

## Achilles Tendon Disorders: Etiology and Epidemiology

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The tendinous portion of the gastrocnemius and soleus muscles merge to form the Achilles tendon, which is the largest and strongest tendon in the human body [1,2]. The Achilles tendon has a high capacity to withstand the tensional forces that are created by the movements of the human body.

The number and the incidence of tendon injuries, in general, have increased substantially during the last few decades [1–5]. It is estimated that tendon injuries account for 30% to 50% of all injuries that are related to sports. The increase in tendon problems has been dominated by problems with the Achilles tendon, which are common among athletes and the general public.

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Achilles tendon injuries have been divided into spontaneous ruptures and overuse injuries. Generally, Achilles tendon problems arise from two different origins: (1) some symptoms are caused solely by the excessive loading-induced injury or degeneration of the Achilles tendon (without any predisposing systemic diseases); and (2) sometimes a systemic disease, such as rheumatoid arthritis, manifests with Achilles tendon symptoms [1]. Only a minority (~2%) of all Achilles tendon complaints and injuries are a result of a systemic, predisposing disease; most tendon problems in a population can be traced to sports and exercise-related overuse [1,6].

## **Chronic injuries: Achilles tendinopathy**

### *Epidemiology of Achilles tendinopathy*

Many terms have been used to describe (Achilles) tendon disorders. Because of the highly confusing terminology for (Achilles) tendon disorders, it recently was recommended that the clinical syndrome—characterized by a combination of pain and swelling (diffuse or localized) in and around the Achilles tendon, accompanied by impaired performance—should be called Achilles tendinopathy [7,8]. Based on histopathologic findings, tendinopathy can be divided into peritendinitis and tendinosis (tendon degeneration), and these entities may coexist in the same, painful Achilles tendon; however, the division cannot be made reliably in the clinical setting [3,4,7,8]. Some investigators avoid the term “degeneration” because they believe it often is interpreted as meaning an irreversible pathologic process, whereas tendinosis likely is reversible. We do not attribute anything to the term degeneration other than to mean the findings that are seen on histopathologic samples.

Achilles tendon overuse injuries are associated commonly with strenuous physical activities, such as running and jumping [1,3,4,9]. The occurrence of Achilles tendinopathy is highest among individuals who participate in middle- and long-distance running, orienteering, track and field, tennis, badminton, volleyball, and soccer [5,9–17]. Johansson [12] and Lysholm and Wiklander [13] reported an annual incidence of Achilles disorders to be between 7% and 9% in top-level runners.

In the studies with extensive material, the most common clinical diagnosis of Achilles disorders is tendinopathy (55%–65%), followed by insertional problems (retrocalcaneal bursitis and insertional tendinopathy; 20%–25%) [5,9–11,17]. In a cohort study with an 11-year follow-up, Kujala et al [18] found questionnaire-reported Achilles tendon overuse injury in 79 of 269 male orienteering runners (29%) and 7 of 188 controls (4%); the age-adjusted odds ratio was 10.0 in runners compared with controls.

Kvist [5,10] studied the epidemiology of Achilles tendon disorders in a large group of competitive and recreational athletes who had Achilles tendon

problems. In this report of 698 patients, 66% had Achilles tendinopathy and 23% had Achilles tendon insertional problems. In 8% of the patients, the injury was located at the myotendinous junction, and 3% of the patients had a complete tendon rupture. Eighty-nine percent of the patients were men. Running was the main sports activity in patients who presented with an Achilles tendon disorder (53%); persons who were runners represented 27% of all patients who were studied in the sports medicine clinic where the research was performed.

Chronic Achilles tendon disorders are more common in older athletes than in young athletes (teenage and child athletes) [19]. In a report of 470 patients who had Achilles tendinopathy and insertional complaints, only 25% of subjects were young athletes and 10% were younger than 14 years; most of these younger patients were diagnosed with calcaneal apophysitis (Sever's disease) [10]. Patients who had unilateral Achilles tendinopathy seem to have a high risk of sustaining Achilles tendinopathy in the uninvolved leg as well; almost half of the patients who had the Achilles tendinopathy (41%) developed symptoms of this in the contralateral leg during the 8-year follow-up [20].

