Return to Play and Player Performance After Achilles Tendon Rupture in UEFA Professional Soccer Players

A Matched-Cohort Analysis of Players From 1999 to 2018

Enrico M. Forlenza,* MD, Ophelie Z. Lavoie-Gagne,* MD, Yining Lu,* MD, Connor C. Diaz,* BA, Jorge Chahla,* MD, PhD, and Brian Forsythe,*† MD

Investigation performed at the Division of Sports Medicine, Midwest Orthopaedics at Rush, Chicago, Illinois, USA

Background: Achilles tendon rupture (ATR) is a potentially career-ending injury in professional athletes. Limited information exists regarding return to play (RTP) in professional soccer players after this injury.

Purpose: To determine the RTP rate and time in professional soccer players after ATR and to evaluate player performance relative to matched controls.

Study Design: Cohort study; Level of evidence, 3.

Methods: We evaluated 132 professional soccer players who suffered an ATR between 1999 and 2018. These athletes were matched 2:1 to uninjured controls by position, age, season of injury, seasons played, and height. We collected information on the date of injury, the date of RTP, and player performance metrics (minutes played, games played, goals scored, assists made, and points per game) from official team websites, public injury reports, and press releases. Changes in performance metrics for the 4 years after the season of injury were compared with metrics 1 season before injury. Univariate comparisons were performed using independent-sample, 2-group *t* tests and Wilcoxon rank-sum tests when normality of distributions was violated.

Results: The mean age at ATR was 27.49 ± 4.06 years, and the mean time to RTP was 5.07 ± 2.61 months (18.19 ± 10.96 games). The RTP rate was 71% for the season after injury and 78% for return at any timepoint. Overall, 9% of the injured players experienced a rerupture during the study period. Compared with controls, the injured players played significantly less (-6.77 vs -1.81 games [$P < .001$] and -560.17 vs -171.17 minutes [$P < .05$]) and recorded fewer goals (-1.06 vs -0.29 [$P < .05$]) and assists (-0.76 vs -0.02 [$P < .05$]) during the season of their Achilles rupture. With the exception of midfielders, there were no significant differences in play time or performance metrics between injured and uninjured players at any postinjury timepoint.

Conclusion: Soccer players who suffered an ATR had a 78% RTP rate, with a mean RTP time of 5 months. Injured players played less and demonstrated inferior performance during the season of injury. With the exception of midfielders, players displayed no significant differences in play time or performance during any of the 4 postinjury seasons.

Keywords: soccer; player performance; return to play; Achilles tendon rupture; Union of European Football Associations

Achilles tendon rupture (ATR) is an infrequent injury that can be detrimental to a patient's quality of life and ability to return to play (RTP). ATRs most frequently occur in middle-aged men during a sudden increase in high-intensity jumping and running after periods of relative deconditioning.[9,13,33] Incidences among the general population have been reported[13,20,23] to range from 4.7 to 24 per 100,000, with a consistent upward trend over a 15-year period.[23] The radiostereometric analysis as well as biomechanical investigations after recovery from ATR have identified inferior elastic properties in the healed Achilles tendon as well as persistently decreased muscle strength and endurance at up to 12 months after surgical repair.[5,8] Functionally, athletes have been found to develop compensatory running mechanics after ATR, indirectly increasing the risks of subsequent knee injuries.[14]

While the injury is common among "weekend warriors," professional athletes are similarly at risk because of the serious ramifications of ATRs on RTP. Previous studies have shown ATRs to have devastating consequences on

The Orthopaedic Journal of Sports Medicine, 9(9), 23259671211024199
DOI: 10.1177/23259671211024199

performance metrics in professional basketball, American football, baseball, and hockey players.[1,2,19,27,35] However, the performance data for RTP after ATRs in professional soccer remains sparse. In a study of the Union of the European Football Association (UEFA) Champions League, Gajhede-Knudsen et al[10] found the incidence of Achilles tendinopathy to be 0.18 injuries per 1000 hours and the incidence of ATR to be 0.01 per 1000 hours, with ATRs resulting in 161 ± 65 days of lost playing time. The authors did not investigate performance metrics as an outcome of interest, despite evidence of long-term healing.

With the increased participation in professional soccer both globally and in the United States,[7] it is important to assess the impact of ATRs on athletes' performance after RTP. The purpose of this investigation was to determine the timing and the rate of RTP among elite professional soccer players and to compare the performance metrics of players after RTP from ATRs with those of matched, uninjured controls. We hypothesized that the rate of RTP after ATR would be low relative to other lower extremity injuries requiring surgical intervention, including anterior cruciate ligament rupture. Furthermore, we hypothesized that of players who did RTP, performance metrics would be comparable with uninjured controls by 2 seasons after their injury.

METHODS

This was a retrospective cohort study of male soccer players with an ATR. Players from the 5 major European soccer leagues (English Premier League, Bundesliga, Serie A, La Liga, and Ligue 1) from 1999 to 2018 were included. Injured and control players were identified using publicly available sources, including transfermarkt.co.uk, uefa.com, fifa.com, official team websites, public injury reports, and press releases, via methods established in previous investigations.[6,11,21,24,26,28-31,34] Injuries and player performance data were manually cross-referenced by 2 authors (E.M.F. and O.Z.L.-G.) via official league injury reports.

