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# Career Outlook and Performance of Professional Athletes After Achilles Tendon Rupture: A Systematic Review

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## Abstract

**Background:** The purpose of this systematic review is to examine the literature on Achilles tendon (AT) injuries in professional athletes to determine their rate of return to play (RTP), performance, and career outcome after AT rupture.

**Methods:** A literature search of MEDLINE, Google Scholar, CINAHL, and Cochrane Library databases was performed. Included studies reported outcomes related to RTP (time and rate), durability and player participation, and player performance following AT rupture in professional athletes of the National Football League (NFL), National Basketball Association (NBA), Major League Baseball (MLB), and professional soccer leagues.

**Results:** Fifteen studies met inclusion criteria for analysis. Athletes were able to return to professional sport participation 76% of the time, with mean time to RTP of 11 months following AT injury. Athletes experienced a decline in player efficiency ratings, power ratings, and sport- and position-specific statistics in the NFL, NBA, and professional soccer leagues compared to noninjured controls. RTP rate was significantly lower following AT rupture in comparison to athletes sustaining other common orthopedic injuries such as anterior cruciate ligament injuries, meniscal tears, and ankle fractures in both NFL and NBA athletes.

**Conclusion:** AT rupture prohibits nearly 25% of professional athletes from returning to their respective sport. Of those able to return to compete at a professional level, the mean time to RTP is 11 months—nearly double the estimated 6-month recovery for RTP in the general population. Furthermore, player performance and durability were curtailed following AT rupture. This review of the literature should be used to set evidence-based goals and establish realistic expectations for RTP for elite athletes following AT injuries.

**Level of Evidence:** Level III, systematic review.

**Keywords:** Achilles tendon, professional athlete, return to sport, sport performance

Achilles tendon (AT) injuries are common among athletes, with ruptures occurring most frequently during athletic participation, notably soccer, tennis, basketball, and football.[6,13,18] Professional athletes participating in frequent acceleration and direction changes with excessive eccentric loading of the AT are at a relatively high risk of AT rupture.[2,5,21,22]

In the midst of the coronavirus disease 2019 (COVID-19) global pandemic, the world's professional sports leagues have largely been suspended or postponed. Injury rate data from the 2011 National Football League (NFL) lockout, when the offseason was prolonged and training camp was shortened, highlights a potential high-risk period for AT rupture as training schedules of professional athletes were altered.[11] Thus, professional athletes, who rely on their health and athletic abilities to perform at the highest level, could be placed into a vulnerable position in which history

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suggests may be high risk for certain orthopedic injuries.[11,12,14]

While there has been extensive study of return to play (RTP) and activity levels after AT rupture in the general population,[23] there has been no prior systematic review specifically examining the RTP and performance level of elite athletes after such an injury. Considering the financial and career implications in addition to the unique physical demands placed on athletes returning to professional sports, it is paramount to determine the impact that AT rupture and repair can have on the livelihood and career outlook of these athletes.

The purpose of this study is to examine Achilles tendon ruptures in professional athletes to determine their rate of RTP, performance, and career outcomes after AT repair. It is our hypothesis that these professional athletes will experience a significant decrease in sport participation levels, longer time to RTP compared to the general population, and, of those who do return to their respective sports, a decline in career performance compared to before AT rupture.

## Methods

The study was designed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol[17] using Cochrane Review Methods.

### *Search Strategy*

MEDLINE, Google Scholar, CINAHL, and the Cochrane Library were searched from their inception to May 10, 2020. The search terms included "Achilles Tendon Rupture," "Achilles Rupture," "Achilles Tendon Repair," "Achilles Repair," "Professional," "Athlete," "Sports," "Sports activity," and "Sport Performance" connected with the Boolean operators "AND" or "OR." Following identification of potential articles for inclusion, a screening of titles and abstracts addressing the research question of interest was performed. Afterward, relevant full-text articles were obtained and evaluated for eligibility based on the inclusion and exclusion criteria below to determine the final articles to be included and analyzed in the systematic review. The bibliographies of all selected publications were also searched for further studies that specifically pertained to RTP, timing of RTP, and performance of professional athletes after AT rupture.

### *Inclusion and/or Exclusion Criteria*

This article includes English-language studies that reported outcomes related to rate of RTP, time to RTP, durability and player participation, and player performance following AT rupture in professional athletes of the NFL, National Basketball Association (NBA), Major League Baseball (MLB), and professional soccer leagues. Studies that were excluded were those written in non-English language, case reports, or did not assess professional athletes, level of sport activity prior to AT injury, or player performance measures after AT rupture.

### *Quality Appraisal and Risk of Bias Assessment*

The Methodological Index for Non-Randomized Studies (MINORS) score was used to assess methodological quality and risk of bias for each study included in this review. This scoring system is a validated 8- or 12-item checklist that was designed to analyze the methodological quality of comparative and noncomparative nonrandomized studies. Comparative studies are evaluated using the 12-item checklist, while the 8-item checklist is used for noncomparative studies. Each checklist item is scored from 0 to 2, where a score of 0 is assigned when a checklist item is not addressed in the study, a score of 1 is assigned if an item is only partially addressed, and a score of 2 is provided if the checklist item was sufficiently addressed in the study.[15]

### *Data Collection and Abstraction*

Two investigators independently extracted data pertaining to return to professional sport and sport performance in athletes following AT rupture. Any disagreements were resolved by discussion among authors, with the senior author making the final decision on development of the data extraction tool and exclusion of case reports. The following data were extracted for the clinical studies: first author, year of publication, journal of publication, sample size, individual group demographics, mean follow-up, and the primary and secondary outcomes. The primary outcome measures were rate of RTP (playing at least 1 professional game since injury at the level prior to injury), player efficiency ratings (PERs), and time to RTP. Secondary outcomes included sport-specific player statistics (touchdowns, home runs, etc), games played, and minutes played.

## Results

### *Search Results*

The search returned a total of 2225 articles. After duplicates were excluded and the title and abstract screen was performed, 40 unique articles were retrieved for full-text screening. A total of 15 articles met the inclusion criteria above. The process of study selection is included in Figure 1. Risk of bias assessment using the MINORS criteria and details on selected studies are included in Tables 1 and 2 and Figure 2. Several studies included data extraction of player information from overlapping periods of time. To avoid such duplications of AT rupture and player performance data, only 1 study from each specific time period was included in the calculation of total number of patients and pooled demographic information. Studies of overlapping time periods included different reported outcomes, which were reported descriptively.