### *Etiology of Achilles tendinopathy*

Sports injuries can be caused by intrinsic or extrinsic factors, either alone or combination [21]. In acute trauma, extrinsic factors predominate, whereas overuse injuries generally are multi-factorial in origin. In chronic tendon disorders, an interaction between these two types of factors is common [21].

The basic etiology of the Achilles tendinopathy is known to be multi-factorial, because several extrinsic and intrinsic factors were identified that predispose to these problems (Boxes 1 and 2; Fig. 1) [21,22]. In the epidemiologic studies, various malalignment of the lower extremity and biomechanical faults are claimed to play a causative role in two thirds of the athletes who had Achilles tendon disorders. Kvist [5,10] found in his large series on chronic Achilles tendon overuse injuries that some kind of predisposing malalignment of the lower extremity was found in 60% of patients who had an Achilles tendon disorder (see Box 1); however, the mechanisms by which these factors contribute to the pathogenesis of Achilles tendinopathy remain in dispute [23]. The most common, and perhaps the most important, malalignment in the ankle is caused by hyperpronation of the foot. Increased foot pronation was proposed to be associated with Achilles tendinopathy [23]. Kvist [5,10] demonstrated that limited subtalar joint mobility and limited range of motion of the ankle joint were more frequent in athletes who had Achilles tendinopathy than in those who had other complaints. In addition, forefoot varus correlates with Achilles tendinopathy [5,10,24,25]. Recently, Kaufman et al [25] observed that increased hindfoot inversion and decreased ankle dorsiflexion with the knee in extension is associated with Achilles tendinopathy.

In addition to hyperpronation and the other aforementioned malalignments, leg length discrepancy is one of the more controversial potential contributing

**Box 1. Predisposing intrinsic factors related to Achilles tendinopathy in sports***General factors*

- Gender
- Age
- Overweight
- Constitution: weak or strong
- Blood group
- HLA-types
- Predisposing diseases
- Blood supply
  - Ischemia
  - Hypoxia
  - Hyperthermia

*Local (anatomic) factors on the lower limb*

- Malalignments
  - Foot hyper- or hypopronation
  - Forefoot varus or valgus
  - Hindfoot varus or valgus
  - Pes planus or cavus
- Leg length discrepancy
- Muscle weakness and imbalance
- Decreased flexibility
- Joint laxity

factors [21]. The traditional orthopedic view is that discrepancies of less than 20 mm are not clinically important [23]. In elite athletes, however, a discrepancy of more than 5 mm to 6 mm may be symptomatic and, consequently, for a discrepancy of 10 mm or more, a built-up shoe or shoe insert has been recommended to prevent overuse symptoms. It must be recognized that the true occurrence of these proposed biomechanical alterations, their magnitude and, above all, their clinical importance is not well-known [21].

The importance of muscle weakness and imbalance, as well as disturbed musculotendinous flexibility, in the development of Achilles tendon disorders also is a matter of debate; however, muscular strength, power, endurance, and flexibility are an important part of physical performance, and thus, can be important in the prevention of certain sports injuries, particularly tendon injuries [21]. If the muscle is weak or fatigued, the energy-absorbing capacity of

**Box 2. Predisposing extrinsic factors related to Achilles tendinopathy in sports***General factors*

- Therapeutic agents
  - Corticosteroids (local and systemic)
- Fluoroquinolone
  - Antibiotics
- Weight-lowering drugs
- Drugs
  - Anabolic steroids
- Drugs/narcotics
  - Cannabis
  - Heroin
  - Cocaine

