

Performance After Anterior Cruciate Ligament Reconstruction in National Basketball Association Players

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Background: Anterior cruciate ligament (ACL) injury in National Basketball Association (NBA) players can have a significant impact on player longevity and performance. Current literature reports a high rate of return to play, but there are limited data on performance after ACL reconstruction (ACLR).

Purpose/Hypothesis: To determine return to play and player performance in the first and second seasons after ACLR in NBA players. We hypothesized that players would return at a high rate. However, we also hypothesized that performance in the first season after ACLR would be worse as compared with the preinjury performance, with a return to baseline by postoperative year 2.

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

Methods: An online database of NBA athlete injuries between 2010 and 2019 was queried using the term *ACL reconstruction*. For the included players, the following data were recorded: name; age at injury; position; height, weight, and body mass index; handedness; NBA experience; dates of injury, surgery, and return; knee affected; and postoperative seasons played. Regular season statistics for 1 preinjury season and 2 postoperative seasons were compiled and included games started and played, minutes played, and player efficiency rating. Kaplan-Meier survivorship plots were computed for athlete return-to-play and retirement endpoints.

Results: A total of 26 athletes underwent ACLR; of these, 84% (95% CI, 63.9%-95.5%) returned to play at a mean 372.5 days (95% CI, 323.5-421.5 days) after surgery. Career length after injury was a mean of 3.36 seasons (95% CI, 2.27-4.45 seasons). Factors that contributed to an increased probability of return to play included younger age at injury (odds ratio, 0.71 [95% CI, 0.47-0.92]; $P = .0337$) and fewer years of experience in the NBA before injury (odds ratio, 0.70 [95% CI, 0.45-0.93]; $P = .0335$). Postoperatively, athletes played a significantly lower percentage of total games in the first season (48.4%; $P = .0004$) and second season (62.1%; $P = .0067$) as compared with the preinjury season (78.5%). Player efficiency rating in the first season was 19.3% less than that in the preinjury season ($P = .0056$). Performance in the second postoperative season was not significantly different versus preinjury.

Conclusion: NBA players have a high rate of RTP after ACLR. However, it may take longer than a single season for elite NBA athletes to return to their full preinjury performance. Younger players and those with less NBA experience returned at higher rates.

Keywords: NBA; ACL; ACLR; performance; player efficiency rating; return to play

Anterior cruciate ligament (ACL) injuries are common in elite-level athletes and occur at an increasingly higher rate in the United States.¹¹ This trend may be a result of the increases in athletic performance or potential overuse, as most professional athletes turn toward yearlong training and have shorter off-seasons than in the past. Athletes are at an increased risk for injury based on sex, sport played, and number of exposures to injury, such as yearlong play.⁸ ACL injuries in the young athletic population nearly always result in surgery and can have a significant impact

on an athlete's subsequent performance and career, especially at the professional level. Furthermore, predicted and actual subsequent performance can have significant financial implications for both players and teams.¹⁷

While return-to-play (RTP) rates vary among sport played, a meta-analysis using the Cochrane database demonstrated an 83% RTP rate in elite-level athletes across multiple sports.¹² However, different sports place different kinematic stresses on the knee; thus, return-to-sport rates can vary among not only sports but also among positions within the same sport. Of the 4 major North American professional sports leagues—National Football League (NFL), National Basketball Association (NBA), Major League Baseball (MLB), and National Hockey League (NHL)—

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NFL athletes who underwent ACL reconstruction (ACLR) had the poorest outcomes with respect to RTP, performance, and career length.¹³ In the NFL, players who had a higher level of performance and more experience before injury were more likely to return but at a lower level.¹³ In contrast, Erickson et al⁶ demonstrated that NHL athletes have a high RTP rate after ACLR with similar statistical performance in the year after reconstruction, indicating that these athletes return to their preinjury performance sooner than their NFL counterparts, perhaps because of the demands of the NHL versus the NFL. Ultimately, RTP and subsequent performance can vary widely among professional athletes of different sports.

