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Factors Affecting Return to Play After Primary Achilles Tendon Tear

A Cohort of NFL Players

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Background: Achilles tendon tears are potentially career-ending injuries for professional athletes. For players in the National Football League (NFL), return requires not only surgery and extensive rehabilitation but also the ability to compete in a market with limited positions that annually introduces new recruits.

Purpose/Hypothesis: We authors sought to evaluate factors related to return to play (RTP) and changes in performance following a primary Achilles tear. Our hypothesis was that "skilled" position players and those drafted in later rounds would return at a lower rate as compared with "unskilled" position players and higher draft-round players.

Study Design: Case-control study; Level of evidence, 3.

Methods: From a previously established database, 80 NFL players were identified as having primary Achilles tendon tears between the 2009 and 2014 seasons. RTP was defined as playing in a regular season or postseason game following injury. Probability of RTP was modeled as a function of time after injury in Kaplan-Meier analysis with demographic variables assessed via generalized linear models. Twelve players (15%) experienced a subsequent Achilles tendon tear during or after the study period and were included in the overall RTP rate but were excluded from performance analyses owing to the confounding effects of an ipsilateral retear or contralateral tear.

Results: The overall RTP rate was 61.3%. Age, number of prior seasons, position type, or draft round status did not significantly affect RTP when evaluated with Kaplan-Meier analysis. In the season before their injury, players who did RTP played in a significantly greater number of regular season games (13.7) compared with players who did not RTP (8.71) ($P = .011$). Players who did not RTP exhibited a significant decrease in performance in the season preceding injury (12.7 regular season games played 2 seasons preinjury vs 8.71 regular season games played 1 season prior preinjury;, $P = .019$). Players who returned did not display a significant change in the number of games played or started in seasons following injury when >1 season after return was evaluated.

Conclusion: Rate of RTP following primary Achilles tendon tears may be lower than previously published. However, for those able to return, performance only in the season immediately following injury appears to be affected; players return to preinjury levels if given the opportunity to play >1 season after injury.

Keywords: ankle; ligaments; Achilles tendon; football (American); physical therapy/rehabilitation

Achilles tendon (AT) tears are devastating injuries for athletes of all levels and are potentially career ending for professional athletes.[22] Despite having the greatest tensile strength of any tendon in the body, the AT is the most commonly injured lower extremity tendon, with an incidence of 18 per 100,000.[1,22,38] The incidence of AT injuries has increased over the past few decades and is projected to rise as more people engage in athletics.[30,33]

The etiology of AT ruptures is multifactorial, with internal factors (eg, intratendinous degeneration)[22,30,41] and external factors (eg, training frequency)[17,35] playing roles. Rupture mechanism is better characterized, with 90% to 100% occurring in several positions: dorsiflexion of the foot with triceps surae contraction, pushing off the weightbearing foot during knee extension, or dorsiflexion on a plantarflexed ankle.[33,35] Athletes who participate in sports that require rapid acceleration and changes in direction, as in

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American football, are at increased risk for rupture because of the frequency, force, and orientations in which they load the tendon.[19,36]

For National Football League (NFL) athletes, return to play (RTP) following an AT rupture requires surgical reconstruction and extensive rehabilitation. For those able to recover, return is contingent on a limited number of positions in a market that annually introduces new recruits. AT tears and the 6 to 11 months required for rehabilitation pose a significant risk to players' careers in a league in which the mean career length is 3.3 years.[5,33] Studies have shown that factors such as the draft round in which a player is selected and the player's position significantly affect RTP rates following major injuries.[6-9,11,12,31,32,39]

Previous studies examining AT tears among NFL players did not distinguish by position, examined only select positions, or did not differentiate by tear type (primary tear, contralateral tear, retear).[23,26,34] The purpose of this study was therefore to evaluate factors related to RTP and changes in performance for all positions following primary AT tears. We hypothesized that being selected in earlier draft rounds would correlate with higher RTP rates and that rates would significantly differ among positions.

METHODS

From a previously established database of AT tears among NFL players,[16,18] athletes were identified with publicly disclosed AT tears occurring between the start of the 2009 season and the end of the 2014 season. All teams are mandated to disclose player injuries in an accurate and timely manner in their weekly reports.[25] News reports were used to determine injury dates and previous AT ruptures. Player demographics and playing history before and after injury were gathered from NFL.com.