*Sports-related factors*

- Excessive loads on the lower extremities
  - Speed of movement
  - Type of movement
  - Number of repetitions
  - Footwear/sportswear
  - Training surface
- Training errors
  - Overdistance
  - Fast progression
  - High intensity
  - Fatigue
  - Poor technique
- Environmental conditions
  - Heat or cold
  - Humidity
  - Altitude
  - Wind
- Poor equipment

the whole muscle–tendon unit is reduced, and the muscle no longer protects the tendon from strain injury and subsequent inflammation and pain [21]. Recently, good short-term improvements have been reported in chronic Achilles tendinosis with heavy-load eccentric training, a rehabilitation program that is based on increasing the length, tensile strength, and force of the muscle–tendon unit

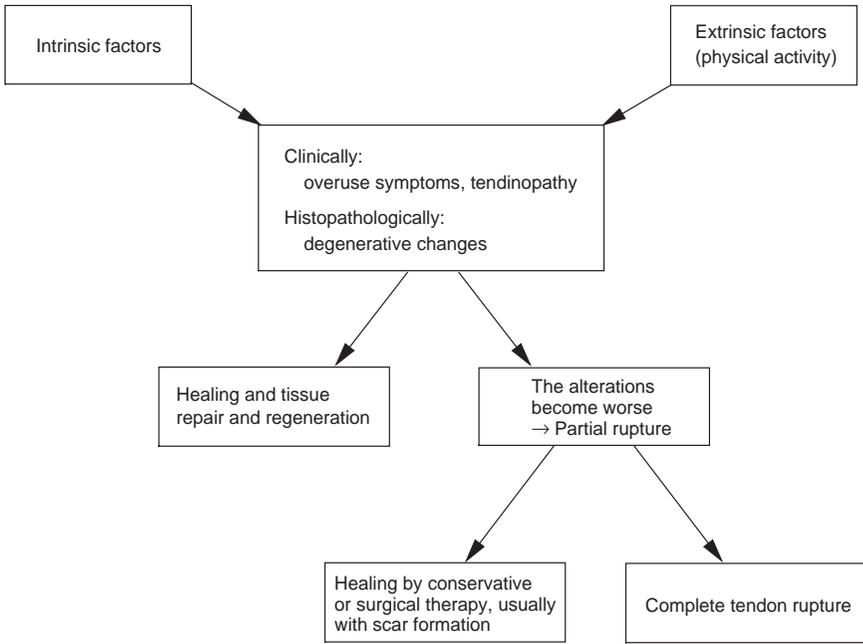


Fig. 1. The pathophysiological mechanisms of Achilles tendon overuse injuries and disorders, which also may lead to Achilles tendon ruptures.

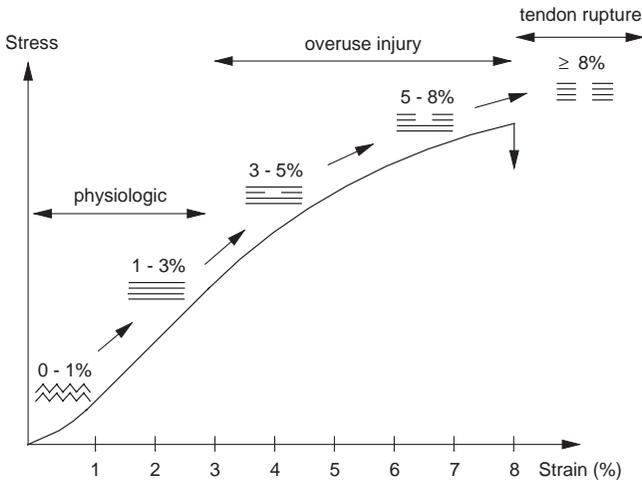


Fig. 2. A schematic presentation of the development of chronic tendon disorders. According to current concepts, repetitive tendon strain (3-5-8% strain) may lead to cumulative fiber microtrauma. If the reparative capacity of the tendon tissue is exceeded, inflammation, edema, pain and tendon degeneration (overuse injury) can ensue.