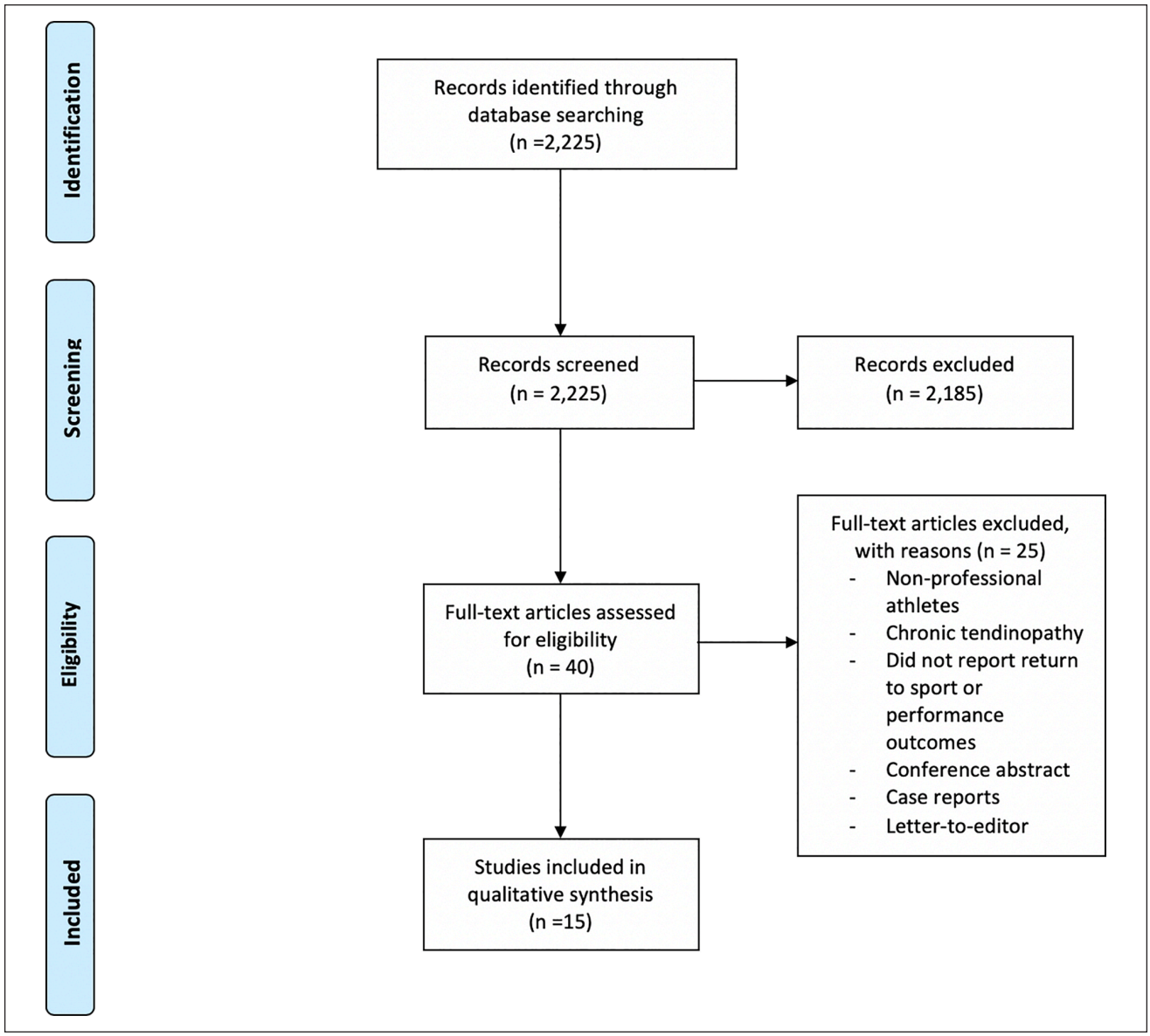


**Figure 1.** Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.

### *Quality of Evidence and Risk of Bias Assessment*

A total of 15 studies were assessed using MINORS criteria, including 9 case-control studies or case series and 6 cohort studies. The mean MINORS score was 15.5, including 18.2 for studies that included a control group and 11.3 for studies without a control group (Tables 1 and 2). Included studies contained clearly stated aims (15/15), end points that were appropriate to the study arm (15/15), inclusion of consecutive patients (11/15), and low loss of follow-up (15/15). No studies reported prospectively collected data (0/15), and prospective calculation of sample size was performed in few studies (4/15).

### *Patient Demographics*

The 15 studies that met inclusion criteria involved a total of 333 professional athletes sustaining AT rupture, including 111 different NFL players,[9,12] 44 NBA players,[7] 26 MLB players,[14] and 152 different professional soccer (including Major League Soccer [MLS] and European professional leagues) players.[3,8,20] Mean reported age of athletes was 29 years, with a mean playing experience of 7 years in their respective sports. Mean follow-up time was 2 years. All studies included patients with AT rupture who underwent operative repair. Specific study details and patient baseline demographic information are included in Tables 1 and 3.

**Table 1.** Study Characteristics From Each Study Included in This Systematic Review.

| Study (journal, year) | Level of evidence | No. of AT ruptures | Sport/league | Study purpose/aim | Inclusion, exclusion, study parameters | Study years | Measured outcomes | MINORS score |
|---|---|---|---|---|---|---|---|---|
| Parkeh et al[12] (*FAS*, 2009) | III, case control | 31 | NFL | To quantify the impact of AT rupture on player performance | Inclusion: NFL players who sustained AT rupture; 3 seasons before and after surgery | 1997-2002 | Timing of injury, games played, player power ratings | 17 |
| Jack et al[4] (*FAI*, 2017) | III, comparative series | 98 | NFL | To determine RTP rate, postoperative career length, and player performance in NFL players following AT repair | Inclusion: NFL players who sustained an AT rupture and underwent repair<br>RTP: Must play in 1 NFL game | 1958-2016 | RTP, career length, games/season, player performance | 17 |
| Yang et al[22] (*OJSM*, 2019) | III, case control | 80 | NFL | To evaluate factors related to RTP and performance following primary AT rupture | Inclusion: NFL player on 53- or 90-person active roster<br>Exclusion: Players with ipsilateral or contralateral AT rerupture<br>RTP: Must play in 1 regular season or postseason NFL game | 2009-2014 | RTP rate, games/season, games started | 18 |
| Mai et al[9] (*AJSM*, 2016) | IV, case series | 80 | NFL | To catalog the postoperative outcomes of orthopedic procedures in NFL athletes to compare respective prognosis and effects on careers | Inclusion: NFL athletes on active roster or injured reserve at the time of surgery<br>Exclusion: Athletes who were injured and underwent procedures before first NFL game<br>RTP: Return to active roster for at least 1 regular-season NFL game; immediate season after procedure was postoperative season 1 | 2003-2013 | Games played, Games started, seasons played, and performance score | 11 |
| Trofa et al[18] (*AJSM*, 2017) | III, cohort | 62 | NFL, NBA, MLB | To compare RTP rates and performance among professional athletes from different major leagues in the United States after AT rupture | Inclusion: Professional participation in ≥1 games for 2 consecutive seasons before injury, no confounding injuries, 2 years of professional play<br>Exclusion: Not 2 years preinjury experience, confounding injury | 1988-2013 | RTP, playing time, performance, player efficiency rating (NBA), season approximate value (NFL), batting average and earned run average (MLB) | 20 |
| Lemme et al[7] (*AJSM*, 2019) | IV, descriptive epidemiological | 44 | NBA | To characterize risk factors and outcomes after AT ruptures in NBA athletes | RTP: Play in at least 1 game after AT rupture; suboptimal recovery: failure to return or return with fewer than 10 career starts after AT rupture | 1969-2018 | Date of injury, laterality of injury, minutes played time to RTP, video analysis examining mechanism of injury | 13 |