For study inclusion, players must have been on a 53-person active roster if the injury occurred during the regular season (RS) or postseason or a 90-person roster if the injury occurred during the preseason. Exclusion criteria included players with previously documented ipsilateral or contralateral AT tears, owing to concerns regarding residual effects from previous tears. Although players who experienced a subsequent tear during or after the study period were included in the overall RTP rate, these players were excluded from performance analyses because of the possible confounding effects of their new injuries. Specifically, recovery from a primary AT tear has been shown to be fundamentally different—temporally, mechanically, and clinically—than recovery from an ipsilateral or contralateral retear.[15,27,37,40]

"Skilled" and "unskilled" positions were defined with conventional groupings utilized in similar studies.[10,11,32] Skilled positions were defined as running backs, fullbacks, wide receivers, quarterbacks, tight ends, cornerbacks, linebackers, and safeties. Unskilled positions included offensive tackles, guards, centers, defensive tackles, and defensive ends. Kickers, punters, and long snappers were considered special teams players. Preseason was defined as the period from the day following the Super Bowl of the previous season to the day preceding the first RS game of the index season. RS was defined as the period from the day of the first RS game to the day of the last RS game. Postseason was defined as the period between the day following the last RS game and the day of the Super Bowl. RTP was defined as playing at least 1 play in an RS or postseason game after the injury, and the date of RTP was the first RS or postseason game in which the athlete played after injury. Play in a preseason game was used as the date of RTP only if the athlete subsequently played in an RS or playoff game during that same season. Play in non-NFL leagues was not deemed to be a successful RTP.

If a player injured his AT in his rookie season or had never been on an active roster preceding the injury season, mean RS games played and started before injury were recorded as null rather than zero. If a player did not RTP following the AT injury, mean RS games played and started after the injury season were also recorded as null rather than zero.

All statistical analyses were performed with SAS (v 9.4; SAS Institute). Players who returned within 18 months following injury were compared with those who did not. For baseline and demographic variables, generalized linear models were used with distribution and link functions based on variable type. Age at injury was modeled as Gaussian, body mass index (BMI) as a negative binomial, and counts (prior active roster seasons) as a zero-inflated binomial. Special teams players were excluded from analyses, given their small sample size (n = 3). Players who had no active roster experience before their injury were excluded from analyses involving number of RS games

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Ethical approval was not sought for the present study.

TABLE 1
Patient Demographics[a]

	No Return to Play (n = 29)	Return to Play (n = 51)	P
Age at injury, y	25.59 (24.19-26.98)	26.22 (25.35-27.08)	.41
Prior active roster seasons	3.00 (1.695-4.35)	3.84 (2.97-4.71)	.27
Body mass index	30.14 (28.70-31.57)	32.54 (31.38-33.70)	.012
Skilled position players, n	23	30	.068[b]
Players by draft round, n			.076[b]
Rounds 1-3	10	26	
Rounds 4-7	5	13	
Undrafted free agent	14	12	
Months to return to play	—	11.90 (10.77-13.02)	—

[a]Data are reported as mean (95% CI) unless otherwise indicated.
[b]Pearson χ^2.

played before and after injury and number of RS games started before and after injury.

Potential covariance among the demographic variables was estimated by Pearson correlation and Spearman rank correlation coefficients. Kaplan-Meier estimation was used to model probability of RTP as a function of time since injury. Wilcoxon weighting was used to compare functions, with alpha maintained at 0.05 via the Tukey-Kramer method. Given the decreasing sample sizes, functions were right-censored at 18 months following injury. Generalized estimating equations were used to model within- and between-player changes for season total metrics. Family-wise alpha was maintained at 0.05 with the Holm method.

RESULTS

A total of 80 NFL players were identified as having a primary AT tear during the 2009-2014 seasons. Of note, 12 players (15.0%) had a subsequent AT tear during the study period or in the 2 years afterward. These players were excluded from performance analyses because of possible confounding effects from previous and subsequent tears. Similarly, 3 players (3.75%) were solely special teams players and were included in the overall RTP analysis but excluded from performance analyses owing to their small sample size.

