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The achilles tendon rupture: A deeper dive into its impact on professional and high-performance athletes

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Abstract

Background: The Achilles tendon rupture (ATR) is an injury that has been detrimental to professional athletes over the years, recently rising to unforeseen heights as the intensity of sports has increased.

Methods: To obtain relevant statistics for this paper, a review of prior research, including original research and case studies, was conducted. Digital publications and clinical data were reviewed to dissect factors such as injury causes, operations, current initiatives, the role of technology, and future implications.

Results: The data revealed a significant increase in documented ATRs in athletes and the National Football League (NFL) over the years; most recently, these injuries increased from 11 in the 2019-2020 season to 24 in the 2021-2022 season.[3] Despite advancements in technology and recovery methods, dynamic changes involving training, conditioning, physicality, and intensity in sports have greatly contributed to the increased rates of injuries. With modernized resources such as advanced testing and rehabilitation procedures incorporating artificial intelligence (AI), specialists continue to search for new ways to treat injury and improve functional outcomes more effectively.

Conclusion: This paper examines ATRs in athletes, its risk factors, current surgical methods for treatment, and modern rehabilitation methods. Future research should continue to develop comprehensive assessment and treatment methods to decrease the time to return to play, reduce the risk of re-injuries, and ensure cost-effective standards in implementing advanced rehabilitation modalities.

Keywords: Achilles tendon rupture; Surgical techniques; Fiberglass; Open Achilles Repair; Percutaneous Achilles Repair; OpenCap AI

1. Introduction

The Achilles tendon is one of the most vital tendons in the body, connecting the calf muscles to the heel bone. The strength of this tendon is essential for athletes because it enables mobility and permits extensive, as well as explosive activities involving running and jumping.[15] Consequently, injuries to the Achilles tendon are often seen in sports, especially those with frequent jumps, landings, rapid changes in speed, and foot maneuvers.[15] The prevalence of Achilles tendon ruptures (ATR) has increased by three to five times within the NFL over the last 25 years.[6] Amongst all Achilles injuries, the ATR has been one of the most substantial and common "one-punch" injuries experienced by athletes, and these injuries are capable of ending their athletic careers.[15] Even well-conditioned and genetically gifted athletes are constantly at risk of injury during every game and practice as their play places high pressure on the tendons, especially during calf contractions.[6] Athletes may feel a huge "pop" of their tendon; a classic sign of Achilles injury, as they initially go down. Preliminary symptoms such as pain, swelling, and tenderness are typically severe, resulting in limited mobility.

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Initial tests in the doctor's office, such as the Thompson test, can help diagnose ATRs and can detect about 96-100% ruptures.[31] However, an imaging test such as an X-ray, ultrasound, or magnetic imaging resonance test is required to confirm the diagnosis. While there is no singular consensus regarding recovery methods, surgical and non-surgical interventions focus on preventing a re-rupture through functional rehabilitation and return to play protocols.[15] Despite developing new surgical solutions, such as the speed bridge procedure for a faster recovery, Achilles injuries continue to occur more frequently than ever among athletes.[7] These are thought to be due to a combination of factors such as the evolution of the sport and its modern-day aggression, deconditioning due to shutdowns and absent preseason conditioning during the COVID pandemic,[19, 22] potential use of anabolic steroids, insufficient training, cleat choices, and surface changes such as the use of turf versus grass.[6]

Achilles tears are one of the most gruesome injuries in sports and are caused by a variety of factors, some increasing their risk depending on the sport, its pace, demographics, and setting. The speed of an NFL game and the way an NFL game is played (i.e., strategy) are different than in previous years. The players are more prominent, stronger, and faster.[16,23] When players collide with each other or against a surface, the velocity and force increase the risk of injuries. Likewise, the average number of plays also increased, with significantly higher plays in 2016 compared to 2009.[23] In professional basketball, players with higher usage rates (athletes who have the ball more often) are more likely to get hurt than those with lower usage rates due to increased fatigue.[11] A three-year study from 2012-2015 on NBA players demonstrated a 2.87% injury risk increase for every 96 minutes of play.[11] Furthermore, players who played the forward or center position requiring frequent twisting and jumping movements were also noted to have higher injuries.[12] Unfortunately, there is no equivalent statistic for American football (i.e., usage rate does not translate to American football). In American football, passing plays are becoming more common than running plays,[28,] which means the quarterback has the ball more often than in prior years. If results are similar to those of the NBA, quarterbacks have a higher usage rate and are potentially more likely to get hurt.

