

A Comprehensive Return-to-Play Analysis of National Basketball Association Players With Operative Patellar Tendon Tears

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Background: Patellar tendon tears impart potentially debilitating sequelae among professional basketball athletes.

Hypothesis: Professional basketball athletes with patellar tendon tears have decreased return-to-play performance in seasons after injury compared with preinjury statistics.

Study Design: Case series; Level of evidence, 4.

Methods: Patellar tendon tears among National Basketball Association (NBA) athletes from the 1999-2000 to 2014-2015 seasons were identified. Player performance statistics for players who underwent operative patellar tendon repair were compared from 1 season before injury to 1 season after injury and 2 seasons before injury to 2 seasons after injury using the primary outcome of player efficiency rating (PER). Secondary performance outcomes were also analyzed.

Results: A total of 13 patellar tendon tears (10 complete, 3 partial) were identified among 12 NBA athletes. Three players (25%) did not return to play in the NBA. No significant differences were found in PER in comparisons of 1 season before and after injury (16.6 ± 1.5 vs 14.3 ± 1.7 ; $P = .20$) or in comparisons of 2 seasons before and after injury (15.8 ± 0.8 vs 6.3 ± 2.3 ; $P = .49$). Diminished performance outcomes were noted for total minutes played (2598 ± 100 vs 1695 ± 78 ; $P = .01$), games played (74.8 ± 1.9 vs 60.5 ± 1.4 ; $P = .04$), and minutes per game (34.8 ± 1.5 vs 28.2 ± 1.8 ; $P = .02$) in comparisons of 1 season before and after injury. Total minutes played per season (2491 ± 190 vs 799 ± 280 ; $P = .045$) decreased in comparisons of 2 seasons before and after injury.

Conclusion: Patellar tendon tears were not associated with diminished efficiency-adjusted performance, as measured by PER, games played, minutes per game played, points per 36 minutes, and rebounds per 36 minutes. However, decreases in total minutes played were observed following patellar tendon tear. Orthopaedic surgeons may be better prepared to counsel basketball athlete patients with patellar tendon tear given these findings.

Keywords: patellar tendon injury; patellar tendon tear; return to play; sports medicine; basketball; National Basketball Association

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One or more of the authors has declared the following potential conflict of interest or source of funding: M.J.A. is a consultant for Arthrex and has received hospitality payments from DePuy Synthes and Gotham Surgical Solutions and Devices. 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.

The Orthopaedic Journal of Sports Medicine, 6(10), 2325967118800479

DOI: 10.1177/2325967118800479

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The supraphysiological nature of professional athletics exposes high-performance athletes to greater risks for all injuries, including risk of patellar tendon injury and rupture among many other injuries.²¹ Biomechanically, patellar tendon tears tend to occur secondary to blunt trauma, eccentric contractions, and repetitive high-stress cycles of loading and unloading, mechanisms that are predominant among professional basketball players.¹³ Predisposing factors to patellar tendon tear include preexisting patellar hypermobility, knee laxity, and local corticosteroid injection.¹⁰ Patellar tendon tears are generally seen in older patients, although such tears can occur in young athletes as well. Biomechanically, patellar tendon tears often occur in athletes as a noncontact injury in which the quadriceps contracts while the knee is in flexion.¹⁸ Patellar tendon tears have a significant impact on athletes' careers and have been associated, subjectively and anecdotally, with poor return-to-play outcomes.^{10,14} Players at highest risk

are those participating in high-demand, impact-driven sports. Patellar tendon injury outcome studies, to date, only exist among professional athletes who have been studied for their play in the National Football League (NFL). In that group, patellar tendon tears requiring operative repair were associated with the worst return-to-play outcomes.^{3,15}

For those who treat patellar tendon tears, return-to-play data are important for prognostication and for management of performance expectations. However, a paucity of literature is available regarding return-to-play statistics among professional basketball athletes after experiencing patellar tendon injury. We hypothesized that patellar tendon tears among professional National Basketball Association (NBA) athletes will result in significant decreases in player performance 1 and 2 years after injury.

METHODS

This study did not require institutional review board approval because it used publicly available data and did not involve human participants. All injury and statistical data were collected from publicly available sources (prosportstransactions.com, basketball-reference.com). Inclusion criteria included professional basketball athletes in the NBA who had season-ending partial- or full-thickness patellar tendon tear and who underwent operative repair. Exclusion criteria included inability to access follow-up statistics and nonoperative patellar tendon injuries. Demographic parameters of height, weight, body mass index (BMI), years played in the NBA before injury, and position were also collected. A control cohort was selected based on a basketball-reference.com player similarity score, which identifies similar players based on matching position and finding the minimum win-share differences among seasons played.