Players who returned to play within 18 months following injury and those who did not were compared (Table 1). The overall percentage of players who were able to RTP within 18 months was 63.75% (n = 51). There were no significant differences with respect to age, number of prior active roster seasons, or draft round between players who did and did not RTP. Of the 29 players who did not return, 23 played unskilled positions, whereas 26 of the 51 players who were able to RTP played unskilled positions ($P = .068$). Players who returned had significantly higher mean BMIs than those who did not (32.54 vs 30.14; $P = .012$). However, this difference was due to the positional composition of the groups—that is, the group that returned had a greater proportion of unskilled position players (ie, linemen, who tend to have higher BMIs) versus the group that did not. Position type and BMI exhibited covariance, with a Pearson rank correlation of 0.670 ($P < .001$). No other significant differences between players who did and did not RTP exhibited significant covariance with other variables. The mean time to RTP among those who returned was 11.90 months, with 2 players returning in the same season as their injury and the remaining 49 returning in the season following injury.

Of the 80 players included in this study, there were 24 unskilled players, 53 skilled players, and 3 special teams players (Table 2). The percentages of unskilled, skilled, and special teams players who were able to RTP were 75.0%, 52.8%, and 100%, respectively. Given the small sample size, special teams players were excluded from Kaplan-Meier analysis evaluating the effect of position type on RTP rates. Regarding the effect of unskilled and skilled position type on RTP rates as a function of time, no significant differences were found per the Kaplan-Meier method ($P = .19$) (Figure 1A). Of the 80 players, 36 were selected in draft rounds 1 to 3 and 18 in draft rounds 4 to 7; the remaining 26 players were signed as undrafted free agents. When the effect of draft round on RTP was examined with the Kaplan-Meier method, no significant differences were found ($P = .49$) (Figure 1B).

Although no significant difference in number of prior seasons was observed, we found that, in the season immediately before injury, players who did RTP played in significantly more RS games than those who did not (13.74 vs 8.71, $P = .011$) (Table 3). There were no significant between-group differences in RS games played in any of the other preinjury seasons. There were no significant differences between the RTP and no-RTP groups in RS games started in any of the preinjury seasons; however, this statistic approached significance in the season immediately before injury (8.32 and 4.29, respectively, $P = .076$).

Players who did not RTP exhibited a significant decrease in performance preceding injury (Table 3). They decreased from playing a mean of 12.69 RS games 2 seasons prior to injury to 8.71 games 1 season prior ($P = .0185$) (Figure 2A). The decrease in performance for this group was also seen in RS games started, with a mean of 6.69 games 2 seasons preinjury to 4.29 games 1 season preinjury ($P = .0595$) (Figure 2B). No

TABLE 2
Return to Play and Draft Round by Position[a]

	n	Return Within 18 mo of Injury	Early Draft (Rounds 1-3)	Late Draft (Rounds 4-7)	Undrafted Free Agent
Unskilled	24	18 (75.0)	10 (41.7)	5 (20.8)	9 (37.5)
Center	1	1	0	0	1
Guard	3	2	0	2	1
Offensive tackle	2	1	1	0	1
Defensive tackle	6	6	4	0	2
Defensive end	12	8	5	3	4
Skilled	53	28 (52.8)	26 (49.1)	12 (22.6)	15 (28.3)
Running back	7	3	2	3	2
Wide receiver	10	4	4	0	6
Tight end	6	4	2	2	2
Linebacker	17	12	10	5	2
Cornerback	10	5	6	2	2
Safety	3	2	2	0	1
Special teams	3	3 (100)	0 (0)	1 (33.3)	2 (66.7)
Long snapper	1	1	0	0	1
Kicker	1	1	0	0	1
Punter	1	1	0	1	0
Total	80	49 (61.3)	36 (45.0)	18 (22.5)	26 (32.5)

[a]Values are presented n (%).