A player was included in the study if he was drafted or signed to a team in 1 of the 5 abovementioned soccer leagues, participated in at least 1 game in the season before sustaining an ATR, and had a minimum of 1 year follow-up after injury. Demographic data for each player, including age, height, position, and number of seasons played, were recorded. Injury and RTP data were documented, including the date of injury, days/games missed, the date of RTP, and subsequent injuries. Finally, we collected performance metrics, including games played, minutes played per game and per season, goals scored, assists, shutouts, and conceded goals.

A matched-cohort analysis was completed to compare performance metrics of injured players to their uninjured matched controls. A representative group of soccer players who had not sustained an ATR were identified and matched to injured players in a 2:1 fashion (ie, 2 controls for each injury case) using the optimized matching methodology of King et al.[16,17] Players with any other lower extremity injury were excluded from the control group. Players were matched by position, height, ±2 years of age, ±1 season year, and ±1 year of seasons played within the league.[16,17]

Changes in performance metrics for 1, 2, 3, and 4 years after the index year were compared with metrics 1 season before the index year. Comparison of metrics with the previous year minimized the confounding effect of missed game time on season performance in the injured cohort. Performance changes at the various postinjury timepoints were compared between the injured and the matched control group by position to account for the differing roles of player positions on the field. Injury history data were summarized as means and standard deviations. All other continuous data were summarized as medians and interquartile ranges (IQRs). Univariate 2-group comparisons were performed using independent-sample, 2-group t tests and Wilcoxon rank-sum tests when normality distributions were violated. Chi-square tests were used to compare categorical data. All analyses were performed using R Studio software Version 3.6.2 (R Foundation for Statistical Computing). Statistical significance was set at $P < .05$.

RESULTS

Characteristics and RTP

We identified 132 soccer players (mean age, 27.49 ± 4.06 years) who suffered an ATR between 1999 and 2018. A total of 79,497 player-years were identified during the 19 seasons included in this study. During each season an athlete who contributed to a team within the top 5 European leagues was counted as a player-year. This investigation found an incidence of 1.66 ATRs per 1000 player-years. Demographic and RTP characteristics for injured players and uninjured controls are presented in Table 1.

Two matched controls were identified for each injured player. No baseline differences were found on any parameter examined between each group's respective index season. The mean RTP time was 5.07 ± 2.61 months (18.19 ± 10.96 games). Of the injured players, 103 (78%) players returned to play

†Address correspondence to Brian Forsythe, MD, Division of Sport Medicine, Midwest Orthopaedics at Rush, 1611 West Harrison Street, Chicago IL 60612, USA (email: brian.forsythe@rushortho.com).

*Department of Orthopaedic Surgery, Rush University Medical Center, Chicago, Illinois, USA.

Final revision submitted February 9, 2021; accepted February 28, 2021.

One or more of the authors has declared the following potential conflict of interest or source of funding: J.C. has received research support from Arthrex; consulting fees from Stryker, Smith & Nephew, Linvatec, and DePuy; education support from Medwest, Smith & Nephew, and Arthrex; nonconsulting fees from Smith & Nephew and Arthrex; and speaking fees from Linvatec. B.F. has received research support from Arthrex, Smith & Nephew, and Stryker and royalties and financial support from Elsevier; and has stock in Jace Medical. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

Ethical approval was not sought for the present study.

TABLE 1
Cohort Characteristics[a]

	Controls (n = 254)	Achilles Rupture (n = 132)	*P* Value
Player position, n			≥.999
Attacker	58	29	
Midfielder	90	45	
Defender	106	53	
Goalkeeper	0	5	
Calendar year of season	2011 ± 4.49	2012 ± 3.83	≥.999
Total years played in league	6.42 ± 3.71	8.23 ± 4.82	≥.999
Height, m	1.82 ± 0.04	1.81 ± 0.06	.980
Age during season	27.29 ± 4.37	27.49 ± 4.06	.997

[a]Data are reported as mean ± SD or n.

TABLE 2
RTP Metrics[a]

Variable	Value
Months missed	5.07 ± 2.61
Games missed	18.19 ± 10.96
Number of reinjuries	10 (9)
RTP at any timepoint	103 (78)
1 season after injury	94 (71)
2 seasons after Injury	101 (77)
3 seasons after injury	103 (78)
4 seasons after injury	103 (78)

[a]Data are reported as mean ± SD or n (%). RTP, return to play.

in 1 of the 5 major European soccer leagues after ATR. The majority (71%) of these players returned the season after their injury, with an additional 7% and 2% returning to play their second and third season after injury, respectively (Table 2). When evaluating by field position, RTP rates were 64.4% midfielders, 70% defenders, and 75.9% attackers. Significantly fewer midfielders returned to play compared with other positions ($P = .0005$). Of the 132 players with ATR, 10 (9%) experienced a retear during the study period.