Frequency of patellar tendon tears in NBA players was estimated by dividing the number of patellar tendon tears identified by the product of the average mandate number outlined in the collective bargaining agreement (14.5) with the number of teams in the NBA (30).¹⁷ Data points representing players with partial tears, repeat tears, or concomitant injury were excluded from the statistical analysis.

A script in Python 2.7 (Python Software Foundation) was used to data-mine injury and performance data from the publicly available databases by cross-referencing all rosters from the 1999-2000 to 2014-2015 seasons to a transactions database that contained data for all games missed due to injuries. All knee injuries in the specified season were identified, and injury type was determined by manually cross-referencing the script-populated injury data against public team injury reports and news sources. This method has been used and validated in a range of return-to-play and epidemiologic studies involving professional athletes in basketball and other sports.^{1,2,8,9,19}

Paired analyses comparing preinjury statistics and the first 2 seasons subsequent to injury were conducted. All players included in this study underwent operative patellar tendon repair. The primary outcome measure assessed was player efficiency rating (PER). PER is an advanced statistic

that attempts to capture a player's entire offensive and defensive performance¹² by being both efficiency and pace adjusted. PER scores are normalized so that the mean annual league PER is 15.0. The use of PER as a comprehensive statistic across all playing positions makes it useful as a primary endpoint for player comparisons, and it has been used and validated in many return-to-play outcome studies among professional basketball players.^{1,2,5,7,12}

Total playing time in the season and minutes per game were compared for 1 season before versus 1 season after injury and for 2 seasons before versus 2 seasons after injury. Player performance statistics (such as points, rebounds, assists, blocks, and steals) were efficiency adjusted per 36 played minutes and compared. For the purposes of reporting playing time-adjusted statistics, per-36-minute statistics have been reported in both traditional sports reporting and for comparisons in orthopaedic literature.^{2,8}

Statistical Analysis

An a priori power analysis for the primary outcome of PER was conducted with an alpha of .05 and power of 0.8. We determined that a sample size of 6 would appropriately power the study for the parameter of PER; this determination was based on estimates of a difference of 5.0 in PER for paired samples, comparing PER 1 season after to 1 season before injury and 2 seasons after to 2 seasons before injury, with a standard deviation of 3.0. Secondary outcome comparisons were also performed, although a priori power analyses were not performed for each parameter. Univariate comparisons comparing 1 season after to 1 season before injury and 2 seasons after to 2 seasons before injury were performed with paired 2-tailed Student *t* tests. Unpaired 2-tailed Student *t* tests were performed on height, weight, and BMI for players and their matched controls to determine significant differences between demographic parameters. A linear regression slope test was performed to determine whether there was a significant relationship between the independent variables height, weight, and BMI and the dependent variables PER and time played. This statistical test determines whether a linear relationship exists between the demographic parameters and playing outcomes; a slope that is not statistically different from 0 suggests that the demographic and playing parameters are not linearly related. A chi-square goodness-of-fit test was performed on player position, assuming a uniform distribution of patellar injury among positions, to determine whether significant differences existed among positions for patellar tendon injury frequency. All data analysis was performed in MATLAB R2016a (The MathWorks), and statistical significance was evaluated at the level of $P < .05$.

RESULTS

Thirteen patellar tendon tears (12 primary injuries and 1 reinjury) were identified among 12 players across a 15-year span. Five of these injuries met the exclusion criteria: 3 injuries were partial tears, 1 injury was associated with a

TABLE 1
Comparisons Between 1 Year Before and 1 Year After Patellar Tendon Tear

	1 Year Before ^a	1 Year After ^a	Difference ^a	95% CI	P Value
Minutes	2598 ± 100	1695 ± 78	-1026 ± 602	-1628 to -423	.012 ^b
Games played	74.8 ± 1.9	60.5 ± 1.4	-26 ± 22.8	-48.8 to -3.2	.036 ^b
Minutes per game	34.8 ± 1.5	28.2 ± 1.8	-7.1 ± 4.7	-11.8 to -2.4	.017 ^b
Player efficiency rating	16.6 ± 1.5	14.3 ± 1.7	-3.5 ± 6.8	-10.3 to 3.3	.198
Points	18.3 ± 2.0	15.7 ± 2.1	-2.4 ± 4.6	-7.0 to 2.2	.195
Rebounds	5.3 ± 0.4	4.5 ± 0.6	-1.3 ± 2.1	-3.4 to 0.7	.134
Assists	3.1 ± 0.77	3.5 ± 1.02	0.48 ± 0.79	-0.32 to 1.27	.153
Blocks	1.13 ± 0.12	0.95 ± 0.12	-0.58 ± 1.04	-1.62 to 0.47	.177
Steals	0.23 ± 0.06	0.2 ± 0.08	-0.1 ± 0.29	-0.39 to 0.19	.353

^aValues expressed as mean ± standard error of the mean.