*(continued)*

**Table 1. (continued)**

| Study (journal, year) | Level of evidence | No. of AT ruptures | Sport/league | Study purpose/aim | Inclusion, exclusion, study parameters | Study years | Measured outcomes | MINORS score |
|---|---|---|---|---|---|---|---|---|
| Amin et al[1] (*Clin Res Foot Ankle*, 2016) | III, case control | 18 | NBA | To evaluate NBA players with a spectrum of reported AT pathologies, from tendinopathy to complete rupture | Inclusion: NBA players with Achilles pathology (insertional and noninsertional tendinopathy)[a] | 1988-2011 | Player efficiency rating, minutes played | 20 |
| Minhas et al[10] (*AJSM*, 2016) | III, cohort | 24 | NBA | To compare RTP rate, career length, and performance-based outcomes after different orthopedic procedures | Inclusion: Players undergoing surgery for a primary reported diagnosis of AT rupture<br>Exclusion: Players with concurrent injuries; player efficiency rating normalized to a league mean of 15<br>RTP: Play at least 1 NBA game during postoperative season | 1984-2013 | RTP, games played, minutes played, player efficiency rating | 11 |
| Amin et al[2] (*AJSM*, 2013) | III, cohort | 18 | NBA | To assess performance before the injury, RTP, and subsequent performance of NBA players who sustained complete AT ruptures; assess variables that might predict a player's ability to return to competition | Inclusion: NBA players sustaining complete AT rupture with subsequent repair<br>Performance Assessment: 2 seasons pre- and postinjury | 1988-2011 | RTP, length of career, minutes played, player efficiency ratings | 20 |
| Saltzman et al[14] (*HSS J*, 2018) | III, therapeutic study | 26 | MLB | To determine the impact of AT rupture and repair on MLB players in terms of return to play and batting/fielding performance metrics | Inclusion: AT rupture with reconstruction<br>Exclusion: Patients injured in 2015 season, AT rupture in pitchers, other coexisting injuries or recent surgeries<br>RTP: Play season prior to injury and at least 50% (81/162) games for any single season | 1876-2015 | Standard baseball statistics (ie, batting average, earned run average, etc) | 18 |
| Grassi et al[3] (*BJSM*, 2020) | III, case series | 118 | Professional soccer | To evaluate the time to RTP following acute AT rupture and repair in professional male soccer players | Exclusion: Female professional soccer players, lower leagues, insufficient follow-up, rerupture of AT, coexisting injury<br>Time to Practice: Days absent from sport<br>RTP/Time to RTP: Play at least 1 minute of official match | 2008-2018 | RTP, time to RTP (practice and games) | 11 |
| Sochacki et al[16] (*JISAKOS*, 2019) | III, case control | 23 | MLS | To determine RTP rate, postoperative career length, and performance in MLS players following AT rupture | Inclusion: MLS players undergoing AT repair, minimum 1-year follow-up | — | RTP, career length, games/season, player performance | 16 |

*(continued)*

**Table 1. (continued)**

| Study (journal, year) | Level of evidence | No. of AT ruptures | Sport/league | Study purpose/aim | Inclusion, exclusion, study parameters | Study years | Measured outcomes | MINORS score |
|---|---|---|---|---|---|---|---|---|
| Trofa et al[19] (*OJSM*, 2018) | III, cohort | 24 | MLS, UEFA | To examine RTP, playing time, and performance of professional soccer players following AT rupture | Inclusion: Professional participation in at least 1 game in season prior to injury<br>Exclusion: Partial AT tear, goalkeeper position, other confounding injury<br>RTP: 1 professional game played in 2 consecutive seasons after injury | 1988-2014 | Playing time, minutes played, performance statistics (ie, games started, goals scored) | 18 |
| Vadala et al[20] (*MLTJ*, 2014) | III, case series | 36 | Soccer, tennis, running, gymnastics, skiing | To verify the mini-open technique as an effective treatment in professional athletes with AT rupture | Inclusion: Professional athlete, lack of prior AT injury, lack of prior local injection in area of AT tendon, surgery within 5 days of AT rupture, 24-month follow-up minimum<br>Exclusion: Prior systematic therapy with corticosteroids, patients with collagen disorders | 2008-2010 | Lower extremity strength, lower extremity elasticity, endurance trial, Hannover scale, VISA-A, sport participation | 11 |
| Maffulli et al[8] (*FAI*, 2011) | IV, case series | 9 | Soccer, tennis, rugby, hockey | To evaluate the outcome of percutaneous repair of an acute AT rupture in a cohort of elite athletes | Inclusion: Elite athlete (professional or at least the national level), sustained acute AT rupture within 2 weeks prior, no prior AT injury, unilateral AT tear, no other injury | 1996-2003 | Time to return to sport, surgical complication (infection) | 11 |

Abbreviations: *AJSM*, *American Journal of Sports Medicine*; AT, Achilles tendon; *BJSM*, *British Journal of Sports Medicine*; *Clin Res Foot Ankle*, *Clinical Research on Foot & Ankle*; *FAI*, *Foot & Ankle International*; *FAS*, *Foot & Ankle Specialist*; *HSS J*, *Hospital for Special Surgery Journal*; *JISAKOS*, *Journal of the International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine*; MINORS, Methodological Index for Non-Randomized Studies; MLB, Major League Baseball; MLS, Major League Soccer; *MLTJ*, *Muscle, Ligaments and Tendons Journal*; NBA, National Basketball Association; NFL, National Football League; *OJSM*, *Orthopaedic Journal of Sports Medicine*; RTP, return to play; UEFA, Union of Europeans Football Associations; VISA-A, Victorian Institute of Sports Assessment–Achilles; —, not applicable.

