Achilles Tendon Rupture: Risk Assessment for Aerial and Ground Athletes

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Context: Achilles tendon (AT) rupture in athletes is increasing in incidence and accounts for one of the most devastating sports injuries because of the threat to alter or end a career. Despite the magnitude of this injury, reliable risk assessment has not been clearly defined, and prevention strategies have been limited. The purpose of this review is to identify potential intrinsic and extrinsic risk factors for AT rupture in aerial and ground athletes stated in the current literature.

Evidence Acquisition: A MEDLINE search was conducted on AT rupture, or “injury” and “risk factors” and “athletes” from 1980 to 2011. Emphasis was placed on epidemiology, etiology, and review articles focusing on the risk for lower extremity injury in runners and gymnasts. Thirty articles were reviewed, and 22 were included in this assessment.

Results: Aerial and ground athletes share many intrinsic risk factors for AT rupture, including overuse and degeneration of the tendon as well as anatomical variations that mechanically put an athlete at risk. Older athletes, athletes atypical in size for their sport, high tensile loads, leg dominance, and fatigue also may increase risk. Aerial athletes tend to have more extrinsic factors that play a role in this injury due to the varying landing surfaces from heights and technical maneuvers performed at various skill levels.

Conclusion: Risk assessment for AT rupture in aerial and ground athletes is multivariable and difficult in terms of developing prevention strategies. Quantitative measures of individual risk factors may help identify major contributors to injury.

Keywords: Achilles; risk; injury; rupture

Rupture of the Achilles tendon (AT) is a devastating injury for athletes. Surgical repair is often required for athletes, with recovery periods lasting 6 to 12 months. Aerial sports with frequent jumps and landings, including gymnastics, cheerleading, dance, and extreme sports, are especially at risk for this injury. Ground sport athletes that perform sports with a great deal of speed variance and rapid footwork, including soccer, football, basketball, tennis, and long-distance running, are also at an increased risk of AT rupture. Prevention of AT rupture requires careful consideration of the risk factors.

ANATOMY AND PATHOGENESIS

Tendon degeneration and poor mechanics are the most common explanations for AT ruptures. Degeneration can cause spontaneous rupture accelerated by a limited blood supply to the watershed region of the AT, approximately 2 to 6 cm from the calcaneal insertion. As many as 97% of spontaneously ruptured tendons examined histologically had degenerative changes consistent with tendinosis. This process usually correlates with aging, but the younger, competitive athlete may accelerate this process through a combination of macro- and microtrauma related to high training loads and shorter recovery phases.

The AT is at the greatest risk for rupture when concentrated forces are oblique to the tendon. A healthy tendon may rupture with a violent muscular strain. Malfunction or suppression of the proprioceptive component of the skeletal muscle due to fatigue or disturbed coordination of the musculotendinous unit predisposes athletes to the rupture of the AT. Athletes who resume training after a period of rest may be particularly susceptible to rupture of the AT as a result of this malfunction.

EPIDEMIOLOGY

Acute AT ruptures often occur in men during the third or fourth decade of life who play recreational sports. Injury in recreational athletes accounts for 75% of AT ruptures, while only 8% to 20% occurs in competitive athletes. However, 76% of partial AT ruptures occur in competitive athletes. Pushing
off a foot while extending the knee in sprint starts and jumping sports account for up to 53% of AT ruptures.6,8,13,22

There is a large sex discrepancy favoring male athletes in AT ruptures, ranging from 2:1 to 19:1.12,22 A significant increase in AT rupture in sports in Europe and the United States over the past 2 decades has favored women.22 This may be due in part to the greater competitive sport participation by women in recent years. A retrospective Finnish study of a National Hospital Discharge Register found that urban areas had a higher incidence of ruptures than rural areas.16 AT ruptures occur on the left more than the right, which may be due to right-sided dominance and pushing off with the left.5,12,13 Simultaneous bilateral total AT ruptures are rare and almost exclusively occur in older patients with underlying systemic disease or a history of long-term corticosteroid or fluoroquinolone usage.15

AERIAL SPORT RISK ASSESSMENT

There are multiple risk factors to consider when determining the risk of AT rupture in an aerial sport athlete.

Landing Surfaces

For gymnasts, the carpeted floor underlined with plywood and foam is softened with 4-in spring coils affording gymnasts more airtime. Reducing the stiffness of the spring floor decreases floor stability and increases the horizontal distance of tumbling flight trajectories altering the joint torques.17,18 Modeling studies show that the gymnast-floor interface produces forces at the feet and ankles ranging from 5- to 17.5-times bodyweight.4,17,18 Gymnasts who consistently land short on tumbling landings increase their risk for anterior ankle impingement. They stretch and load across the gastrosoleus complex through the AT, which can accelerate degeneration of the tendon.19 In practice, athletes are more protected by preventing repetitious hard impact through the use of foam pits, soft mats, belts, and bungee devices.14

Training Period

Preseason is a high-risk period when new skills are attempted in preparation for competition if physical conditioning is poor and fatigue occurs from training intensity.18 There is a significant increase in injuries during seasonal competition likely due to higher levels of fatigue while performing full routines.18

Scoring/Competition

The International Gymnastics Federation’s scoring code rewards gymnasts for difficult aerial maneuvers. Gymnasts attempt greater heights and riskier maneuvers that enhance scoring and gain bonus points with judges. Unfortunately, this also increases the potential for greater ground reaction forces upon landing.14

Technique

Loads on the ankle, AT, and the spine are highly dependent on the posture of the gymnast during the landing impact.17

Gymnasts often underrotate a landing (land “short”) forcing dorsiflexion at the ankle with a violent stretch of the AT.