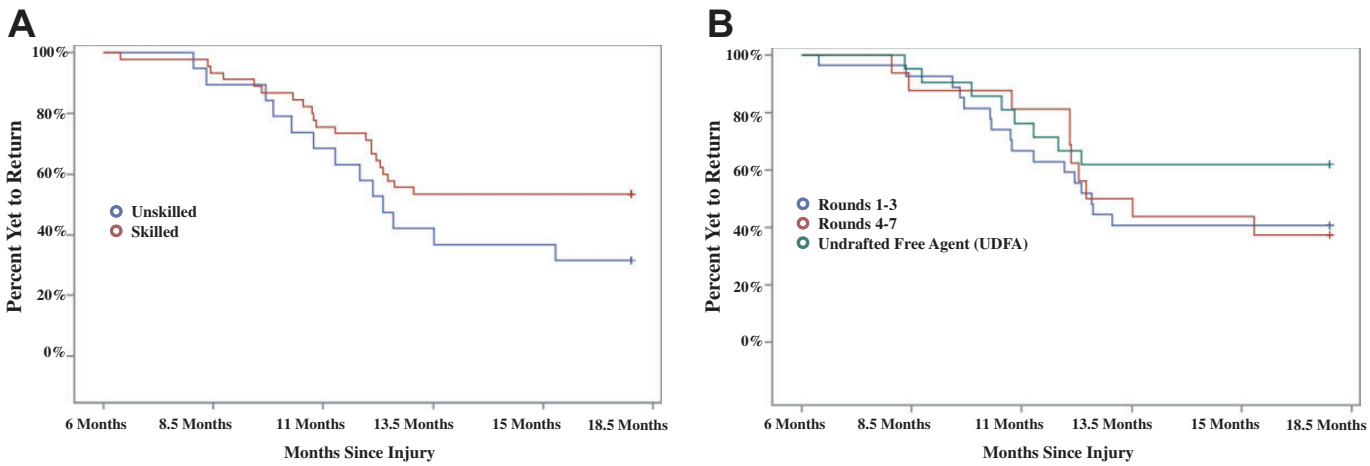

Figure 1. Kaplan-Meier analysis evaluating the effect of (A) position type and (B) draft round in which the player was selected on return-to-play rates as a function of months since injury date. Kaplan-Meier curves for (A) unskilled players (blue) and skilled players (red), $P = .19$; (B) rounds 1-3 (blue), rounds 4-7 (red), and undrafted free agents (green), $P = .49$.

significant changes in the number of RS games played or started were observed in the other preinjury seasons. For players who did RTP, there was no significant change in the number of RS games played or started in the preinjury seasons (Table 4).

Players who did RTP played in significantly fewer RS games in the season in which they returned as compared with the 2 seasons immediately before their injury. The observed decrease was from a mean of 14.52 games 2 seasons preinjury and 13.74 games 1 season preinjury to 10.94 games in the RTP season ($P = .0005$ and .0071, respectively) (Table 4). After the RTP season, there were no significant differences in the number of games played before and after injury.

DISCUSSION

Although AT injuries are relatively uncommon in the NFL, with incidence rates of 0.93% per game and 0.015% per player per game,[26] they are career-threatening injuries. As compared with an RTP rate of 80% for nonprofessional athletes, the rate for NFL players has been reported at 66% to 78%.[23,26,34] This study found an RTP rate of 61.3%—the lowest reported for this population. This difference in rates may stem from the current study comprising the largest and most inclusive cohort examined. The difference cannot be explained by methodology, as Parekh et al[26] and Trofa et al[34] similarly utilized NFL player registries, injury reports, and press releases to compile their lists of NFL

TABLE 3
Games Played and Started Before and After Injury[a]

	No RTP	RTP	*P*
Games Played			
Season before injury			
Seventh	13.67 ± 1.22	13.17 ± 1.23	.77
Sixth	12.86 ± 2.02	15.00 ± 0.58	.34
Fifth	13.88 ± 1.36	14.18 ± 1.18	.87
Fourth	11.83 ± 1.31	12.22 ± 1.22	.83
Third	12.92 ± 0.82	12.90 ± 1.18	.99
Second	12.69 ± 1.01	14.52 ± 0.61	.14
First	8.71 ± 1.51	13.74 ± 0.49	.011
RTP season	—	10.94 ± 0.87	—
Season after return			
First	—	12.46 ± 0.96	—
Second	—	10.82 ± 1.39	—
Third	—	10.08 ± 1.66	—
Games Started			
Season before injury			
Seventh	7.67 ± 2.51	8.00 ± 2.48	.92
Sixth	7.57 ± 2.54	5.67 ± 2.39	.59
Fifth	6.38 ± 2.20	8.45 ± 1.91	.49
Fourth	5.42 ± 1.52	8.78 ± 1.43	.14
Third	7.85 ± 1.69	9.85 ± 1.47	.39
Second	6.69 ± 1.33	9.17 ± 1.36	.20
First	4.29 ± 1.48	8.32 ± 1.15	.076
RTP season	—	6.30 ± 1.11	—
Season after return			
First	—	7.71 ± 1.37	—
Second	—	8.94 ± 1.62	—
Third	—	9.33 ± 1.85	—