[a]Only cohort with AT rupture was examined.

**Table 2.** Methodological Index for Non-Randomized Studies (MINORS) Assessment of Risk of Bias.[a]

| Study (journal, year) | Study aim | Inclusion of consecutive patients | Prospective data | End point appropriate to study arm | Unbiased evaluation of end points | Follow-up period appropriate | Loss to follow-up not >5% | Prospective calculation of sample size | Control group having gold-standard intervention | Present groups | Baseline similar groups | Analyses adapted to the study design | Overall MINORS score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parkeh et al[12] (*FAS*, 2009) | 2 | 1 | 0 | 2 | 1 | 2 | 2 | 0 | 1 | 2 | 2 | 2 | 17 |
| Jack et al[4] (*FAI*, 2017) | 2 | 1 | 0 | 2 | 1 | 2 | 2 | 0 | 1 | 2 | 2 | 2 | 17 |
| Yang et al[22] (*OJSM*, 2019) | 2 | 1 | 0 | 2 | 1 | 2 | 2 | 0 | 2 | 2 | 2 | 2 | 18 |
| Mai et al[9] (*AJSM*, 2016) | 2 | 2 | 0 | 2 | 1 | 2 | 2 | 0 | | | | | 11 |
| Trofa et al[18] (*AJSM*, 2017) | 2 | 2 | 0 | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 20 |
| Lemme et al[7] (*AJSM*, 2019) | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | | | | | 13 |
| Amin et al[1] (*Clin Res Foot Ankle*, 2016) | 2 | 2 | 0 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 20 |
| Minhas et al[10] (*AJSM*, 2016) | 2 | 2 | 0 | 2 | 1 | 2 | 2 | 0 | | | | | 11 |
| Amin et al[2] (*AJSM*, 2013) | 2 | 2 | 0 | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 20 |
| Saltzman et al[14] (*HSS J*, 2018) | 2 | 2 | 0 | 2 | 1 | 2 | 2 | 0 | 1 | 2 | 2 | 2 | 18 |
| Grassi et al[3] (*BJSM*, 2020) | 2 | 2 | 0 | 2 | 1 | 2 | 2 | 0 | | | | | 11 |
| Sochacki et al[16] (*JISAKOS*, 2019) | 2 | 1 | 0 | 2 | 1 | 1 | 2 | 0 | 1 | 2 | 2 | 2 | 16 |
| Trofa et al[19] (*OJSM*, 2018) | 2 | 2 | 0 | 2 | 1 | 2 | 2 | 0 | 1 | 2 | 2 | 2 | 18 |
| Vadala et al[20] (*MLTJ*, 2014) | 2 | 2 | 0 | 2 | 1 | 2 | 2 | 0 | | | | | 11 |
| Maffulli et al[8] (*FAI*, 2011) | 2 | 2 | 0 | 2 | 1 | 2 | 2 | 0 | | | | | 11 |

Abbreviations: *AJSM*, *American Journal of Sports Medicine*; *BJSM*, *British Journal of Sports Medicine*; *Clin Res Foot Ankle*, *Clinical Research on Foot & Ankle*; *FAI*, *Foot & Ankle International*; *FAS*, *Foot & Ankle Specialist*; *HSS J*, *Hospital for Special Surgery Journal*; *JISAKOS*, *Journal of the International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine*; *MLTJ*, *Muscle, Ligaments and Tendons Journal*. *OJSM*, *Orthopaedic Journal of Sports Medicine*.

[a]Studies without controls were only assessed with the 8-point MINORS scale.


**Figure 2.** Risk of bias summary: review authors' judgments about each risk of bias item of Methodological Index for Non-Randomized Studies (MINORS) subscale for each included study (+, low risk of bias; ?, unclear risk of bias; –, high risk of bias). Studies without controls were only assessed with the 8-point MINORS scale.

**Table 3.** Patient Demographics/Athlete Factors.

| Study (journal, year) | Age, mean ± SD, y | Mean BMI at time of surgery, kg/m$^2$ | Playing experience prior to injury, mean ± SD, y | Timing of injury | Time to return to play, mean ± SD, mo | Postinjury career length, mean ± SD, y | Performance evaluation period (after injury) |
|---|---|---|---|---|---|---|---|
| Parkeh et al[12] (*FAS*, 2009) | 29 ± 3.3 | | 6 ± 3.5 | Preseason: 11/31 (35%)<br>Regular-season game: 20/31 (65%); no injuries during practice in regular season | 11 | | 3 seasons |
| Jack et al[4] (*FAI*, 2017) | 28 ± 2.8 | | 5.5 ± 2.8 | Offseason: 63/98 (64%) | 11.2 ± 2.8 | Control: 3.6 ± 2.1<br>Cases: 2.7 ± 2.1 | 3 seasons |
| Yang et al[22] (*OJSM*, 2019) | 26 ± 0.73 | No-RTP: 30.14<br>RTP: 32.54 | No-RTP: 3.0 ± 0.7<br>RTP: 3.84 ± 0.4 | | 11.9 ± 0.6 | | |
| Mai et al[9] (*AJSM*, 2016) | | | | | 12.3 ± 4.3 | 1.6 (27.3 games) | 3 seasons |
| Trofa et al[18] (*AJSM*, 2017) | 29.5 ± 3.2 | NFL: 33.3<br>NBA: 26.1<br>MLB: 27.7 | Overall: 6.4 ± 3.5<br>NFL: 6.0<br>NBA: 7.2<br>MLB: 5.0 | | | | 2 seasons |
| Lemme et al[7] (*AJSM*, 2019) | 28.3 ± 3.5 | 25.6 ± 2.5 | 6.8 ± 3.7 | Regular-season game: 29/37 (78.3%)<br>Practice: 8/37 (21.7%) occurred during practice<br>Early regular season: 12/44 (27.3%) | 10.5 ± 2.75 | 2.8 ± 2.3 | |
| Amin et al[1] (*Clin Res Foot Ankle*, 2016) | 28.8 ± 4.3 | 25.4 ± 2.4 | 6 ± 4.5 | | | | |
| Minhas et al[10] (*AJSM*, 2016) | 28.4 ± 3.2 | 25.6 ± 2.8 | 6.5 ± 3.8 | | | 3.7 ± 0.6 | 3 seasons |
| Amin et al[2] (*AJSM*, 2013) | 29.7 ± 2.5 | 25.6 ± 1.75 | 7.6 ± 2.5 | | | 7.6 ± 2.5 | 2 seasons |