Athletes in the NBA place unique stresses on the knee as a result of the fast pace of the game, resulting in unpredictable landing and quick cutting, leaving them susceptible to injuries such as ACL tears. Busfield et al³ showed that from 1993-1994 to 2004-2005, NBA players experienced ACL ruptures at a rate of <3%, with a high RTP rate. However, recent data continue to be limited in regard to NBA players in terms of not only RTP rates but also performance after these injuries on a year-to-year basis after ACLR. While prior studies regarding NBA athletes focused on the RTP rate, few examined player performance after RTP, specifically the point at which an injured player returns to his preinjury level of competition. The purpose of this study was to determine detailed performance outcomes of NBA players undergoing ACLR. In addition, we wanted to see if these statistics varied by player position and demographics, as well as years after the injury. We hypothesized that players would RTP at a high rate (>80%). However, we also hypothesized that once players returned, their first season back from ACLR would be worse than their preinjury performance, with a return to baseline by postoperative year 2.

METHODS

Data Collection

An online database of publicly available NBA athlete injuries between 2010 and 2019 was queried for the terms *ACL repair* or *ACL reconstruction*.¹⁶ These results were confirmed using NBA team websites, publicly available Internet-based information, and press releases when necessary. Twenty-six NBA players who tore their ACLs and underwent reconstructive surgery between 2010 and 2019 were identified. This method of data collection has been used in multiple orthopaedic studies.^{2,6}

Demographic information was recorded for each player, including name, age at injury, team played for, position, height, weight, body mass index, handedness, NBA experience (years), date of injury, date of surgery, date of RTP, number of days between injury and return, knee affected, and seasons played postoperatively. For the purposes of this study, the first game on an active roster defined successful RTP. Regular season statistics for 1 season before surgery and the 2 seasons immediately after surgery were compiled. Games started, games played, minutes played, and player efficiency rating (PER) were recorded for seasons before and after surgery. If the athlete had ACL injury in his first season of NBA play, his player statistics were taken from the season of injury to describe baseline performance before injury. Demographic information and statistics were discovered using NBA team websites and publicly available, internet-based information.¹

PER was also taken from publicly available statistical information. PER is calculated by summing positive performance measures (eg, points, rebounds, and steals) and subtracting negative measures (eg, turnovers and fouls). PER is an objective and standardized method of assessing a player's performance and often used by coaches and front office administrators in making personnel decisions.^{4,9} PER allows for comparisons of (1) player performance across seasons and (2) players across teams and positions to standardize their given skill sets. The league mean PER is adjusted each year to a value of 15. To minimize the effect of team or playing time variables, PER is adjusted to a per-minute basis, and allocations are made for team pace and playing style to represent a player's overall team contribution.⁴ Percentage of preinjury PER was used to evaluate for changes in performance over the course of a given player's career.

Statistical Analysis

Mean, range, and 95% confidence intervals were used to characterize player demographic and characteristic data. Kaplan-Meier survivorship plots were computed for athlete RTP and retirement endpoints with 95% confidence intervals. In comparing pre- and postinjury performance—specifically, for the percentage of games played in a season and the performance score metric—2-tailed paired *t* tests were used to evaluate players against themselves across the different time points. Factors contributing to whether players returned to play (laterality of injury, position, age, experience) were assessed via single-variate logistic regression on the panel of available player characteristics. For predicting days until RTP and percent change of PER score, linear

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Ethical approval was not sought for the present study.

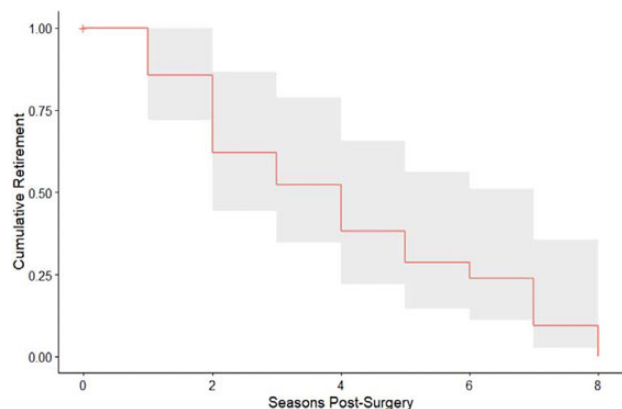


Figure 1. Survival rate for National Basketball Association athletes after anterior cruciate ligament reconstruction (seasons after surgery). Shaded area indicates 95% CI.