[a]Data are reported as mean ± SD. RTP, return to play.

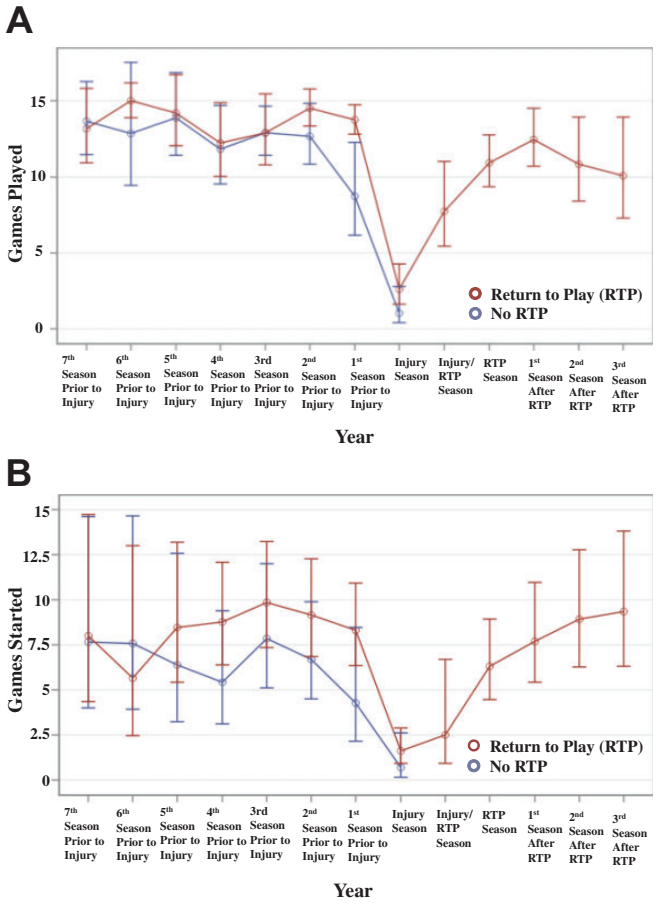

Figure 2. Number of games (A) played and (B) started before and after the season of injury between players who did return to play (RTP; red) and players who did not (blue). Data are shown as mean ± SD. (A) A significant decrease in games played occurred between the second and first seasons prior to injury for players who did not RTP ($P = .0185$). (B) No significant differences were found across seasons for both groups.

players. In contrast, McCullough et al[23] examined only athletes treated by the senior author using a mini-open repair technique; thus, their relatively higher reported RTP rate of 78% may have been affected by selection bias and cofounding factors. Despite a significant difference in position types between those who were able to RTP and those who were not, position did not significantly influence RTP probability in the Kaplan-Meier analysis we conducted.

Recovery time for NFL athletes also appears to be longer than that of nonprofessional athletes. Parekh et al[26] examined 28 NFL players and found that the mean time to RTP was 11 months—much greater than the 4 to 6 months required for nonprofessional athletes.[20] Similarly, in a study of NFL players who underwent mini-open repairs, McCullough et al[23] found that the mean time to RTP was 8.9 months. The current study reports the longest recovery time for this population: 11.90 months. The difference in time required to RTP between nonprofessional athletes and NFL players may reflect the difference between nonprofessional athletes who are returning to participation and NFL players who must be able to not only return but also perform at maximal exertion.[33]

For players who return, the long-term effects remain unclear. Parekh et al[26] found a >50% reduction in performance following an AT rupture. However, they examined only select position types and calculated performance using "power ratings," a scoring system similar to that used in fantasy football. The current study examined all positions and found that the players who did RTP played in significantly fewer RS games in their return season versus the season preceding injury. Notably however, these players returned to their preinjury levels of RS games played and started when allowed to play >1 season following injury.