[26–30]. This concept, however, is open to speculation because the studies do not provide conclusive evidence on whether muscular weakness, imbalance and musculotendinous tightness are the causes or consequences of injuries.

By one definition, an overuse tendon injury is caused by repetitive strain of the affected tendon such that the tendon can no longer endure tensile stress. As a result, tendon fibers begin to disrupt microscopically, and inflammation and pain result (Fig. 2) [21]. Of the extrinsic risk factors, excessive loading of the lower extremities and training errors were said to be present in 60% to 80% of the patients who had Achilles tendon overuse injuries (see Box 2; see Fig. 1) [5,10,22]. The most common of these include running too long a distance, running at too high an intensity, increasing distance too greatly or intensity too rapidly, and performing too much uphill or downhill work [5,10,22,25]. Monotonous, asymmetric, and specialized training, such as running only (ie, without cross-training), as well as poor technique and fatigue are further risk factors for Achilles tendon overuse injuries (see Box 2). Poor environmental conditions, such as cold weather, hard ground surface, and slippery/icy surface also were suggested to promote Achilles tendon problems [1,3,21,23,31]. The lack of high-quality prospective studies limits the strength of the conclusions that can be drawn regarding these extrinsic risk factors.

## **Achilles tendon ruptures**

### *Epidemiology*

Although the incidence of Achilles tendon ruptures is difficult to determine accurately, it is generally agreed that the incidence has increased in the industrialized countries in recent decades [1,2,32–35]. The incidence of ruptures of the Achilles tendon in the city of Oulu, Finland was approximately 18 per 100,000 in 1994 [32], 6 per 100,000 in Scotland in 1994 [33], 37.3 per 100,000 in Denmark (a single county of 220,000 inhabitants) [34], and 17.9 per 100,000 in a single-hospital district (93,000 inhabitants) in eastern Finland [35].

Of all spontaneous tendon ruptures, complete Achilles tendon tears are associated most closely with sports activities. Schönbauer [36] found in his study population that 75% of all Achilles tendon ruptures were related to sports, whereas Plecko and Passl [37] found that the proportion of sports-related Achilles tendon ruptures was 60%. In the material of 430 tendon ruptures that were analyzed by Józsa et al [38], the number of sports-related Achilles ruptures was similar (62%) to the two aforementioned studies, whereas only few (2%) ruptures of other human tendons were sports related.

The distribution of Achilles tendon ruptures according to different sports varies considerably from country to country, according to the national sports traditions. For example, in northern and middle Europe, soccer, tennis, track and field, indoor ball games, downhill skiing, and gymnastics are the most common

sports during which the Achilles tendon ruptures take place [1,2]. In North America, American football, basketball, baseball, tennis, and downhill skiing dominate the statistics [1,2].

There also are indications that patients who have spontaneous Achilles tendon ruptures are at increased risk for sustaining a rupture in the contralateral Achilles tendon as well [39].

### *Etiology of a spontaneous Achilles tendon rupture*

The exact cause of Achilles tendon ruptures is not known, because most of the patients who sustain a spontaneous rupture never had any symptoms (tenderness, stiffness, discomfort, diagnosed disease in the region of the ruptured Achilles tendon) before the rupture [1,2,40]. Histopathologic studies on ruptured Achilles tendons show, however, that almost all of these subjects have clear degenerative changes, such as hypoxic and mucoid degeneration, poor vascular supply, tissue and cell necrosis, calcification, and tendolipomatosis, as well as irregular, degenerated collagen fibers at and around the rupture site [41–44]. Furthermore, there is evidence that professional, white-collar workers are overrepresented among patients who have Achilles tendon ruptures [38]. Taking these findings together, it is believed that a sedentary lifestyle (possibly by contributing to poor circulation and subsequent, hypoxic degeneration of the Achilles tendon), together with mechanical factors (sudden or repetitive movements), lead to spontaneous tears of the Achilles tendon [38,40]. A substantial proportion of Achilles tendon ruptures occur in situations in which degeneration of the tendon cannot be traced as an etiologic factor, however. In these cases, the rupture is more a consequence of the remarkably high forces that are involved in the performance (eg, high or triple jump) [1,2].