^bStatistically significant difference between 1 year before and 1 year after injury ($P < .05$).

TABLE 2
Comparisons Between 2 Years Before and 2 Years After Patellar Tendon Tear

	2 Years Before ^a	2 Years After ^a	Difference ^a	95% CI	P Value
Minutes	2491 ± 190	799 ± 280	-1408 ± 1358	-2766 to -50	.045 ^b
Games played	78 ± 2.0	40 ± 12	-29 ± 43	-72 to 14	.133
Minutes per game	32.4 ± 2.7	15.5 ± 2.5	-9.5 ± 14.1	-23.6 to 4.5	.133
Player efficiency rating	15.8 ± 0.8	6.3 ± 2.3	-3.1 ± 11.1	-14.2 to 8.0	.487
Points	16.2 ± 1.0	12.4 ± 1.0	-3.4 ± 7.8	-11.2 to 4.4	.294
Rebounds	5.2 ± 0.4	3.5 ± 0.8	0.4 ± 1.5	-1.1 to 2.0	.490
Assists	3.5 ± 0.6	2.6 ± 0.8	0.1 ± 0.7	-0.6 to 0.8	.767
Blocks	1.05 ± 0.11	1.2 ± 0.18	-0.5 ± 0.51	-1.01 to 0.01	.053
Steals	0.33 ± 0.09	0.08 ± 0.03	0.38 ± 0.76	-0.38 to 1.14	.239

^aValues expressed as mean ± standard error of the mean.

^bStatistically significant difference between 2 years before and 2 years after injury ($P < .05$).

patellar dislocation, and 1 injury was associated with an anterior cruciate ligament (ACL) and medial collateral ligament tear in the same player. The positions of the 12 players were 2 point guards, 1 shooting guard, 3 small forwards, 1 power forward, and 5 centers. Player position was not significantly associated with frequency of patellar tendon tear ($P = .33$). The number of seasons (mean ± standard error of the mean) played in the NBA before injury was $7.5 ± 4.6$ seasons. Three of the 12 (25%) players did not return to play in the NBA after patellar tendon injury. The frequency of patellar tendon tears in the NBA was estimated at 1.99 patellar tendon tears per 1000 player-years over the 15-year study period. One player had known previous patellar tendon injury, which was a prior full-thickness patellar tendon tear with patellar dislocation. For the following statistical comparisons, the exclusion criteria of partial tear, repeat tear, or concomitant injury were applied, for a final study cohort size of $n = 7$ players.

Height (injury vs control, $79.3 ± 2.1$ vs $80.6 ± 2.0$ inches) and weight ($226.7 ± 13.0$ vs $221.5 ± 12.5$ pounds) were not significantly different ($P > .05$) between injury and control cohorts. BMI in the injury group was significantly greater than in the control group ($25.8 ± 0.3$ vs $24.4 ± 0.6$, $P = .026$). No significant linear relationship was found between

height, weight, or BMI with PER or minutes played in the regular season ($P > .05$ for all comparisons). The average age of players in the injury cohort at the time of injury was $28.7 ± 2.0$ years.

Comparing 1 season before with 1 season after injury, we found that the primary outcome of PER was not significantly different ($16.6 ± 1.5$ vs $14.3 ± 1.7$, $P = .20$). However, significant decreases were observed for comparisons in total minutes played in season ($2598 ± 100$ vs $1695 ± 78$, $P = .012$), games played ($74.8 ± 1.9$ vs $60.5 ± 1.4$, $P = .04$), and minutes per game ($34.8 ± 1.5$ vs $28.2 ± 1.8$, $P = .02$). We observed no significant differences in the per-36-minute playing statistics when comparing 1 season before with 1 season after injury (Table 1).

Comparing 2 seasons before with 2 seasons after injury, we observed no significant difference in PER ($15.8 ± 0.8$ vs $6.3 ± 2.3$, $P = .49$). We observed a significant decrease in comparisons of total minutes played in season when comparing 2 seasons before with 2 seasons after injury ($2491 ± 190$ vs $799 ± 280$, $P = .045$). No significant differences were observed in comparisons of games played ($78 ± 2$ vs $40 ± 12$, $P = .13$), minutes per game ($32.4 ± 2.7$ vs $15.5 ± 2.5$, $P = .13$), or per-36-minute playing statistics when we compared 2 seasons before with 2 seasons after injury (Table 2).