Play Time and Player Performance

Soccer players with ATR played significantly fewer games (-6.77 vs -1.81 games; $P < .001$) and minutes (-560.17 vs -171.17 minutes; $P < .05$) during their season of injury relative to matched controls (Appendix Table A1). There were no significant differences in these metrics between injured and uninjured controls during any of the postinjury seasons. There were no significant differences in the number of minutes played per game between injured and uninjured soccer players at any timepoint.

Injured players scored significantly fewer goals (-1.06 vs -0.29 goals; $P < .05$) and made significantly fewer assists (-0.76 vs -0.02 assists; $P < .05$) during the season of their Achilles rupture. While injured players continued to score fewer goals and make fewer assists in the 4 seasons after their injury compared with controls, none of these differences were statistically significant, and there were no statistically significant differences in points per game between injured and uninjured players at any timepoint.

Player Position

Attackers. A total of 29 attackers were identified as having suffered an ATR. Games and minutes played per season as well as minutes played per game were not significantly different from controls during any of the seasons (Appendix Table A2). With respect to player performance, while injured attackers scored fewer goals per season and points per game compared with their matched controls for all 4 postinjury seasons, none of these differences were statistically significant. Likewise, although injured attackers recorded fewer assists for the first 3 postinjury seasons, the differences were not significant.

Midfielders. Midfielders accounted for 45 players identified as suffering an ATR. Injured midfielders played significantly fewer games (-9.82 vs -2.22 games; $P < .05$) and minutes (-875.71 vs -233.15 minutes; $P < .05$) per season during the season of their injury relative to their matched controls (Appendix Table A3). Injured midfielders continued to play fewer games per season than their uninjured controls during the 4 postinjury seasons, but this difference was only significant during their first postinjury season ($P < .05$). Similarly, injured players recorded fewer minutes per season during the 4 postinjury seasons, but none of these differences were statistically significant. With respect to player performance, injured midfielders recorded fewer assists per season and points per game during their season of injury and the subsequent 4 seasons; however, none of these differences were statistically significant. There were no significant differences between the number of goals scored per season at any timepoint.

Defenders. A total of 53 defenders with an ATR were identified. Injured defenders played fewer games per season, minutes per season, and minutes per game during the season of their injury and their first postinjury season, but these differences were not statistically significant from controls (Appendix Table A4). By the second postinjury season, injured players had recorded more games per season, minutes per season, and minutes per game than their matched controls; however, these differences were not statistically significant. Injured defenders scored significantly fewer goals per season during their first (-0.48 vs 0.09 goals; $P < .05$) and second (-0.57 vs -0.06 goals; $P < .05$) postinjury seasons. There were no significant differences in goals scored for any other seasons. While injured defenders made fewer assists during the season of injury and their first postinjury season, there were no significant differences in assists or points per game between injured and uninjured defenders at any timepoint.

Goalkeepers. Five goalkeepers with an ATR were identified. There were no significant differences in games and minutes played per season or minutes played per game between injured and uninjured goalkeepers at any timepoint (Appendix Table A5). Injured goalkeepers recorded fewer clean sheets per season during their season of injury

and subsequent 4 seasons relative to uninjured controls; however, none of these differences were statistically significant. There were no significant differences in conceded goals between injured and uninjured goalkeepers at any timepoint.

DISCUSSION

The principal findings of this study were as follows: (1) the mean age at ATR was 27.49 ± 4.06 years; (2) the mean RTP was 5.07 ± 2.61 months; (3) the RTP rate was 71% for returning the season after injury and 78% for returning at any timepoint; (4) 9% of players experiencing ATR experienced a rerupture during the study period; (5) compared with uninjured controls, the injured players played significantly fewer games (-6.77 vs -1.81 games; $P < .001$) and minutes (-560.17 vs -171.17 minutes; $P < .05$), and recorded fewer goals (-1.06 vs -0.29 goals; $P < .05$) and assists (-0.76 vs -0.02 assists; $P < .05$) during the season of their Achilles rupture; and (6) with the exception of midfielders, there were no significant differences in play time or performance metrics at any postinjury timepoint between uninjured players and injured players who returned to play.

The mean RTP time in this study was 5.07 months, which substantiates the findings of previous investigations that ATR results in significant loss of play time. The mean layoff after ATR has been reported to be 161 days among professional soccer players and 4.8 months for elite athletes.[10,22] Additionally, we found that 71% of injured players returned to high-level play within the first postoperative year and 78% returned at any timepoint. Previous investigations have demonstrated similar outcomes in the context of ATR. Grassi et al[11] found that 82% of male professional soccer players had returned to their previous level of play at 2 seasons after Achilles tendon repair. Incomplete rates of RTP are not unique to soccer.[32,35] In an analysis of major American professional athletes, Trofa et al[35] demonstrated that across the National Basketball Association (NBA), the National Football League (NFL), and the Major League Baseball (MLB), 30.6% of players were unable to return to their sport after suffering an isolated ATR. Thus, despite modern rehabilitation protocols, surgical techniques, and the best efforts of players and teams, Achilles rupture may represent a career-ending injury in over 20% of elite athletes.[36]