The biomechanically undesired positions of the ankle and foot, such as forefoot or calcaneal valgus and varus malalignments that cause horizontal, axial, and rotational alterations on the collagen fibers of the Achilles tendon during running are important predisposing factors to rupture [1,2,40].

Generally speaking, patients who have Achilles tendon rupture are younger than those who have other tendon ruptures [6], and there is a clear male predominance among this group of patients [6,38]. Although there are case reports on pre-existing distinct intratendinous diseases as well as a wide range of different generalized concurrent diseases (eg, rheumatoid arthritis, gout, ankylosing spondylitis, chronic uremia, hyperparathyroidism) causing tendon ruptures, they rarely are responsible (<2%) for Achilles tendon rupture and for tendon ruptures, in general [1,6].

Several drugs can cause spontaneous tendon ruptures [40]. Recent literature provides strong evidence that the abuse of anabolic steroids increases the risk of tendon rupture [45]. Since the initial report by Ribard et al [46] that described seven cases of Achilles tendinopathy (three were complicated further by spontaneous rupture of the tendon) after fluoroquinolone antibiotic treatment, several

similar cases have been reported around the world [47,48]. Thus, it has become accepted that the fluoroquinolone antibiotics have an unspecific, toxic effect that may cause tendonitis or spontaneous rupture of the Achilles tendon [47].

The issue of corticosteroids and the risk of tendon rupture is controversial in the orthopedic literature [49,50]. In this context, it needs to be emphasized that current literature that was derived from experimental or clinical studies provides no convincing evidence either for or against (intratendinous or peritendinous) corticosteroid injections increasing the risk of tendon rupture (for a review see [50]). Furthermore, rheumatologists have been injecting corticosteroids directly into the tendon tissue for decades without any evidence of increased prevalence of tendon ruptures [51]. A recent study, although small in number of patients treated, indicates that the corticosteroids can be beneficial and safe, even when injected directly into the tendon in athletes who have Achilles tendinopathy [52]. Thus, based on the current evidence on the topic, one plausible explanation for the tendon ruptures that are seen after corticosteroid injection is that rapid pain relief, and consequently, a quick return to strenuous physical activity provides an opportunity for the degenerated tendon to rupture, which merely is a final manifestation of the disease for which the corticosteroids were applied [50].

The role of genetic background of the patient in Achilles tendon rupture is almost unknown. There is evidence of a relationship between ABO blood groups and spontaneous tendon ruptures. A strong association between blood group O and Achilles tendon rupture was identified in a large series of patients in Hungarian and Finnish populations [53,54]. The exact reason for the identified relationship is unknown; the above described relationship has not been found in other populations [55].

## Summary

The Achilles tendon is the strongest tendon in the human body. The number and incidence of Achilles tendon overuse injuries and complete, spontaneous ruptures have increased in the industrialized countries during the last decades because of the increased participation in sports.

The most common clinical diagnosis of Achilles overuse injuries is tendinopathy, which is characterized by a combination of pain and swelling in the Achilles tendon accompanied by impaired ability to perform strenuous activities. Achilles tendinopathy is common in sports that require strenuous physical activity. Extrinsic and intrinsic factors contribute to Achilles tendinopathy.

Among the different ruptures of the human tendons, a complete rupture of the Achilles tendon is the one that is associated most closely with sports. Although histopathologic studies showed that ruptured Achilles tendons have clear degenerative changes before the rupture, many Achilles tendon ruptures take place suddenly without any preceding signs or symptoms. Considering that

professional white-collar workers are overrepresented among the patients who have Achilles tendon rupture, in conjunction with the degenerative changes that are identified in ruptured tendons, a potential mechanism for the causative effect of a sedentary lifestyle on the increased incidence of spontaneous tendon ruptures has been introduced.

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