DISCUSSION

Patellar tendon tears are uncommon in the NBA, occurring less than once per season on average over the years included in this study. For professional basketball players, patellar tendon tears can be potentially career-ending injuries and are associated with somewhat poor prognostication and return to play. When we compared 2 years after with 2 years before injury and 1 year after with 1 year before injury, the results rejected our hypothesis, suggesting that based on the primary outcome of PER, NBA players can return to their previous level of play after patellar tendon tear. Of the players with patellar tendon injury, 25% did not return to play in the NBA. For players who did return to play, total minutes played in season were significantly reduced in the 2 seasons after patellar tendon injury. Total minutes played in season, minutes per game, and games played were reduced in 1 season after compared with 1 season before injury. These results indicate a reduction in playing time while playing in the first and second seasons after patellar tendon injury, although efficiency-adjusted statistics remained unchanged. Height and weight were not significantly different between the injury and control cohorts. BMI was significantly higher in the injury cohort than the control cohort, suggesting an association between higher BMI and incidence of patellar tendon tear. Height, weight, and BMI did not have a significant association with playing outcomes, as measured by PER and total regular season playing time in the cohort of injured players.

These results are slightly different than return-to-play outcomes in football: In the NFL, patellar tendon tears are associated with significant reductions in games played and on-field performance when seasons after injury versus seasons before injury are compared. According to the NFL Orthopedic Surgery Outcomes Database study, only 50% of NFL players returned to play after patellar tendon tear. Additionally, patellar tendon injuries were associated with the largest reduction in performance score among all operative injuries in professional football.¹⁴ A study of patellar tendon tears in professional football by Boublik et al³ suggested more favorable outcomes. In that study, 79% of football athletes with patellar tendon tears played in the NFL after their injury, although the study did not include a statistical analysis of playing performance after injury. Quadriceps tendon tears in professional football are also associated with poor rates of return to play, with only 50% of players with quadriceps tendon tears returning to play.⁴

As with other operative knee injuries in the NBA, patellar tendon tears are generally associated with poor return-to-play outcomes. Several studies of ACL tears in NBA athletes found different return-to-play results when comparing seasons after versus seasons before injury: Kester et al¹¹ reported significant PER differences, and Busfield et al⁵ reported no significant PER differences. Similar rates of career-ending injury are seen for ACL tears, with 22% to 26% of players never returning to play in the NBA after this injury.^{5,11} Microfracture surgery is also associated with significantly decreased playing time in seasons after compared with seasons before surgery.¹⁶ Namdari et al¹⁶ found that PER was significantly reduced after

microfracture surgery; however, Cerynik et al⁶ did not find a significant reduction in PER. In these studies, 17% to 21% of players did not return to play in the NBA after microfracture surgery.^{6,16} Yeh et al²⁰ reported that 19% of NBA players with isolated meniscal tear did not return to play in the NBA. Additionally, these authors observed no significant differences in PER when comparing postinjury seasons with preinjury seasons in players with medial or lateral meniscus tears.¹²

In a general population cohort of patellar tendon tear repairs, 20 of 23 patients (87%) had returned to sports activity; however, only 8 reported that they returned to their pretrauma level (35%).¹⁸ This poor status regarding return to baseline sports activity mirrors what we found in the professional basketball player cohort studied here; some athletes returned to sport but at a decreased level relative to preinjury, given that playing time significantly decreased in our injury cohort.

The literature provides no return-to-play data regarding patellar tendon tears in professional hockey or baseball players. During the process of identifying players who had patellar tendon tears from the 1999-2000 to 2014-2015 seasons, we identified 6 Major League Baseball players and 2 National Hockey League players who had patellar tendon tears, when using the same methods that we used to identify basketball players. Based on this preliminary injury identification, the incidence of patellar tendon tear appears to be lower in professional baseball and hockey.

This study has several limitations. Our study focused on athletic playing outcomes and parameters rather than typical orthopaedic outcome measures. Because patellar tendon injuries are relatively uncommon in basketball players, the sample size is small despite our reviewing 16 seasons of injury data in the NBA. Due to the small sample size in this study, there is a higher risk of type 2 error. Comparison between players with partial versus complete patellar tendon tears was not completed due to insufficient sample size for appropriate statistical power. All players in the injury cohort underwent operative repair. However, specific treatment details such as comorbidity, surgical technique, rehabilitation methods, and other patient characteristics were unavailable due to the nature of data collection through publicly available databases. As in any sport, factors outside of the players' control, such as roster changes or coaching, may have affected playing time and performance. Additionally, all the participants in this study were male.

Of the 75% of players who returned to play in the NBA after patellar tendon injury during the 1999-2000 to 2014-2015 seasons, an association was found regarding playing time and performance decreases in the seasons following injury. Additionally, patellar tendon tears were associated with higher BMI.

CONCLUSION

Patellar tendon tear outcomes have been sparsely characterized in the orthopaedic literature, especially regarding

return-to-play outcomes for professional athletes. This study demonstrated that professional basketball athletes may return to similar levels of play 1 and 2 seasons following injury, although with reduced playing time. These data are useful to orthopaedic surgeons and other sports medicine physicians for prognostication and management of patient expectations.

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