*(continued)*

**Table 3. (continued)**

| Study (journal, year) | Age, mean ± SD, y | Mean BMI at time of surgery, kg/m$^2$ | Playing experience prior to injury, mean ± SD, y | Timing of injury | Time to return to play, mean ± SD, mo | Postinjury career length, mean ± SD, y | Performance evaluation period (after injury) |
|---|---|---|---|---|---|---|---|
| Saltzman et al[14] (*HSS J*, 2018) | 31.5 ± 3.2 | 25.9 ± 1.6 | 9 | Preseason or regular season: 18/26(69%)<br>Offseason: 5/26 (19%)<br>Playoffs: 3/26 (12%) | | | 3 seasons |
| Grassi et al[3] (*BJSM*, 2020) | 27.2 ± 7.2 | 23.64 | | | Return to practice: 6.5 ± 1.7<br>Return to play: 9.0 ± 3.7 | | |
| Sochacki et al[16] (*JISAKOS*, 2019) | 28.4 ± 4.0 | | | | 10.1 ± 6.5 | Controls: 4.5 ± 3.0<br>Cases: 2.5 ± 2.2 | 1 season |
| Trofa et al[19] (*OJSM*, 2018) | 29 | 24 ± 1.9 | 8.3 ± 3.8 | | | | 2 seasons |
| Vadala et al[20] (*MLTJ*, 2014) | 29.7 ± 13.5 | | | Regular-season match: 5/36 (13.8%)<br>Practice/training: 31/36 (86.2%) | | | 2 years |
| Maffulli et al[8] (*FAI*, 2011) | 34.2 ± 13.1 | | | | 4.8 ± 0.9 | | 3.5 years |

Abbreviations: *AJSM*, *American Journal of Sports Medicine*; *BJSM*, *British Journal of Sports Medicine*; BMI, body mass index; *Clin Res Foot Ankle*, *Clinical Research on Foot & Ankle*; *FAI*, *Foot & Ankle International*; *FAS*, *Foot & Ankle Specialist*; *HSS J*, *Hospital for Special Surgery Journal*; *JISAKOS*, *Journal of the International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine*; MLB, Major League Baseball; *MLTJ*, *Muscle, Ligaments and Tendons Journal*; NBA, National Basketball Association; NFL, National Football League; *OJSM*, *Orthopaedic Journal of Sports Medicine*; RTP, return to play.

### Rate of Return to Play

Fourteen of 15 studies, including 315 different professional athletes, specifically addressed the ability to return to professional sports following AT rupture.* The determination of RTP required participation in at least 1 professional event after the index procedure, and the mean overall rate of RTP was 76.4%.[1,3] Specifically, 5 studies addressed RTP in the NFL,[4,9,12,18,22] with RTP rates ranging from 65.6% (21/32)[18] to 72.5% (58/80).[9] When compared to other common orthopedic procedures, RTP following AT repair was the second lowest (72.5%), even lower than that of anterior cruciate ligament (ACL) reconstruction and ankle fracture fixation, with patellar tendon repair (50.0%) being the lowest.[9] Furthermore, nonskill position players (linemen) were found to return to play 75% of the time, whereas skilled position players only returned 52.8% of the time.[22]

Four studies, consisting of 111 total patients, analyzed RTP after AT rupture for NBA players. Return to play ranged from 61% (11/18) to 79.5% (35/44), with older and more experienced players generally having a lower rate of RTP.[2,7,10,18] AT tears caused a significantly lower rate of RTP (70.8%, $P = .005$) than that of other procedures such as ACL reconstruction (84.6%), meniscus repair (81.5%), and fixation of hand/wrist/foot fractures (>90%). For MLB players, however, there was a 61.9% (13/21) RTP rate, in which RTP was defined as the ability to play at least 81 games the season following their index injury.[14] Four studies specifically examined RTP in professional soccer players.[3,16,19,20] RTP rate was as high as 94.9% (112/118) in professional soccer players across the world's top leagues,[3] while RTP rate specifically for MLS players was 70% to 78%.[16] In addition, 86% of professional athletes (31/36) resumed their preoperative sports level within 5 months and 100% (36/36) of the athletes had returned by 10 months following combined percutaneous and mini-open repair for AT rupture.[20]

### Time to Return to Play

Seven of 15 studies reported on the time to return to play for professional athletes following AT repair.[3,4,7,9,12,16,22] Overall, the mean time to return to play for professional athletes was 10.6 months. Specifically, the time to return to play of NFL players was 11 to 12 months.[4,9,12,22] In NFL players, the mean time to return to play following AT rupture (12.3 ± 4.3 months) was significantly longer or comparable to many commonly used orthopedic procedures (knee microfracture surgery, ACL reconstruction, patellar tendon repair, ankle or tibial shaft fracture fixation).[9] In addition, running backs experienced the longest time to return to play (11.9 ± 3.9 months) of all NFL positions.[4] In the NBA, mean time to return to play was 10.5 months (range, 5-16) following AT repair.[7] In professional soccer players, Grassi et al[3] reported average time until practice of 6.6 ± 1.7 months. Interestingly, those who played at an international level returned significantly quicker, approximately 1 ± 0.4 months faster that those who did not participate in international competition (participation on their national team roster). Overall, professional soccer players returned to competitive matches between 9 and 10 months following AT rupture.[16]

### Player Durability and Playing Time Before and After Achilles Tendon Rupture

Eleven of 15 studies compared player durability, specifically the number of games played per season, and amount of playing time for professional athletes before vs after AT rupture.† Five studies specifically examined games played per season in NFL players, which overall demonstrated a 13.7% to 47.1% decrease in mean games per season following AT rupture.[4,9,12,18,22] Specifically, Parekh et al[12] reported an average of 11.67 NFL games played in the 3 seasons prior to injury but an average of 6.17 games played in the 3 seasons following AT rupture. In addition, Mai et al[9] reported that NFL players returning to play following AT rupture injuries played 2.7 ± 0.9 fewer games in postinjury season 1 compared to preinjury seasons and played significantly fewer future career games (27.3) and had shorter careers (average post-AT repair career length: 1.6 years vs 2.1 years overall) than those undergoing other common orthopedic sports medicine procedures such as ACL reconstruction and patellar tendon repair. Interestingly, while Trofa et al[18] reported a significant reduction in pre- to postinjury average games/season (15 vs 12.9 games/season), there was no statistical significance in total games/season ($P = .053$) or number of games started ($P = .119$) by year 2 following injury.

