with macroscopic disruption of the tendon fiber bundles. Within four hours of a tendon strain, fibronectin and fibrin permeate the damaged area. Within 24 hours, there occurs inflammation with hemorrhage, edema, muscle cell necrosis, and proliferation of leukocytes. Tendon fibers also break down, with macrophage phagocytosis, and continued inflammation. After about a week, inflammation decreases, capillaries and fibroblasts (tenoblasts) increase, and granular tissue forms. Approximately three weeks after a strain, the inflammation and proliferation of capillaries and fibroblasts gradually disperse so the remodeling phase can begin. Remodeling after a tendon strain can last a year or more after injury. During this period, granulation tissue matures into scar tissue, and vascularity decreases. However, it is common for the healing process of a strain injury to incur further stress, resulting in constant biomechanical deficits.

**Partial Ruptures**

A partial tendon rupture suggests there is macroscopic disruption of the tendon fibers, and the tendon is partially intact with its associated muscle. In the acute phase of a partial rupture, tendon swelling is the most prevalent symptom, and scar formation begins 3-4 weeks after the injury. As the damaged site gradually fills with scar tissue, it is unlikely that normal tendon structure and functionability are reestablished. Rupture at the MTJ is also characterized by muscle-cell discontinuation and hemorrhage. This is quickly followed, within 24 hours, by leukocyte and macrophage perforation at the site. Soon thereafter, necrosis of the muscle cells and homogenization (blood formation) of the myofibrillar structure occurs. The myotendinous collagen fibers disconnect from the contractile elements of the muscle-cell endings.

The problem with most partial tendon ruptures is that there is only slight discomfort or no symptoms. As a result, the initial stages of disruption are often ignored, leading to more serious problems, or a complete rupture. Tendon strains and partial tendon ruptures are somewhat mild injuries, but unfortunately tendon injuries generally result in long-term pain and disability.

**Complete Ruptures**

Complete tendon ruptures are rare, but do occur with resistance trainees who engage in plyometrics or other ballistic/explosive practices. Over the past ten years, and at an increasing pace, numerous bodybuilders and strength athletes have completely ruptured tendons in their pectorals, biceps, and patellar area. A few of the more famous cases include the torn biceps tendon of Tom Platz, former Mr. Universe, the torn pectoral of Kevin Levrone, current Mr. Olympia contender, and the many muscle and tendon tears of Mr. Olympia, Dorian Yates.

Complete tendon ruptures greatly increase the amount of intramuscular connective tissue, which impairs intramuscular blood circulation. Consequently, there is a decrease in capillary count which then leads to a further increase in intramuscular connective tissue. This whole process repeats itself in a vicious cycle, leading to further macroscopic loss of muscle extensibility, contractility, and other tensile properties. During the first stage of a complete rupture, within days, atrophy of the myofibrils begin, sarcomere length decreases, mitochondria enlarge, glycogen content of the cells decrease greatly, and the nuclei and the motor endplates are no longer detectable. Stage two begins within two weeks after a rupture, characterized by myofibril disintegration, disruption, and disorientation in both fast twitch and slow twitch muscle cells, with no observable difference between fast and slow twitch muscle cells due to extreme atrophy. After successful surgery and effective rehabilitation of a complete rupture, it can often take a year or more for complete healing of the musculotendinous unit.

**The Effect of Steroids**

Tendon injury is more prevalent with anabolic steroid users than with non-steroid users. In most instances, tendon collagen dysplasia (abnormal development of tissue), dissociation, and rupture are in direct proportion to the magnitude of anabolic steroid administration. Although tensile strength of tendons can increase after short-term use of anabolic steroids, long-term use decreases tendon elasticity and energy absorbing capacity, as well as tensile strength. Similarly, it is probable that long-term use of the male hormone testosterone will likewise decrease tensile strength of tendons.

### Injury Prevention

Although the passive elements of the musculotendinous unit can likewise absorb energy, it is the active component (muscle) that is most important for injury prevention. Hence, activity that results in extensive muscle fatigue and weakness - i.e., high-volume training - diminish the contractile ability of muscle, predisposing the unit to a strain injury. Even at light weight loads, injury is more likely during high-volume than high-intensity training, particularly if the weights produce high kinetic energy from uncontrolled eccentric movement. Training errors, due to fatigue of long workouts, and progression that is too fast, contribute to a majority of overuse injuries. (NOTE: a stretching routine may decrease potential soft tissue injury by increasing the length to which a muscle can stretch [viscoelasticity] before failure occurs. Stretch after a training session, and not as part of the warm-up; since stretching also producing tension, thereby contributing to muscle fatigue, and could reduce force output during high-intensity sets. This is most important with fast-twitch muscles, since muscles with poor endurance fatigue easily, and absorb less energy than unfatigued muscles; this makes them more prone to injury, especially during high-volume training. It should be emphasized that an optimal length of musculotendinous tissue will eventually be achieved with a sound stretching program. Beyond a specific length, further stretch is of no anatomic or physiologic value. In other words, it is not necessary to obtain incredible degrees of flexibility, but to optimize your flexibility within your capabilities and requirements, then maintain that level.)

### Rehabilitation

In the event of an injury, a brief layoff is essential, accompanied by appropriate intervention, i.e., RICE therapy, anti-inflammatories, etc. When recommended by your physician, it is best to incorporate proper functional rehabilitation through high-intensity, low force exercise utilizing well-designed machines, such as those manufactured by MedX and Nautilus. Free weights should be avoided due to their uncontrolled and balancing nature, which only serves to aggravate the injury. Regardless of most physiotherapy intervention practices, it is not necessary to exercise the injured area every day. One set, once per week is often adequate, as suggested by various studies conducted at the University of Florida's Medical Center, and so long as the set is carried to the point of momentary muscular failure, in a slow and deliberate manner. Implementing more exercise than this only serves to make inroads into your recovery ability, which is even more vital for a slow-healing, injured tendon.

Athletes involved in high-impact sports, i.e., hockey and football, should note that prior injuries predispose the musculotendinous unit to further strain. Premature return to strenuous activity could therefore cause reinjury, and long-term disability.

#### Resources and Suggested Reading

Human Tendons: Anatomy, Physiology, and Pathology. László Józsa and Pekka Kannus. 1997. Human Kinetics.

The Lumbar Spine, the Cervical Spine and the Knee: Testing and Rehabilitation. 1993. Arthur Jones.

The Stress of Life. Hans Selye, M.D. 1984. McGraw Hill.