This investigation found that almost 10% of players experiencing a primary ATR sustained a rerupture at some point during the study period (median, 3 years; IQR, 2.25-3.75 years). Significant rerupture rates have been reported among professional soccer players returning from Achilles rupture. Grassi et al[11] reported that 8% of soccer players suffered rerupture within their first 2 seasons after returning to play. Interestingly, 1 investigation found shorter recovery periods to be significantly associated with reinjury, highlighting the importance of adhering to rehabilitation timelines to allow adequate healing of the repair.[10]

The present investigation found the mean age of ATR among professional soccer players to be 27.49 years. This is consistent with previous studies that have examined similar but smaller cohorts.[10] The mean age of UEFA Champions League players has ranged from 24.9 to 26.5 years, notably younger than the mean age of players sustaining an ATR.[15] In their investigation of NBA, NFL, and MLB players, Trofa et al[35] found that athletes who sustained ATR were, on average, 2.7 years older than the average professional athlete. Soccer players typical peak between ages 25 and 27 years, evidenced by the performance decline in matched controls.[3] As such, players sustaining an ATR are often entering the latter portion of their careers before injury. This finding is likely related to the underlying pathogenesis of ATR, which requires both underlying tendinosis and a forceful eccentric contraction.[4] Achilles tendinosis is common among professional soccer players, and its incidence increases with age, which may account for this result.[12,13,36]

The present study found that soccer players sustaining an ATR played significantly fewer games and minutes during the season of their injury relative to their matched controls. Similarly, we found that injured players recorded significantly fewer goals and assists relative to matched controls during their season of injury. These findings are fairly intuitive, as ATR precludes players from participating in the remainder of the season, thus limiting their play time and ability to record goals and assists. Before injury, athletes in the ATR and control cohorts contributed nearly equal minutes per game, suggesting the absence of prodromal symptoms before ATR. Importantly, with the exception of midfielders, who played significantly fewer games during their first postinjury season, there were no significant differences in play time or performance metrics at any postinjury timepoint between uninjured players and injured players who had returned to play. This finding contrasts somewhat with the results of Trofa et al,[36] who reported no significant differences in player performance at any postinjury timepoint but found persistently decreased play time at 2 years postinjury. However, these authors performed a relatively small matched-cohort analysis of 24 American and European soccer players who underwent Achilles tendon repair from 1988 to 2014. The inclusion of players who underwent surgical repair in 1988, when advanced rehabilitation protocols and minimally invasive surgical techniques were not yet implemented, may have influenced their results.

The results of this investigation support the findings of previous studies that among elite soccer athletes, ATR is a serious, potentially career-ending injury that tends to affect older athletes. While those older athletes who suffer an ATR may be less incentivized to undergo the rigorous rehabilitation process required to return to their sport, those who do decide to return demonstrate excellent play time and performance metrics upon their return.

Limitations

An important limitation to consider when interpreting the presented results include the use of public data sources in generating the ATR player cohort. This lends the possibility of a selection bias toward players with publicly reported injuries while not capturing information on injuries players

sustain that remain undisclosed to the public. This limitation is minimized in the context of investigating ATR because of the prolonged rehabilitation necessary after injury and thus low likelihood of a player's reason for absence remaining undisclosed to the public. Additionally, it was not possible to note any differences in surgical treatment (ie, standard open vs percutaneous vs minimally invasive) and rehabilitation without access to official medical record documentation. Finally, creating matched cohorts for elite athletes poses the challenge of maximizing similarities in player characteristics within a relatively small and fixed number of players. Prior investigations have relied on either manual selection of players or matching of calculated propensity scores to generate matched cohorts. Manual matching imparts a significantly elevated risk of selection bias, whereas use of an aggregated propensity score imparts the significant limitation of generating higher levels of imbalance, thus skewing and potentially masking the effects of statistical models calculated.[16-18,25]

To minimize these potential risks of bias associated with matching, we used a method that optimizes the matching solution for a given data set and thus minimizes the imbalances within each group that are otherwise unaccounted for with manual and propensity score matching. The matching method did not control for baseline performance metrics between groups or contract status, which may affect teams' personnel decision making. Because of the inclusion criteria and the inherent limitations of utilizing public data sources, a relatively small size of athletes was identified, potentially confounding the results reported in this investigation and emphasizing the need for a centralized UEFA medical database to more accurately identify correlations between athlete performance and ATR. The fate of athletes who did not return to the same level of competition, along with the associated reasons for being unable to RTP, was also rarely reported. The impact of additional athlete-related and team-based variables on time lost, RTP timing, and performance metrics in athletes sustaining ATR were not recorded and thus cannot be inferred based on the current data.

CONCLUSION

In the current study, 78% of the elite, professional European League soccer players suffering an ATR returned to play at any timepoint, with a mean RTP of 5 months. Injured players played less and demonstrated inferior player performance during their season of injury. With the exception of midfielders, injured and uninjured players displayed no significant differences in play time or performance during any of the 4 postinjury seasons.