Five studies specifically addressed durability or playing time in NBA athletes following AT repair.[1,2,7,10,18] There was a 32% reduction in games/season (preoperative: 72 games, first postoperative season: 48.9 games, second postoperative season: 49.7 games) and approximately 53% reduction in total minutes played preoperatively compared to the first and second seasons postoperatively following AT repair.[18] NBA athletes started significantly fewer games 1 year postoperatively compared to the season prior to injury (20.8 vs 49.4),[7] and NBA players played approximately 5 fewer minutes per game after AT injury.[1,2]

Professional soccer players who returned to play after AT rupture played in significantly fewer games compared to matched controls (23.2 ± 6.5 vs 13.4 ± 8.4 games/season).[16] Specifically, players participated in 82.1% (27.9

* References 1-3, 4, 7, 9, 10, 12, 14, 16, 18-20, 22.

† References 1, 2, 4, 7, 9, 10, 12, 16, 18, 19, 22.

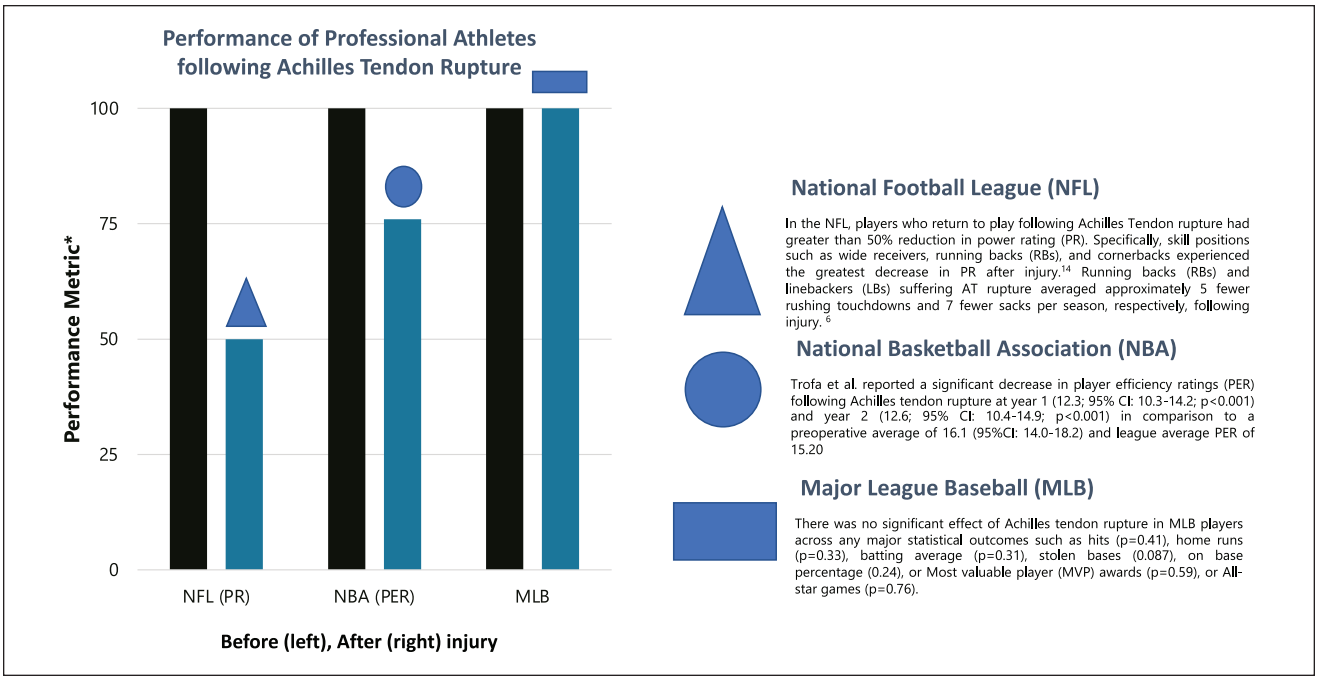


**Figure 3.** Performance of professional athletes following Achilles tendon rupture.

± 7.8 vs 22.9 ± 9.9 games) of games in their first full season and 78.1% (27.9 ± 7.8 vs 21.8 ± 10.1 games) of games in season 2 after injury compared to the season prior to injury.[19] Furthermore, total minutes played following injury was only 71.7% that of total minutes played prior to injury (2112 ± 785 vs 1514 ± 876 minutes).[19]

## *Performance of Professional Athletes Following Achilles Tendon Rupture*

Twelve of 15 studies specifically compared player performance ratings of professional athletes prior to injury vs following AT rupture and repair, including 5 studies addressing NFL athletes,[4,9,12,18,22] 5 studies including NBA players,[1,2,7,10,18] 2 studies of professional soccer players,[16,19] and 2 studies analyzing MLB athletes (Figure 3).[14,18] Measures of player performance were primarily demonstrated through position-relevant statistics, calculations of PERs, and power rating (PR), which is a numerical value commonly used by analysts to indicate the relative strength of a player's performance based on a collection of performance variables.[12] In the NFL, players who returned to play following AT rupture had greater than 50% reduction in PR. Specifically, skill positions such as wide receivers, running backs, and cornerbacks experienced the greatest decrease in PR after injury.[12] Running backs and linebackers sustaining AT rupture averaged approximately 5 fewer rushing touchdowns and 7 fewer sacks per season, respectively, following injury.[4] Using calculations of a player's season approximate value (SAV), a performance metric created to indicate a player's performance as it contributes to a fraction of his or her team's overall success,[18] Trofa et al[18] demonstrated significant reductions in years 1 (69.5%; 5.6; 95% CI, 3.9-7.3) and 2 (67.1%; 5.9; 95% CI, 4.1-7.7) postoperatively compared to preoperative SAV (8.7; 95% CI, 6.5-10.8).