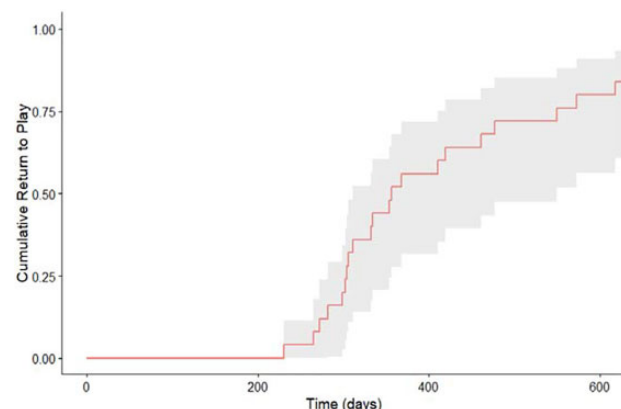


Figure 2. Cumulative return to play for National Basketball Association after anterior cruciate ligament reconstruction. Shaded area indicates 95% CI.

regression was used. Statistical analysis was performed using RStudio (Version 1.1.442; RStudio). An α value of .05 was used.

RESULTS

A total of 26 athletes were identified who underwent ACLR between 2010 and 2019. Based on this, the mean incidence of ACL injuries in the NBA between 2010 and 2019 was 2.88 cases per year. This resulted in a mean incidence of 0.64 cases per 100 player-years, with an assumed 450 players in the NBA per year (30 teams, 15 players per team). These injured athletes had a mean body mass index of 24.6 kg/m² (range, 20.9-26.9 kg/m²), a mean age at injury of 25.3 years (range, 19.0-38.0 years), and a mean playing experience of 4.77 seasons (range, 1-14 seasons). Four athletes had an ACL injury in their first season in the NBA. With regard to laterality, 46% of ACLRs were performed on the right knee. The rate of revision ACLR in this cohort was 4%.

RTP and Career Length After ACLR

Of all injured athletes undergoing ACLR, 84% (95% CI, 63.9%-95.5%) returned to play (Figure 1). The athletes returned to play a mean of 372.5 days (95% CI, 323.5-421.5 days) after ACLR, with a mean career length after injury of 3.36 seasons (95% CI, 2.27-4.45 seasons). The earliest RTP was at 230 days postoperatively (Figure 2). Nearly all returned in the season after injury (88% of those returning). Of note, all athletes with left knee injuries returned to play, as compared with 66.7% of those with right knee injuries.

Factors that contributed to an increased probability of RTP included younger age the time of at injury (odds ratio [OR], 0.71 [95% CI, 0.47-0.92]; $P = .0337$) and fewer years of experience in the NBA prior to injury (OR, 0.70 [95% CI, 0.45-0.93]; $P = .0335$) (Table 1). Eight players playing the forward position had an ACL injury versus 16 guards. Forwards had a lower probability of RTP as compared with

TABLE 1
Factors Affecting RTP ^a

Risk Factor	Whether Player Did RTP		Days Until RTP	
	OR (95% CI)	P Value	β	P Value
Body mass index	0.72 (0.28-1.49)	.4280	2.586	.8930
Preinjury PER score	1.17 (0.99-1.56)	.1310	-5.596	.2610
Age at injury	0.71 (0.47-0.92)	.0337	11.283	.0684
Years of experience	0.70 (0.45-0.93)	.0335	12.988	.0801
Forward position (vs guard)	0.12 (0.0005-1.17)	.0930	118.62	.0598
Injury on right side (vs left)	— ^b	—	43.58	.4580

^aBold P values indicate statistical significance ($P < .05$). OR, odds ratio; PER, player efficiency rating; RTP, return to play.

^bAll players with left-sided injuries and 66.7% with right-sided injuries returned to play.

guards (OR, 0.12 [95% CI, 0.0005-1.17]; $P = .0930$). There were no significant risk factors for increased days until RTP.

Performance After ACLR

Performance was assessed via the percentage of available games played after injury (Figure 3) and the relative percentage change in PER. Of athletes who underwent ACLR, 40% had a decrease in PER >5 points in the first year postoperatively; 20% had a decrease in PER <5 points; and 40% had a positive increase in PER. After ACLR, athletes played in a significantly fewer percentage of games in the first postoperative season (48.4%; $P = .0004$) and the second postoperative season (62.1%; $P = .0067$) as compared with the preinjury season (78.5%), although there was no difference in the percentage of games played between the first and second postoperative seasons ($P = .4675$) (Table 2). Accordingly, athletes after ACLR played a mean