Opportunity to RTP may be different in the NFL than in other professional leagues. The RTP rate of 61.3% reported in this study and rates reported in other studies of NFL players are lower than those reported in studies examining AT ruptures in the National Basketball Association (NBA) and Major League Baseball (MLB). Trofa et al[34] examined 32 NFL, 25 NBA, and 5 MLB athletes who experienced an isolated AT rupture between 1989 and 2013 and reported

TABLE 4
Family-wise Comparisons for Games Played and Started Among Players Who RTP[a]

	Season Before Injury							Season After Return		
Games Played	Sixth: 15.00 ± 0.58	Fifth: 14.18 ± 1.18	Fourth: 12.22 ± 1.22	Third: 12.90 ± 1.18	Second: 14.52 ± 0.61	First: 13.74 ± 0.49	RTP Season: 10.94 ± 0.87	First: 12.46 ± 0.96	Second: 10.82 ± 1.39	Third: 10.08 ± 1.66
Season before injury										
Seventh: 13.17 ± 1.23	.2751	.5529	.5904	.8663	.345	.6636	.1233	.6399	.2041	.1595
Sixth: 15.00 ± 0.58		.5457	.0573	.1367	.5582	.1015	**.0006**	.0381	**.014**	**.0193**
Fifth: 14.18 ± 1.18			.2265	.4639	.8036	.7106	**.0325**	.2789	.098	.0956
Fourth: 12.22 ± 1.22				.6445	.1249	.2922	.3515	.8739	.4818	.3579
Third: 12.90 ± 1.18					.2237	.4723	.112	.764	.1977	.1752
Second: 14.52 ± 0.61						.3032	**.0005**	.076	**.029**	**.0319**
First: 13.74 ± 0.49							**.0071**	.2732	.0776	.078
RTP season: 10.94 ± 0.87								.2248	.9379	.6344
Season after return										
First: 12.46 ± 0.96									.1939	.1688
Second: 10.82 ± 1.39										.5289

Games Started	Sixth: 5.67 ± 2.39	Fifth: 8.45 ± 1.91	Fourth: 8.78 ± 1.43	Third: 9.85 ± 1.47	Second: 9.17 ± 1.36	First: 8.32 ± 1.15	RTP Season: 6.30 ± 1.11	First: 7.71 ± 1.37	Second: 8.94 ± 1.62	Third: 9.33 ± 1.85
Season before injury										
Seventh: 8.00 ± 2.48	.2141	.8337	.7885	.5237	.6887	.905	.4727	.9165	.7566	.6759
Sixth: 5.67 ± 2.39		.2566	.3379	.2006	.2708	.3794	.802	.4886	.3007	.285
Fifth: 8.45 ± 1.91			.8748	.5289	.7432	.9485	.3237	.7541	.8503	.7563
Fourth: 8.78 ± 1.43				.4243	.7759	.7857	.1292	.5587	.9409	.8235
Third: 9.85 ± 1.47					.6299	.2999	**.0252**	.2317	.643	.8244
Second: 9.17 ± 1.36						.5048	.0833	.3821	.904	.9388
First: 8.32 ± 1.15							.1641	.7067	.7254	.6163
RTP season: 6.30 ± 1.11								.3188	.068	.1006
Season after return										
First: 7.71 ± 1.37									.2929	.2968
Second: 8.94 ± 1.62										.7345

[a]Values are presented as mean ± SD and *P* values. Bolded values indicate statistical significance, $P < .05$. RTP, return to play.