Demographics, such as age and sex, play a significant role in the risk of ATRs. A 2009 study found that the average age of all players sampled when suffering from an ATR injury was 29 years old (range 23-36 years) compared to the average age of all players in the NFL at 26.5 years, suggesting that these injuries are more common among experienced players.[17] The intensity of the sport being more extreme has caused older players to deteriorate quicker, with their bodies unable to keep up.[17] A four-year study in the US population from 2012 to 2016 also determined the highest incidence of ATRs in male patients 20-39 years who engaged in sports activities, with male players 3.5 times more likely to experience an Achilles rupture than females.[10] Other risk factors for ATRs are an athlete's prior injury history, style of play, and surface conditions. There is a possible correlation between the athletes who had experienced an injury to the lower extremities, especially foot injuries, during the prior season and the risk of subsequent ATRs during the NFL season.[9] A study with 197 elite Swedish football (soccer) players between the 2001 and 2002 seasons, respectively, found that 77% (151) of the players were injured in 2001, and 87% (131/151) of those injured players were also injured in the 2002 season.[5] Conversely, 48% (22/46) of the players without injury in 2001 remained healthy through the 2002 season.[5] In another study from 2009 to 2014, 80 NFL players suffered from their first career Achilles tendon tear, and of those 80 players, 12 (15%) reinjured themselves over the next two years.[34] From this data, many Achilles tears are often preceded by previous injuries. Despite advancements in physical therapy and kinesiology, there is still a huge risk for injury.

2. Limiting Factors

Injuries may still occur despite an individual's solid physical disposition and intensive training. Notably, the field of play conditions has also contributed to the drastic rise in injuries over the years. A key argument often brought up is how sports have evolved, such as using turf fields over grass fields. A 2018 study by Mack et al. analyzed that turf fields were associated with a 16% statistically significant increase in lower extremity injury compared to a natural field.[14] The same study concluded that the risk of noncontact injuries on synthetic turf was higher, between 1.20 to 2.10 times than on grass. These findings are significant because they highlight the risks of injuries on turf fields. The rationale for the increase in injuries is that synthetic turf fields are firmer than grass fields, thus making explosive movements on their surface more challenging. For example, if a player were to make a shifty or quick movement on a grass surface, cleats can rip through the grass, which ensures stability and allows for greater freedom of motion. Yet on artificial turf, cleats are less likely to break free from the ground, keeping the foot stuck and applying more strain onto the player's lower body. As a result, the likelihood of injury may increase due to this higher resistance. These explosive techniques, which include driving cleats into the ground or even aggressively taking a hit, pose a considerable threat to these fields.[14]

Medicine has made significant advancements through research and technology in recent years, all aimed at recovering athletes to their pre-injury condition and speeding up the return to play. It takes about 11 months (six to twelve months) to recover post-rehabilitation.[32,34] However, there has recently been an anomaly with NFL Quarterback and future Hall of Famer Aaron Rodgers of the New York Jets.[1] On September 11th, 2023, Rodgers was injured on the fourth play of the

game as his ankle snapped while being taken down.[1] With the Jets having a promising season ahead of them, this was a devastating loss for the team and fans. Contrary to general recovery timelines, Rodgers began throwing on the field within two months,[27,] and it became clear how unprecedented his recovery had been. He made such significant progress that in December 2023, he was officially cleared to start doing a modified practice with the team.[25] Rodgers was not allowed to take game-like repetitions with the team but participated in condensed movement, agility, and throwing drills.