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, et al. Performance outcomes after repair of complete Achilles tendon ruptures in National Basketball Association players. *Am J Sports Med*. 2013;41(8):1864-1868.
3. Dendir S. When do soccer players peak? A note. *J Sports Analytics*. 2016;2(2):89-105.
4. Egger AC, Berkowitz MJ. Achilles tendon injuries. *Curr Rev Musculoskelet Med*. 2017;10(1):72-80.
5. Eliasson P, Agergaard AS, Couppe C, et al. The ruptured Achilles tendon elongates for 6 months after surgical repair regardless of early or late weightbearing in combination with ankle mobilization: a randomized clinical trial. *Am J Sports Med*. 2018;46(10):2492-2502.
6. Erickson BJ, Harris JD, Heninger JR, et al. Performance and return-to-sport after ACL reconstruction in NFL quarterbacks. *Orthopedics*. 2014;37(8):e728-e734.
7. Farber J, Harris JD, Kolstad K, McCulloch PC. Treatment of anterior cruciate ligament injuries by Major League Soccer Team physicians. *Orthop J Sports Med*. 2014;2(11):2325967114559892.
8. Frankewycz B, Penz A, Weber J, et al. Achilles tendon elastic properties remain decreased in long term after rupture. *Knee Surg Sports Traumatol Arthrosc*. 2018;26(7):2080-2087.
9. Fredberg U, Bolvig L, Andersen NT. Prophylactic training in asymptomatic soccer players with ultrasonographic abnormalities in Achilles and patellar tendons: the Danish Super League Study. *Am J Sports Med*. 2008;36(3):451-460.
10. Gajhede-Knudsen M, Ekstrand J, Magnusson H, Maffulli N. Recurrence of Achilles tendon injuries in elite male football players is more common after early return to play: an 11-year follow-up of the UEFA Champions League injury study. *Br J Sports Med*. 2013;47(12):763-768.
11. 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.
12. Ho G, Tantigate D, Kirschenbaum J, Greisberg JK, Vosseller JT. Increasing age in Achilles rupture patients over time. *Injury*. 2017;48(7):1701-1709.
13. Houshian S, Tscherning T, Riegels-Nielsen P. The epidemiology of Achilles tendon rupture in a Danish county. *Injury*. 1998;29(9):651-654.
14. Jandacka D, Silvernail JF, Uchytil J, et al. Do athletes alter their running mechanics after an Achilles tendon rupture? *J Foot Ankle Res*. 2017;10:53.
15. Kalen A, Rey E, de Rellan-Guerra AS, Lago-Penas C. Are soccer players older now than before? Aging trends and market value in the last three decades of the UEFA Champions League. *Front Psychol*. 2019;10:76.
16. King G, Lucas C, Nielsen RA. The balance-sample size frontier in matching methods for causal inference. *Am J Pol Sci*. 2017;61(2):473-489.
17. King G, Zeng L. The dangers of extreme counterfactuals. *Polit Anal*. 2017;14(2):131-159.
18. LeBrun DG, Tran T, Wypij D, Kocher MS. How often do orthopaedic matched case-control studies use matched methods? A review of methodological quality. *Clin Orthop Relat Res*. 2019;477(3):655-662.
19. Lemme NJ, Li NY, Kleiner JE, et al. Epidemiology and video analysis of Achilles tendon ruptures in the National Basketball Association. *Am J Sports Med*. 2019;47(10):2360-2366.
20. Leppilahti J, Puranen J, Orava S. Incidence of Achilles tendon rupture. *Acta Orthop Scand*. 1996;67(3):277-279.
21. Lu Y, Okoroha KR, Patel BH, et al. Return to play and performance after shoulder instability in National Basketball Association athletes. *J Shoulder Elbow Surg*. 2020;29(1):50-57.
22. Maffulli N, Longo UG, Maffulli GD, Khanna A, Denaro V. Achilles tendon ruptures in elite athletes. *Foot Ankle Int*. 2011;32(1):9-15.
23. Maffulli N, Waterston SW, Squair J, Reaper J, Douglas AS. Changing incidence of Achilles tendon rupture in Scotland: a 15-year study. *Clin J Sport Med*. 1999;9(3):157-160.
24. Makhni EC, Lee RW, Morrow ZS, et al. Performance, return to competition, and reinjury after Tommy John surgery in Major League