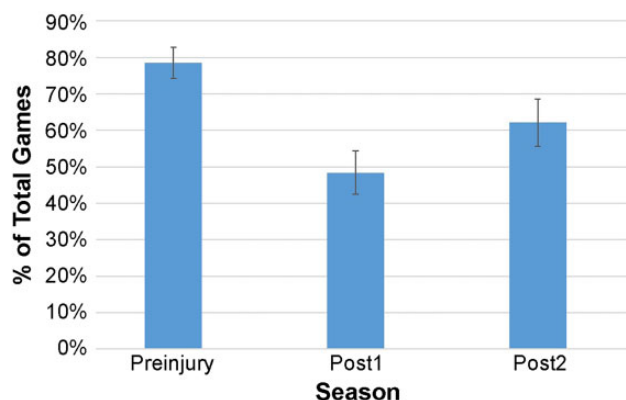


Figure 3. Percentage of games played before injury and after anterior cruciate ligament reconstruction. Error bars indicate 95% CI.

TABLE 2
Percentage of Games Played and PER Before Injury and After ACLR^a

Season	Total Games Played, %	Minutes Played, Mean ± SD	PER, Mean ± SD
Preinjury	78.5	1612 ± 714	13.9 ± 5.8
Postoperative 1	48.4	710 ± 658	11.4 ± 4.2
Postoperative 2	62.1	949 ± 919	13.6 ± 5.5
<i>P</i> value			
Postoperative 1 vs preinjury	.0004	.0002	.0056
Postoperative 2 vs preinjury	.0067	.0049	.3481
Postoperative 2 vs postoperative 1	.4675	.1494	.2396

^aBold *P* values indicate statistically significant difference ($P < .05$). ACLR, anterior cruciate ligament reconstruction; PER, player efficiency rating.

710 minutes in the first season ($P = .0002$) and 949 minutes in the second season ($P = .0049$) as compared with the preinjury season mean of 1612 minutes.

Performance via PER showed that performance in the first season after ACLR was significantly less than that of the preinjury season ($P = .0056$), as players had a 19.3% decrease in PER. Performance in the second season after ACLR was not significantly different from that of the preinjury season ($P = .3481$) (Table 2).

Additionally, each 1-point increase in a player's preinjury PER score was associated with a 3.9% decrease in PER from preinjury to post-ACLR ($\beta = -3.894$; $P = .0479$) (Table 3). Increasing age at injury ($\beta = -4.033$; $P = .0628$) and increasing years of experience ($\beta = -4.352$; $P = .0976$) were also associated with greater decreases in change in PER.

DISCUSSION

Among NBA players who underwent ACLR, the RTP rate was relatively high (84%) between 2010 and 2019. Based on

TABLE 3
Factors Influencing Percentage Change in PER Score From Preinjury to Post-ACLR^a

Risk Factor	β	<i>P</i> Value
Body mass index	-3.029	.5380
Preinjury PER score	-3.894	.0479
Age at injury	-4.033	.0628
Years of experience	-4.352	.0976
Forward position (vs guard)	-22.828	.2210
Injury on right side (vs left)	-21.867	.1540

^aBold *P* values indicate statistical significance ($P < .05$). ACLR, anterior cruciate ligament reconstruction; PER, player efficiency rating.

our data, the mean incidence of ACL injuries in the NBA between 2010 and 2019 was 2.88 cases per year. Nearly all returned in the season after reconstruction (88% of those returning), with players returning after a mean of 372.5 days (range, 230-618 days) postoperatively. Interestingly, all athletes who underwent reconstruction on the left knee returned, as compared with 66.7% of players for the right knee. We also found that younger players and those with less NBA experience were more likely to RTP, though age at injury and years of experience before injury are closely linked. This likely reflects players earlier in their careers being more willing and able to undergo the rigors of the rehabilitation involved after ACLR, while more veteran players may never fully be able to return. While no significance existed with regard to position, forwards were less likely to return than guards. It is difficult to determine the clinical relevance of this finding, as statistical significance was not reached, especially in the current NBA environment where players typically change positions and roles, sometimes in the course of a same game.