RTP rates of 65.6%, 68.0%, and 100%, respectively. Other studies have reported RTP rates of 61.1% and 70.8% in the NBA[4,24] and 62% in MLB.[29] The lower RTP rate of NFL players versus those of their NBA and MLB peers may stem from shorter mean careers and nonguaranteed contracts that allow NFL teams to more easily cut players.[5,13,28]

The cause-and-effect relationship of decreased games played before injury and AT rupture is unclear. This study

found a notable decrease in number of games played when comparing the 2 seasons prior to injury among players who did not RTP. The difference in the number of RS games played by those who did and did not RTP approached significance 2 seasons preinjury but was significant only in the season immediately preceding injury. These findings may be indicative of many possibilities and trajectories. First, players who did not RTP may have been playing in fewer games than their peers owing to a lack of skill or talent and may have been released regardless of their injuries. Second, the significant decline in the number of preinjury RS games among the players who did not RTP may reflect the natural decline of a player's performance; that is, his subsequent inability to RTP reflected this decline rather than the injury. Last, this decline in the number of RS games played, which was significant only for the players who did not RTP, may reflect degenerative changes of the AT, which may have hindered performance and predisposed to rupture.[2,14,21] If reduced performance precedes rupture, this prodromal period could afford players and health professionals an opportunity to intervene. In a study of 43 NBA players, Amin et al[3] found that Achilles tendinopathy was associated with significant declines in playing time and Player Efficiency Rating. Surveillance of degenerative changes associated with AT rupture, such as tendinopathy, and awareness of significant performance decline may allow for clinicians to detect tendons prone to rupture.[33]

This study analyzed the largest known cohort of NFL players with regard to RTP following AT ruptures. The players were treated at multiple institutions, limiting selection bias. To the best of our knowledge, all included players experienced a primary AT rupture. This is the only known study to differentiate between primary and secondary AT tears and to evaluate pre- and postinjury levels of performance for all positions. Limiting the study to only those who had primary tears allowed us to evaluate recovery from AT tears as isolated injuries without any confounding residual effects from previous tears. Patients with subsequent tears during or after the study period were also excluded from performance analyses that evaluated the number of RS games played and started following injury, to eliminate ipsilateral retear and contralateral tear as confounders in analyzing other factors affecting postrecovery performance.

This study has several limitations. First, we evaluated RTP within 18 months following injury, as effective sample sizes became underpowered with longer periods. We chose to evaluate RTP within this shorter period with greater accuracy rather than over a longer period with limited statistical power. We believe that a more comprehensive performance analysis with position-specific metrics, such as yards per rush for running backs, is an area for future study. Many positions were limited by small sizes prohibiting a robust analysis. Consequently, we used RS games played and started as performance metrics, as these are ubiquitous measures across all positions. In addition, players may have not been able to RTP, not because of their injuries but rather because of a lack of skills or a natural decline in performance unrelated to future injuries, leading them to be replaced by players from different teams, other players returning from injuries, or new players entering the league. A small but respectable number of players (12 of 80) had a subsequent ipsilateral retear or contralateral tear during the study period. Although these players were included in the overall RTP rate and demographic analyses, they were excluded from performance analyses owing to the confounding effects of their new injury. Further evaluation of these players represents a possible area of future study that could elucidate the recovery process from a primary AT tear complicated by a subsequent retear or contralateral tear. Also, this study is a retrospective cohort analysis, and subsequently, causation between AT tear and ability to RTP cannot be proven.

All data used in this study were obtained from publicly available data. Although every effort was made to identify all players and even though the NFL requires teams to report injuries, it is possible that our database is not comprehensive. Last, the players who contributed to the overall RTP rate in our study had a minimum of 2 full seasons to RTP. Although it is unlikely for a player to RTP after 2 full seasons, as evidenced by none of the 80 players studied taking >2 years to RTP, it is possible that a player in our data set who did not return by the end of the 2016 season may RTP.

CONCLUSION

We found that 61.3% of NFL players were able to successfully RTP at a mean 11.90 months following a primary AT tear. Unlike other major injuries, draft round and position type were not significantly associated with likelihood of returning after an AT tear. Players who did RTP played in more games the season immediately preceding injury as compared with players who did not RTP, indicating that preinjury performance is an important predictive factor for RTP. Players who returned displayed a significant decrease in the number of games played in the return season when compared with seasons preceding injury. However, when we examined >1 season following return, AT tears appeared to not affect ability, as there was no significant difference in pre- and postinjury number of games played or started. Our findings suggest that players may return to preinjury performance levels if given the opportunity.

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