Baseball pitchers: a review of 147 cases. *Am J Sports Med*. 2014; 42(6):1323-1332.
25. Mansournia MA, Jewell NP, Greenland S. Case-control matching: effects, misconceptions, and recommendations. *Eur J Epidemiol*. 2018;33(1):5-14.
26. Marshall NE, Keller RA, Lynch JR, Bey MJ, Moutzouros V. Pitching performance and longevity after revision ulnar collateral ligament reconstruction in Major League Baseball pitchers. *Am J Sports Med*. 2015;43(5):1051-1056.
27. Minhas SV, 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.
28. Niederer D, Engeroff T, Wilke J, Vogt L, Banzer W. Return to play, performance, and career duration after anterior cruciate ligament rupture: a case-control study in the five biggest football nations in Europe. *Scand J Med Sci Sports*. 2018;28(10): 2226-2233.
29. Okoroha KR, Fidai MS, Tramer JS, et al. Length of time between anterior cruciate ligament reconstruction and return to sport does not predict need for revision surgery in National Football League players. *Arthroscopy*. 2019;35(1):158-162.
30. Okoroha KR, Kadri O, Keller RA, et al. Return to play after revision anterior cruciate ligament reconstruction in National Football League players. *Orthop J Sports Med*. 2017;5(4):2325967117698788.
31. Okoroha KR, Taylor KA, Marshall NE, et al. Return to play after shoulder instability in National Football League athletes. *J Shoulder Elbow Surg*. 2018;27(1):17-22.
32. 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.
33. Sankey RA, Brooks JH, Kemp SP, Haddad FS. The epidemiology of ankle injuries in professional rugby union players. *Am J Sports Med*. 2008;36(12):2415-2424.
34. Schiffner E, Latz D, Grassmann JP, et al. Fractures in German elite male soccer players. *J Sports Med Phys Fitness*. 2019;59(1):110-115.
35. Trofa DP, Miller JC, Jang ES, et al. Professional athletes' return to play and performance after operative repair of an Achilles tendon rupture. *Am J Sports Med*. 2017;45(12):2864-2871.
36. Trofa DP, Noback PC, Caldwell JE, et al. Professional soccer players' return to play and performance after operative repair of Achilles tendon rupture. *Orthop J Sports Med*. 2018;6(11): 2325967118810772.

APPENDIX

APPENDIX TABLE A1
All Player Metrics Compared With 1 Year Before Index Year[a]

Player Metrics[b]	Control	Achilles Rupture	*P* Value
Games per season			
Index year	-1.81 ± 11.12	-6.77 ± 11.62	**<.001**
1 year post	-2.28 ± 12.39	-5.12 ± 11.76	.156
2 years post	-5.28 ± 14.14	-5.28 ± 12.15	.743
3 years post	-5.04 ± 15.46	-5.26 ± 11.45	.953
4 years post	-3.16 ± 17.24	-2.50 ± 14.05	.927
Minutes per season			
Index year	-171.17 ± 985.52	-560.17 ± 1014.89	**<.05**
1 year post	-250.71 ± 1110.80	-474.04 ± 1027.80	.213
2 years post	-495.14 ± 1280.86	-512.49 ± 1075.39	.747
3 years post	-348.52 ± 1375.30	-493.76 ± 1121.19	.690
4 years post	-165 ± 1667.94	-148.67 ± 1209.85	.893
Minutes per game			
Index year	-2.35 ± 26.65	-5.57 ± 27.70	.548
1 year post	1.12 ± 24.46	-8.11 ± 34.09	.129
2 years post	-4 ± 26.60	-6.64 ± 26.76	.774
3 years post	-5.03 ± 34.70	-1.27 ± 33.91	.618
4 years post	3.17 ± 23.67	4.71 ± 35.87	.822
Goals per season			
Index year	-0.29 ± 3.10	-1.06 ± 3.22	**<.05**
1 year post	-0.46 ± 3.24	-0.83 ± 3.29	.291
2 years post	-0.82 ± 3.56	-1.38 ± 3.40	.322
3 years post	-0.48 ± 3.40	-1.18 ± 3.52	.423
4 years post	0 ± 2.11	-1.28 ± 4.20	.617
Assists per season			
Index year	-0.02 ± 2.02	-0.76 ± 2.14	**<.05**
1 year post	0.08 ± 2.11	-0.61 ± 2.21	.098
2 years post	0 ± 2.36	-0.45 ± 2.17	.188
3 years post	0.02 ± 2.31	-0.62 ± 3.20	.136
4 years post	0.11 ± 1.41	-0.17 ± 1.54	.624
Points per game			
Index year	-0.09 ± 0.78	-0.06 ± 0.79	.649
1 year post	-0.05 ± 0.65	-0.22 ± 0.87	.097
2 years post	-0.03 ± 0.68	-0.24 ± 0.77	.206
3 years post	-0.13 ± 0.75	-0.16 ± 0.82	.869
4 years post	-0.16 ± 0.60	-0.22 ± 0.71	.915

[a]Data are presented as mean ± SD. Bolded *P* values indicate statistically significant differences between groups ($P < .05$). Post, postindex year.
[b]Change in player performance metric as compared with 1 year before the index year (ie, timepoint of injury for players with Achilles tendon rupture and index year for matched controls).

APPENDIX TABLE A2
Attacker Metrics Compared With 1 Year Before Index Year[a]