In the NBA, PER is used as an effective metric to demonstrate the per-minute rating of a player's performance. A total of 5 studies reported a decrease in PER for NBA players following AT rupture.[1,2,7,10,18] Specifically, Trofa et al[18] reported a significant decrease in PER following AT rupture at year 1 (12.3; 95% CI, 10.3-14.2; $P < .001$) and year 2 (12.6; 95% CI, 10.4-14.9; $P < .001$) in comparison to a preoperative average of 16.1 (95% CI, 14.0-18.2) and league average PER of 15. Furthermore, Minhas et al[10] compared changes in PER following common orthopedic procedures and demonstrated an average PER decrease of 2.46 (95% CI, −4.86 to −0.10; $P = .045$) in those with AT rupture—a greater decrease in PER than that seen following ACL reconstruction, meniscus repair, and knee microfracture surgery. Interestingly, there was no significant effect of AT rupture in MLB players across any major statistical outcomes such as hits ($P = .41$), home runs ($P = .33$), batting average ($P = .31$), stolen bases (0.087), on-base percentage (0.24), most valuable player awards ($P = .59$), or all-star games ($P = .76$).[14]

### *Rate of Achilles Reinjury Upon Return to Sport*

Two studies reported the rate of ipsilateral Achilles rerupture following the return of professional soccer players to competition.[3] In a study of 80 NFL players sustaining AT rupture, 12 (15%) of these players had a subsequent AT rerupture within 2 years following surgery.[22] Of the 71 athletes who returned to play at least 2 years of professional soccer following injury, 8 (6%) sustained a rerupture of the previously injured AT.

## Discussion

The results of this systematic review demonstrate that AT rupture is a potentially career-altering injury for professional athletes, with 24% of athletes not being able to return to sport. For those who do return to professional play following AT rupture, return to play at a professional level, across all sports, takes approximately 11 months on average. Despite RTP, performance commonly falls short compared to preinjury levels among professional athletes, as clearly seen in professional basketball, football, and soccer (Figure 3).

Return to play was about 76% for professional athletes. Literature predicting the likelihood and speed at which this return can safely occur is limited, however, with respect to the general population and professional athletes. In their 2016 systematic review and meta-analysis on RTP rates following AT rupture in the general population, Zellers et al[23] reported that 80% of patients successfully returned to play. While this statistic alone is noteworthy, this statistic must be interpreted with respect to the limitations and subjective biases inherent in the methods used to delineate RTP across all included studies that spanned both professional athletes and the general population. The resumption of preinjury levels of activity is a common goal for many patients who endure an AT rupture. The validity of their analysis relies heavily on the objectivity of determining a given patient's return to preinjury level of sport (eg, performance). For professional athletes, the meticulous cataloguing of sports statistics such as player efficiency ratings, minutes played, points scored, or yards earned after contact allows for an objective comparison to be drawn between performance levels before and after AT rupture. For the general population, on the other hand, the most likely scenario is a subjective estimate without the luxury of nuanced statistics but, nevertheless, an important component of determining success of treatment following AT rupture.

The results of our systematic review demonstrate that RTP—to full, game-ready participation—at a professional level, across all sports, takes approximately 11 months. This duration is nearly double what has previously been reported for time to return to play for the general population described by Zellers et al.[23] This finding may relate to the heightened physical demands, durability requirements, and frequency of activity that professional athletes must endure relative to the general population whose work does not demand frequent acceleration and direction changes that precipitate risk of a healing AT.[2,5,21,22] Thus, it is not just returning to the sport but returning at the required "elite" level to play. Specifically, NFL athletes who rely heavily on speed and agility—skill-position players (running backs, wide receivers, cornerbacks)—experienced a significantly reduced performance and career production following AT rupture in comparison to linemen, thus potentially delaying their return to play.[12]

Upon initial analysis, Saltzman et al[14] found no significant effect of AT rupture on MLB player performance before and after injury. However, when "sidedness" (eg, a player's dominant foot) was able to be determined, players with an AT rupture of the "power" side had fewer stolen bases, fewer triples, increased times caught stealing, and lower speed scores compared to "nonpower" Achilles injuries—suggesting that a player's speed and explosiveness are most significantly affected by AT rupture.[14]

With this rationale, expectations for when one can safely return to preinjury performance levels with respect to Achilles rupture may correlate with the anticipated demands that that specific athlete has for their specific position for their specific sport. These athletes must understand that the higher demand on their position might require longer/sustained conditioning and strengthening to achieve an appropriate durability for safe participation with likely a lower performance production upon return.

With respect to professional basketball, player efficiency ratings were significantly reduced across 5 studies focusing on NBA competition following AT rupture. Studies focusing on AT rupture in professional football saw efficiency ratings similarly fade, especially for skill positions (eg, running backs, cornerbacks, and receivers) compared to linemen. Interestingly, player statistics following AT rupture were largely unaffected compared to uninjured controls in MLB play. The results of our study may provide elite athletes and their providers an approximation of future performance following AT rupture but may also help temper the expectations of lesser athletes' performance upon returning to play.

The consequences of making too brisk a return to full competition in professional sports with respect to AT injury are evident from widespread stoppage of conditioning during the NFL lockout in 2011. During the 2011 NFL offseason, players spent the entirety of their 14-week offseason with minimal access to workout facilities, strength and conditioning coaches, and the health professionals and training staff that they are usually accustomed to. When the lockout ended, players had a mere 19 days of access to training facilities and staff prior to the start of the first preseason game. Myer et al[11] examined injury rate data before and

after the 2011 NFL lockout. Despite previous estimates of 5 to 8 AT ruptures per NFL season,[9,12] in 2011, there were a total of 12 AT ruptures—within the first 30 days of the lockout ending. Furthermore, 10 of these injuries occurred within the first 2 weeks after the lockout ended.[11] Parekh et al[12] had previously reported that only 35% (1.75-2.8) of AT ruptures in the NFL occurred in the preseason. After the lockout, the yearly average was already surpassed after the second 2011 *preseason* game. Although unfortunate, this professional sports-historical anomaly provides evidence of the relative vulnerability of the AT in elite competition when not subject to sustained conditioning and strengthening and also highlights the importance of recovery in returning to elite competition following AT rupture.

### *Limitations*

The findings of this study must be considered with respect to its limitations. First, in both amateur and professional athletes, uniformity with regard to clear definitions or criteria for return to play is lacking. While the study methods are unique, we feel that the use of objectively obtainable data such as player statistics and performance metrics offers some reliability and validity in the present study compared to self-reported measures in the nonprofessional athletes. Second, many of the included studies included methodology relying on online resources of injury lists and player registries to identify included cases. Such methodology precludes obtainment of patient medical data and potential confounding injuries to include along with the performance outcomes reported in this study. A few of the studies included in this review sought to minimize this bias through the use of matched controls, accounting for factors such as preinjury performance, patient age, and previous playing experience. Furthermore, since most of this information was obtained from public records, this introduces selection bias for higher-profile athletes to be identified and examined, and we cannot guarantee that all AT rupture cases were captured. In addition, while all of the reported AT rupture cases were managed with operative repair, the nature of these studies and data obtainment precluded further insight into the specific operative details or techniques offered to athletes in all but 2 studies.[8,20] Last, the assessment of RTP in professional athletes, in which seasons do not last an entire calendar year, is difficult to account for considering that AT rupture is typically a season-ending injury. Injuries sustained at the end of a season may have the appearance of a faster time to return to play than those occurring at the beginning of a season. We acknowledge this limitation and believe that inclusion of additional athlete parameters such as RTP rate, player durability, and player performance upon returning to play compared to athletes sustaining other orthopedic injuries is subject to fewer temporal biases and helps to provide an all-encompassing review of the overall impact that AT rupture has on professional athletes. Despite these biases and limitations, this study provides valuable information to the foot and ankle and sports medicine community as it provides a comprehensive review of professional athletes across 4 major sports and highlights the inherent differences in return to play between professional athletes and the general population.