3. Surgical Methods

In a typical rupturing of the Achilles, medical professionals use many different surgical methods. One of these forms of treatment is known as the Percutaneous Achilles Repair (PAR). PAR is a commonly used method involving several small incisions on the back of the calf to damage as little as possible.[29] These small incisions ensure maximized preciseness and allow it to be minimally invasive. Torn tendons are treated with needles and sutures to not only repair them (i.e., connect the separated ends as well). While surgeons conduct this process, they may potentially need to attach the tendon to the heel and the screws into the bone.[29]

Another frequent method is Open Achilles Repair (OAR). Contrary to PAR, OAR involves one large incision on the back of the calf to locate the ruptured Achilles tendon.[29] During the process, damaged tissue is removed, and strong sutures are utilized to repair the broken ends together.[29] After the sutures close the incision, the back of the calf is likely to be swollen for a few days following the procedure.

However, severely damaged tendons require an entirely separate treatment process. When a tendon is significantly severed or too short for sewing back together, the recommended method is the Tendon Transfer. Before the process, the big toe, or the Flexor Hallucis Longus, responsible for flexing and located at the back of the calf and inside from the ankle to the foot, is repositioned. It is disconnected from the big toe with about two to three ankle/calf incisions and anchored to the heel bone with a plastic screw. Finally, the tendon is sutured to the Achilles for reinforcement.[29]

Although these techniques have been proven effective, a meta-analysis[33] showed significant pros and cons within each method. In the Percutaneous surgery method, there was a drastically higher rate of sural nerve injury compared to open repair.[33] The sural nerve is located below the skin's surface, towards the back of the lower leg. It is responsible for how the lower part of the ankle and outside of the foot can feel external stimuli. An injury to this area is detrimental because of the chronic pain, loss of feeling, and limited mobility. Of the data collected, the Risk Ratio of sural nerve injury using the Percutaneous method was 3.52, meaning that it was 252% more likely to result in a nerve injury than the Open Repair ($P = 0.006$).[33] However, the deep infection rate for the Open Repair group was greater than the Percutaneous group. The risk ratio of deep infection in the percutaneous group was only 0.33,[33] which shows a 67% lower likelihood of contracting a deep infection. In other words, the Percutaneous group is much more likely to be at risk of sural nerve injury but less likely to get deep infection in relation to the Open Repair group. The meta-analysis also considered time of operation as another essential element to surgical decision-making. The operation time in the Percutaneous group was shorter, which benefits both the surgeon and the patient. Most notably, the risk ratio of the time of operation in the Percutaneous group was -1.99,[33,] indicating that a patient is roughly 100% less likely to have a longer time in surgery. Despite fundamental differences in each group, the Percutaneous and Open Repair groups had no differences in re-rupturing the tendon ($P = 0.61$).[33] The higher p-value of 0.61 indicates statistical insignificance, suggesting that the choice between Percutaneous or Open Repair does not impact the likelihood of a re-rupture. This data is an important consideration when choosing treatment options. The PAR is advantageous over tendon transfer because of its *pullout strength*,[30], which means that the repaired tendon can bear greater force and have a *larger surface area of contact between the bone and tendon*[30], promoting healing.

4. Case Study

A prime example of an outlier in the recovery process was NFL star QB Aaron Rodgers, who had a remarkable journey as he returned to playing only 77 days after an Achilles rupture.[13] In most cases, an Achilles tendon rupture is an injury that takes athletes an entire season to recover from, but Rodgers came back from this nine-month injury in just four months. He was treated using a relatively new speed bridge procedure,[2,] which creates an hourglass pattern of Fiberglass suture over the tendon's distal end. The method allows for foot stability with the ability to bear weight and range of motion immediately after the procedure,[2] which is crucial for regaining tendon strength. Even though it is a relatively new surgical procedure, the technique works to copy the tendon insertion's footprint. Fiberglass sutures are extremely strong and durable, which allows them to maximize healing and ensure a secure tendon. This method proves

to excel in many ways because it will enable one to resume activities early due to a decreased need for immobilization and prompt rehabilitation.[30]