Player Metrics[b]	Control	Achilles Rupture	*P* Value
Games per season			
Index year	-0.75 ± 12.20	-5.21 ± 14.52	.266
1 year post	-2.87 ± 13.37	-2.83 ± 14.50	.906
2 years post	-4.87 ± 13.40	-2.54 ± 12.71	.854
3 years post	-5.75 ± 16.74	-1.71 ± 7.70	.643
4 years post	-7 ± 21.21	-3 ± 18.46	.800
Minutes per season			
Index year	-104.78 ± 967.46	-313.63 ± 1119.39	.444
1 year post	-274.35 ± 1118.31	-369.17 ± 1036.21	.805
2 years post	-515.87 ± 1013	-410.77 ± 959.34	.854
3 years post	-414.12 ± 1543.63	-118.14 ± 848.88	.613
4 years post	0.50 ± 2297.39	-132.50 ± 1668.71	≥.999
Minutes per game			
Index year	-4.43 ± 22.27	3.84 ± 24.48	.103
1 year post	-1.98 ± 24.26	-8.05 ± 31.27	.706
2 years post	-3.27 ± 19.42	-11.33 ± 30.82	.467
3 years post	-12.30 ± 35.45	7.81 ± 21.77	.232
4 years post	16.60 ± 40.65	-3.18 ± 40.82	.800
Goals per season			
Index year	-0.62 ± 5.45	-2 ± 6.02	.283
1 year post	-1.52 ± 5.57	-2.28 ± 5.40	.712
2 years post	-2.87 ± 5.69	-3.54 ± 6.01	.945
3 years post	-0.25 ± 6.32	-2.00 ± 6.45	.728
4 years post	1.50 ± 4.95	-5.50 ± 7.94	.533
Assists per season			
Index year	0.02 ± 2.51	-0.58 ± 2.69	.642
1 year post	-0.30 ± 2.42	-1.11 ± 2.65	.349
2 years post	-0.20 ± 3.34	-0.85 ± 2.30	.349
3 years post	0 ± 2.56	-0.86 ± 1.77	.639
4 years post	-0.50 ± 3.54	0.50 ± 1.29	≥.999
Points per game			
Index year	-0.07 ± 0.70	-0.15 ± 0.87	.470
1 year post	-0.05 ± 0.71	-0.16 ± 1.09	.172
2 years post	0.05 ± 0.39	-0.25 ± 0.70	.249
3 years post	-0.14 ± 0.72	-0.60 ± 0.88	.336
4 years post	-0.12 ± 1.48	-0.27 ± 0.49	≥.999

[a]Data are presented as mean ± SD. Post, postindex year.
[b]Changes in player performance metric as compared with 1 year before the index year (ie, timepoint of injury for players with Achilles tendon rupture and index year for matched controls).

APPENDIX TABLE A3
Midfielder Metrics Compared With 1 Year Before Index Year[a]

Player Metrics[b]	Control	Achilles Rupture	*P* Value
Games per season			
Index year	-2.22 ± 10.17	-9.82 ± 9.55	**<.05**
1 year post	0.60 ± 11.25	-6.05 ± 11	**<.05**
2 years post	-5.79 ± 16.45	-9.24 ± 10.24	.799
3 years post	-10.23 ± 15.82	-14.17 ± 9.13	.327
4 years post	-9.67 ± 12.10	-17 ± 5.66	.800
Minutes per season			
Index year	-233.15 ± 940.03	-875.71 ± 876.28	**<.05**
1 year post	-75.72 ± 1096.36	-468.45 ± 1075.11	.181
2 years post	-543.79 ± 1590.41	-791.24 ± 1057.81	.925
3 years post	-685.15 ± 1374.15	-1377.08 ± 931.56	.168
4 years post	-878.33 ± 1791.67	-1333 ± 86.27	.800
Minutes per game			
Index year	-4.52 ± 23.45	-11.85 ± 20.52	.159
1 year post	1.01 ± 23.34	-8.10 ± 30.47	.216
2 years post	-9.38 ± 37.81	-5.19 ± 23.09	.490
3 years post	-12.21 ± 46.11	-23.01 ± 31.70	.470
4 years post	-5.53 ± 46.40	1.21 ± 23.33	≥.999
Goals per season			
Index year	-0.34 ± 2.38	-1.50 ± 2.40	.087
1 year post	-0.48 ± 2.77	-0.25 ± 3.34	.749
2 years post	-0.74 ± 3.89	-0.88 ± 2.09	.936
3 years post	-1.69 ± 3.86	-2.33 ± 2.67	.337
4 years post	0 ± 1.73	0.50 ± 0.71	≥.999
Assists per season			
Index year	0 ± 2.72	-1.21 ± 2.56	.144
1 year post	0.28 ± 2.53	-0.60 ± 2.23	.442
2 years post	0.37 ± 2.97	-1 ± 2.03	.460
3 years post	0 ± 3.14	-2.17 ± 3.07	.130
4 years post	-1.33 ± 0.58	-1.50 ± 2.12	≥.999
Points per game			
Index year	0.02 ± 0.80	-0.08 ± 0.45	.793
1 year post	0.17 ± 0.68	-0.22 ± 0.58	.091
2 years post	-0.07 ± 0.62	-0.33 ± 0.43	.254
3 years post	-0.14 ± 1.05	-0.21 ± 0.64	.979
4 years post	-0.12 ± 0.44	-0.18 ± 0.01	.800

[a]Data are presented as mean ± SD. Bolded *P* values indicate statistically significant differences between groups ($P < .05$). Post, postindex year.
[b]Change in player performance metric as compared with 1 year before the index year (ie, timepoint of injury for players with Achilles tendon rupture and index year for matched controls).