Lack of Footwear

Traditional footwear is not used by aerial athletes because of their weight and distortion of bodylines. Gymnasts have a forefoot strike when running and perform in constant plantarflexion with toe pointing in most skills until landing. Shoe wear would make this difficult. Without shoes, there is no support to limit pathologic foot pronation, which can strain the AT complex on unstable surfaces.7

Age/Anthropometrics

The aerial athlete’s age, weight, body proportions (fat), rapid growth, strength, experience, and tendon health may put an individual at risk.20 Older gymnasts may be more at risk because of more complex and difficult skills and accumulated training.1,2,20 Gymnasts of an atypical body type lost the most time from training due to injury.1,2

Lack of Concentration

Lack of concentration correlates to injury risk in jumping athletes because of the need for coordination.20 Anxiety, time pressure, and physical or emotional fatigue are related to the number and severity of injuries in the nonelite athlete.1,2,10 In a Swedish team study, 53% of injuries occurred while the gymnasts were in a negative mood, 52% felt “as usual,” and only 12% were in a positive mood.20

GROUND SPORTS RISK ASSESSMENT

Intrinsic factors play a larger role for ground athletes because of the shoe-surface interaction. Preexisting degenerative tendon, cavus foot, tibia vara, or underdeveloped hamstrings may increase the risk of AT ruptures.5,22 Over- or underpronating is linked with poor shock absorption and may increase stress on the AT.9,3 Increased femoral anteverision, leg length discrepancy, muscle weakness, increased body mass index, and aging increase intrinsic risk of AT rupture in running athletes.8

Repetitive Overuse

Biomechanical force analysis and implanted electrodes demonstrate tendon loads of 600% to 800% of body weight during running, close to the ultimate strength of the AT.19 Excessive repetitive overload in running can be a pathologic stimulus that leads to Achilles tendinopathy and rupture.9,13

Footwear

Inadequate athletic shoes with minimal flexibility, poor heel wedges, and soft heel counters all place the athlete at risk for AT injury.3,9,22 Wearing high heels all day followed by low running shoes puts runners at risk for injury.3
Training Errors/Terrain

Sudden increases in interval training, solitary intense runs, increases in terrain elevation, uneven or density differing surfaces, or an increase in eccentric loading may increase the risk of injury.6,9,10 Asphalt running decreases midportion Achilles tendinopathy by nearly one-half, while sand running increased this pathology nearly tenfold.11

Lack of Stretching/Fatigue

In the fatigued or poorly trained athlete, injury occurs after 30 minutes of activity.1,6,9 As distances increase, muscle fatigue results in tendon elongation and microtearing.3,6,9 This damage can occur within the tendon’s physiologic limits, if time for repair is not adequate.6,9,13,21,22 In athletes of all ages, morning stiffness correlates to the severity of Achilles tendinopathy.9,13 Proper initiation of an athletic and consistent stretching regimen to prevent injury are vital in the ground sports athletic population.

Discussion

Risk assessment of AT rupture in the competitive athlete is a vital consideration of training preparation. Aerial and ground athletes have several intrinsic and extrinsic factors that may put them at risk for AT injury and rupture. Aerial athletes can obliquely load the AT, while ground athletes can accelerate degeneration over time.

Many elite sports teams provide standard shoe wear to running athletes without consideration of anatomical variation, which may put athletes at risk for AT injury.3,6,9,11,19,22 Well-fitted athletic shoes with a heel counter to prevent medial/lateral excess motion of the hindfoot can help reduce load on the AT.3

Risk assessment of AT rupture in competitive athletes can minimize morbidity by initiating prevention strategies. Low fitness levels, muscle imbalances, neuromuscular deficits, and errors in training may all contribute.22 Calculated, progressive training schedules that allow for adequate rest technique should be considered with rigorous training environments. Optimizing lower extremity flexibility and strength may allow athletes to adapt to the varying dynamics of each sport.

Clinical Recommendations

| Clinical Recommendation | SORT Evidence Rating |
|-------------------------|----------------------|
| Careful risk assessment of individual athletes can minimize morbidity of Achilles tendon rupture through various prevention strategies (ie. addressing neuromuscular deficits, biomechanics, training errors, or unforgiving training environments). | C |

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