When doctors were asked about Rodgers' procedure, they all spoke about their amazement at his recovery process. Dr. Sgana, one of the doctors working on Aaron, stated, "I do think that his recovery is much faster than expected and much faster than the majority of people with an Achilles rupture… already several months ahead of the typical Achilles repair." Later, Sgana would also mention, "I don't know if he's going to get there by the end of the season… This is a lot faster than I would have expected."[8] From this, it was clear that Rodgers was making substantial strides towards recovery but was nowhere near in the ideal shape to return to full-speed play. When giving the final verdict regarding the issue, the New York Jets' team doctors said that he was not in proper shape to return due to re-injury risk and should continue waiting for this recovery. None of them recommended he should go out there, but Aaron was determined. Finally, he was cleared to return to practice on November 29th, 2023, exactly 11 weeks following surgery.[4] As his 21-day practice window opened, this marked the fastest return from an Achilles surgery in NFL history.

5. Methods of Testing Recovery

After being deemed ready for practice, there is only speculation regarding the methods Rodgers could have used for rehabilitation. In the standard process, many functional and clinical tests are available to measure a player's readiness for return to play. A clinical test would measure the strength and flexibility of one part of the body, whereas a functional test measures the ability of that part to move and perform in a play.[7] Functional tests mimic a player's strength, flexibility, body coordination, and balance during play. Other psychological tests, such as the ALR-RSI, measure a player's psychological readiness and confidence to return to play after an Achilles tendon rupture.[24] The tests assess various data points, including potential similarities within the limbs, overall stability, control, and strengths and weaknesses. Ultimately, these variables collectively determine how effective an athlete's rehabilitation process will be and how it progresses. In recovery, athletes often categorize movement or flexibility as a key to complete rehabilitation. Strength is also crucial with movement and flexibility, offering clinicians an additional variable or metric to guide rehabilitation. For example, one of the tests to measure strength is the single leg hop for distance, when an individual jumps horizontally for distance using their weak leg to see how far they can jump. Typically, this is done as a comparison with the more muscular, healthy leg, and the goal is to have a less than '*10% difference in hop distance between the injured limb and uninjured limb*'.[20] Other hop tests to measure strength are the crossover hop test, the six-meter timed hop test,[20,] and the triple hop for distance. The only difference between a single and a triple-leg hop is that three consecutive hops are measured instead of a singular hop.[20] In a crossover hop, the player jumps as far as they can three consecutive times, and in a six-meter times hop, the player jumps as fast as they can over six meters, maintaining their balance each time. [20] Utilizing hop tests is easy to conduct and grade, making their interpretation simple for clinicians. There are other functional forms of testing, such as the Cooper test to measure endurance, the shuttle run test to measure speed, the T-test for agility, and the Y-balance test to measure stability.[7]

The functional tests focus on measuring symmetrical restoration between the affected and unaffected sides, assessing at-risk movement patterns, and assisting in making return-to-play decisions. Functional tests are often utilized for ease, affordability, and functional integration. Newer technological advancements, such as motion capture, can offer more insight than the distance covered in functional tests. As the name suggests, motion capture can capture the player's body mechanics in real-time as they perform various activities such as running, jumping, and hopping. This helps the player to evaluate their movements, which is vital during rehabilitation, and identify those that place them at a higher risk of an injury or a re-injury.[18] The disadvantage of this highly advanced resource is that only experienced professionals are skilled and licensed to operate it. Conversely, hop tests are usually done with local kinesiologists and physical therapists during rehabilitation, requiring little to no training. However, hop tests do not offer the same detailed analysis and accuracy as motion-capturing systems. While basic hop tests can identify immediate issues, they cannot perform an in-depth study and accuracy as motion-capturing systems. The affordability of motion capture is another disadvantage; therefore, it is primarily marketed toward upper-class and high-income athletes.