APPENDIX TABLE A4
Defender Metrics Compared With 1 Year Before Index Year[a]

Player Metrics[b]	Control	Achilles Rupture	*P* Value
Games per season			
Index year	-2.39 ± 11.27	-6.29 ± 9.73	.102
1 year post	-3.67 ± 12.76	-5.39 ± 10.39	.502
2 years post	-6.23 ± 13.40	-2.76 ± 11.86	.249
3 years post	-3.13 ± 14.74	-0.15 ± 11.39	.458
4 years post	-4.17 ± 18.24	-0.18 ± 13.38	.644
Minutes per season			
Index year	-195.60 ± 1042.69	-532.58 ± 891.26	.181
1 year post	-344.95 ± 1153.24	-502.09 ± 988.51	.575
2 years post	-553.09 ± 1226.27	-261.48 ± 1061.66	.257
3 years post	-241.48 ± 1345.52	9.77 ± 1038.72	.515
4 years post	-293.50 ± 1677.02	26.82 ± 1150.54	.566
Minutes per game			
Index year	0.88 ± 29.41	-6.62 ± 28.27	.523
1 year post	2.77 ± 26.11	-6.96 ± 31.01	.218
2 years post	-1.86 ± 23.24	-1.26 ± 21.67	.960
3 years post	0.77 ± 28.47	0.37 ± 13.70	.673
4 years post	2.91 ± 17.91	1.83 ± 33.20	.695
Goals per season			
Index year	-0.10 ± 1.21	-0.39 ± 1.37	.363
1 year post	0.09 ± 1.19	-0.48 ± 1.18	**<.05**
2 years post	-0.06 ± 1.63	-0.57 ± 0.93	**<.05**
3 years post	0.09 ± 1.28	0.15 ± 1.68	.973
4 years post	-0.25 ± 2.01	-0.18 ± 1.33	≥.999
Assists per season			
Index year	-0.06 ± 1.15	-0.61 ± 1.55	.092
1 year post	0.16 ± 1.72	-0.42 ± 2.09	.178
2 years post	-0.11 ± 1.49	0.19 ± 2.23	.629
3 years post	0.04 ± 1.87	0.85 ± 3.63	.774
4 years post	0.58 ± 1.08	-0.18 ± 1.60	.196
Points per game			
Index year	-0.18 ± 0.82	0.02 ± 0.81	.115
1 year post	-0.18 ± 0.59	-0.17 ± 0.80	.793
2 years post	-0.06 ± 0.82	-0.13 ± 1.01	.966
3 years post	-0.15 ± 0.60	-0.04 ± 0.74	.439
4 years post	-0.27 ± 0.50	-0.31 ± 0.80	.878

[a]Data are presented as mean ± SD. Bolded *P* values indicate statistically significant differences between groups ($P < .05$). Post, postindex year.

[b]Change in player performance metric as compared with 1 year before the index year (ie, timepoint of injury for players with Achilles tendon rupture and index year for matched controls).

APPENDIX TABLE A5
Goalkeeper Metrics Compared With 1 Year Before Index Year[a]

Player Metrics[b]	Control	Achilles Rupture	*P* Value
Games per season			
Index year	-1.81 ± 11.12	-6.77 ± 11.62	≥.999
1 year post	-2.28 ± 12.39	-5.12 ± 11.76	≥.999
2 years post	-5.28 ± 14.14	-5.28 ± 12.15	.400
3 years post	-5.04 ± 15.46	-5.26 ± 11.45	≥.999
4 years post	-3.16 ± 17.24	-2.50 ± 14.05	.667
Minutes per season			
Index year	239.75 ± 688.16	60.40 ± 1809.36	.806
1 year post	-140 ± 333.75	-742.50 ± 1434.60	≥.999
2 years post	592.67 ± 932.88	-1440 ± 2036.47	.400
3 years post	871 ± 1096.02	218.50 ± 72.83	≥.999
4 years post	1510.50 ± 218.50	225 ± 0	.667
Minutes per game			
Index year	-17.63 ± 44.58	1.95 ± 57.94	.901
1 year post	2.76 ± 4.58	-17.95 ± 82.76	.800
2 years post	1.33 ± 4.06	-45 ± 63.64	.800
3 years post	4.05 ± 2.75	86.75 ± 4.60	.333
4 years post	4.32 ± 2.37	75 ± 0	.667
Clean sheets per season			
Index year	1 ± 1.83	-0.20 ± 6.65	.902
1 year post	1 ± 1.41	-3.25 ± 4.57	.159
2 years post	4 ± 3.61	-5 ± 7.07	.236
3 years post	1 ± 1.41	0.50 ± 0.71	≥.999
4 years post	2.50 ± 0.71	0 ± 0	.667
Conceded goals per season			
Index year	1.50 ± 12.45	0.60 ± 27.43	≥.999
1 year post	0 ± 0	-10.25 ± 21.96	.475
2 years post	4.33 ± 11.59	-21.50 ± 30.41	.400
3 years post	14 ± 19.80	6.50 ± 2.12	≥.999
4 years post	25.50 ± 2.12	7 ± 0	.667

[a]Data are presented as mean ± SD. Post, postindex year.

[b]Change in player performance metric as compared with 1 year before the index year (ie, timepoint of injury for players with Achilles tendon rupture and index year for matched controls).