## Conclusion

AT rupture is a devastating injury that leaves 24% of professional athletes unable to return to their respective sports. While reporting on the timing of an injured athlete's return to sport can be skewed by such factors as seasonal patterns and injury timing, the existing literature demonstrated that athletes who are able to return to professional sports required 11 months of postinjury rehabilitation and recovery.[8,23] Of those able to return to compete at a professional level, player performance, durability, and career length were reduced following AT rupture, specifically with NFL, NBA, and professional soccer players being more significantly affected than MLB players. This review of the literature will allow high-level athletes, sports medicine physicians, and orthopedic surgeons to set evidence-based goals and establish realistic expectations for postoperative return to professional sports.

### Declaration of Conflicting Interests

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### References

1. Amin NH, McCullough KC, Mills GL, et al. The impact and functional outcomes of Achilles tendon pathology in National Basketball Association players. *Clin Res Foot Ankle*. 2016;4(3):205.
2. Amin NH, Old AB, Tabb LP, Garg R, Toossi N, Cerynik DL. Performance outcomes after repair of complete Achilles

tendon ruptures in national basketball association players. *Am J Sports Med*. 2013;41(8):1864-1868.
3. Grassi A, Rossi G, D'Hooghe P, et al. Eighty-two per cent of male professional football (soccer) players return to play at the previous level two seasons after Achilles tendon rupture treated with surgical repair. *Br J Sports Med*. 2020;54(8):480-486.
4. Jack RA II, Sochacki KR, Gardner SS, et al. Performance and return to sport after Achilles tendon repair in National Football League players. *Foot Ankle Int*. 2017;38(10):1092-1099.
5. Kujala UM, Sarna S, Kaprio J. Cumulative incidence of Achilles tendon rupture and tendinopathy in male former elite athletes. *Clin J Sport Med*. 2005;15(3):133-135.
6. Lemme NJ, Li NY, DeFroda SF, Kleiner J, Owens BD. Epidemiology of Achilles tendon ruptures in the United States: athletic and nonathletic injuries from 2012 to 2016. *Orthop J Sport Med*. 2018;6(11):2325967118808238.
7. Lemme NJ, Li NY, Kleiner JE, Tan S, DeFroda SF, Owens BD. Epidemiology and video analysis of Achilles tendon ruptures in the National Basketball Association. *Am J Sports Med*. 2019;47(10):2360-2366.
8. Maffulli N, Longo UG, Maffulli GD, Khanna A, Denaro V. Achilles tendon ruptures in elite athletes. *Foot Ankle Int*. 2011;32(1):9-15.
9. Mai HT, Alvarez AP, Freshman RD, et al. The NFL Orthopaedic Surgery Outcomes Database (NO-SOD): the effect of common orthopaedic procedures on football careers. *Am J Sports Med*. 2016;44(9):2255-2262.
10. Minhas S V, Kester BS, Larkin KE, Hsu WK. The effect of an orthopaedic surgical procedure in the National Basketball Association. *Am J Sports Med*. 2016;44(4):1056-1061.
11. Myer GD, Faigenbaum AD, Cherny CE, Heidt RSJ, Hewett TE. Did the NFL lockout expose the Achilles heel of competitive sports? *J Orthop Sports Phys Ther*. 2011;41(10):702-705.
12. Parekh SG, Wray WH III, Brimmo O, Sennett BJ, Wapner KL. Epidemiology and outcomes of Achilles tendon ruptures in the National Football League. *Foot Ankle Spec*. 2009;2(6):283-286.
13. Raikin SM, Garras DN, Krapchev P V. Achilles tendon injuries in a United States population. *Foot Ankle Int*. 2013;34(4):475-480.
14. Saltzman BM, Tetreault MW, Bohl DD, Tetreault D, Lee S, Bach BRJ. Analysis of player statistics in Major League Baseball players before and after Achilles tendon repair. *HSS J*. 2018;14(2):223-224.
15. Slim K, Nini E, Forestier D, Kwiatkowski F, Panis Y, Chipponi J. Methodological Index for Non-Randomized Studies (MINORS): development and validation of a new instrument. *ANZ J Surg*. 2003;73(9):712-716.
16. Sochacki KR, Jack II RA, Hirase T, et al. There is a high return to sport rate but with reduced career lengths after Achilles tendon repair in Major League Soccer players. *JISAKOS*. 2019;4(1):15-20.
17. Stovold E, Beecher D, Foxlee R, Noel-Storr A. Study flow diagrams in Cochrane systematic review updates: an adapted PRISMA flow diagram. *Syst Rev*. 2014;3(1):54.
18. Trofa DP, Miller JC, Jang ES, Woode DR, Greisberg JK, Vosseller JT. Professional athletes' return to play and performance after operative repair of an Achilles tendon rupture. *Am J Sports Med*. 2017;45(12):2864-2871.
19. Trofa DP, Noback PC, Caldwell J-ME, et al. Professional soccer players' return to play and performance after operative repair of Achilles tendon rupture. *Orthop J Sport Med*. 2018;6(11):2325967118810772.
20. Vadala A, Lanzetti RM, Ciompi A, Rossi C, Lupariello D, Ferretti A. Functional evaluation of professional athletes treated with a mini-open technique for Achilles tendon rupture. *Muscles Ligaments Tendons J*. 2014;4(2):177-181.
21. Wertz J, Galli M, Borchers JR. Achilles tendon rupture: risk assessment for aerial and ground athletes. *Sports Health*. 2013;5(5):407-409.
22. Yang J, Hodax JD, Machan JT, et al. Factors affecting return to play after primary Achilles tendon tear: a cohort of NFL players. *Orthop J Sport Med*. 2019;7(3):1-8.
23. Zellers JA, Carmont MR, Gravare Silbernagel K. Return to play post-Achilles tendon rupture: a systematic review and meta-analysis of rate and measures of return to play. *Br J Sports Med*. 2016;50(21):1325-1332.