6. Modernized Rehabilitation

Rather than the conduction of standard testing procedures, the incorporation of force plates and Artificial Intelligence (AI) tools have revolutionized how athletes have recovered in recent years. A force plate is a device that measures the amount of force (in Newtons) an individual releases through impact on a particular surface. It is a surrogate measure of strength assessed when an individual *absorbs* and *generates* force. Absorption is the initial landing of the jump, representing the ground contact to the lowest point of the center of mass. On the other hand, the generation of force is the push-off, or the lowest point of the center of mass, to the toe leaving the ground. To evaluate whether athletes are

in their best form, they must ensure they can withstand and create a force. While there was not a single cut-off force difference between legs similar to the 10% difference in hop distance, a difference in forces *may* indicate that an individual is not at 100% clear to return. With Aaron Rodgers as an example, we can speculate that both legs must function with equal strength. Going onto a football field with an imbalance would cause significant performance barriers because one leg could not keep up with the other. In other words, Rodgers may continually favor his stronger leg, leading to overuse of that limb or the inability to withstand sudden forces through the weaker leg. As the sport continues to have a random and ever-changing competitive environment, both legs should be capable of withstanding the necessary force, absorption, and generation.

Technological advancements, such as machine learning, have served as substantial factors in learning about injuries and improving the rehabilitation process for athletes through data collection and analysis.[21] A tool that can potentially represent advancements is the OpenCap AI software,[26] a musculoskeletal tool that allows individuals to see their live motion capture on their smartphones.[18] The software is free to use and has mobile accessibility. The accessibility and free price make this modified form a better value option than a traditional motion capture system. Traditional motion capture systems require specialized infrared cameras, anywhere between six to ten cameras, and specialized processing software for those cameras. With the incorporation of only two phones, all joint angles and kinematics are accessible in OpenCap AI, which provides the whole picture regarding aspects such as progression, mobility, and flexibility. For example, jumping the exact distance during a functional test (e.g., triple hop jump test) does not mean both legs use the same biomechanics. When a healthy and unhealthy leg can jump the same distance, the unhealthy leg may rely on other compensatory joints and muscles to cover for it or use the same muscle differently. A healthy leg uses the glutes, quads, and calf muscles to propel the lower body and perform the jump. If one of these muscles is injured, the other muscles will overcompensate. As a result, an athlete may jump the same distance, but the muscles used for the jump may differ. The kinematics provided by OpenCap AI can capture these asymmetrical movements, assist the clinician in detecting and interpreting poor body mechanics, and reduce the risk of re-injuries. In this regard, OpenCap AI is superior to functional tests such as the triple hop jump test because it provides real-time visual feedback, as described above. Functional tests such as the hop test could still be used concurrently, given its benefit in studying the impact of body mechanics and applying it to develop healthy body mechanics while reducing the risk of injuries and re-injuries

7. Conclusion

As the intensity of the sport continues to grow, NFL players remain at high risk for injuries. Evidence indicates the rise of Achilles tendon injuries in athletes. Options for surgical and nonsurgical interventions are widely available. Methods such as Open Achilles Repair (OAR) and Percutaneous Achilles Repair (PAR) are the primary surgical methods professionals use when repairing tendons. Both of them are effective, as neither influences the rate of re-injury. During recovery, functional tests such as the single and triple leg hop for distance measure the progression of the tendon's rehabilitation, which are also helpful alongside open AI and similar technologically advanced tests. Although clinicians can interpret readiness for return to play using data from these tests, they cannot predict risks of re-injuries or train the player in body mechanics to prevent them. These limitations can be overcome with the use of new AI tools. However, advanced technology for improved rehabilitation often comes at a higher cost and may only be accessible to the wealthier population. Cheaper alternatives are needed to expand the use of these emerging technologies to the general population, and this could be an area for future research.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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