Our RTP rate is similar to that found by Lai et al¹² for elite athletes in general (83%) and NBA players in particular (82%). However, RTP discrepancies exist among elite athletes of varying sports. Previous studies reported the NHL to have the highest RTP rate (97%), while the NFL demonstrates the poorest outcomes after ACLR, with RTP rates ranging from 63% to 79%.^{6,13} Other studies cited RTP rates of 77% and 78%-80% in Major League Soccer and the NBA, respectively.^{3,7,9} These discrepancies highlight that sport-specific physical demands and kinematics may affect athletes' recovery and performance postoperatively. Additionally, there may be sport-specific variables that increase the risk of certain ACL injury patterns. Erickson et al^{6,7} reported that 68% of Major League Soccer athletes underwent ACLR on the left knee, while 68% of injured NHL players were left-handed shooters. Conversely, our data, which revealed that 46% of ACLRs were performed on the right knee, do not demonstrate a significant difference in injury pattern in NBA players, which is similar to previous NBA ACL findings indicating a right knee ACLR prevalence of 51%.⁹ However, patients who underwent surgery on the left knee were more likely to RTP in our study. This could be due to the right leg being the leg that a majority of NBA players use to push off during more aggressive

offensive moves. Further investigation is warranted to determine if laterality of injury is significant or just a coincidence among a small sample size.

While the RTP rate itself was high, the length of time to RTP is worth noting. Our cohort averaged 372 days to RTP, just over 12 months. This is an important timeline to keep in mind when counseling patients, and it is worth highlighting that this is just a mean (ie, some players will take longer to RTP). This finding is longer than that found in prior studies, which noted a mean time to RTP between 10.7 and 11.8 months.^{3,9,12} Also of note is that even once players returned, they did not do so at their preinjury performance levels. Furthermore, mean career survival in the present study's cohort of injured athletes was 3.36 seasons, which is fewer than the 4.3 seasons reported by a study of ACL tear in NBA athletes from 1975 to 2012. We did not find any significant association between player demographics and time to RTP.⁹

More importantly, our findings demonstrate that NBA players experience performance declines after ACLR, particularly in the first postoperative season, with regard to games played as well as PER. In the season before injury, NBA athletes played in a mean of 78% of games, as opposed to only 48% and 62% in the first and second seasons after ACLR, respectively. This could be due to several reasons. First, because of the time that it takes to return from injury, it is highly likely that a player's injury carries over to the following season. Second, while the mean time to RTP in the present study was 12 months, some athletes may not be ready, either physically or psychologically, to return to the rigors of daily professional basketball. Third, there has been an increasing trend toward load management in the NBA, in which high-profile players, particularly those with a history of injury, are given planned games off to limit their injury exposure risk.¹⁵ Harris et al⁹ reported similar findings among 58 NBA players. Specifically, 50 players resumed an NBA level of competition at a mean return of 11.6 months; however, they also demonstrated a significant decrease in games played in the season after surgery. Statistical performance also decreased significantly but was not different when compared with a noninjured control group.⁹

PER may be the best metric to evaluate true player performance, as it combines games played as well as key offensive and defensive metrics in an attempt to normalize player performance.¹⁰ Among this ACLR cohort, athletes' PER decreased 19% from the presurgery baseline during the first season after surgery. However, PER returned to baseline during the second season after surgery, indicating once again that it likely takes >1 year for an athlete to truly return to his preinjury performance. In a 2009 study of 27 NBA players who underwent ACLR, Busfield et al found mixed results with regard to PER.³ The authors reported a 78% RTP, with 44% of the players having a decrease in PER >1 point, 19% remaining within 1 PER point, and 15% experiencing an increase. When we performed a similar analysis for the year after surgery, 40% had a decrease in PER >5 points, 20%, a decrease in PER <5 points; and 40%, a positive increase in PER, indicating varying response in performance after ACLR. Clearly, the majority of players

(60%) had a decrease in performance based on our findings, and this does not include patients who were unable to make a complete return. The players in our study had a mean decrease in PER of 2.5 in the season after ACLR, and similar to the aforementioned study, there was a range with a subset of players who improved their PER. In the second postoperative season, however, we found that players tended to return to baseline PER, with the mean only 0.3 points less than that of the preinjury season. Therefore, NBA players can be expected to return to their preinjury levels, but this return may take longer than 1 season.

This study is not without limitations. First, without access to the NBA injury database, it is possible that not all athletes were included in this review. This is a notable weakness of studying publicly available data. Information can be captured only when patients have their injuries made available in team reports or the media. While access to the NBA medical database would be the optimal method for ensuring inclusion of all injured athletes, prior literature has proven that publicly available information as well as league sources can be extremely effective in collecting injury data as well as postoperative performance.^{5,13,14} The risk with this method is that selection bias may have led to a greater percentage of well-known, more popular athletes being included as opposed to backup players or players who are considered professional but may be in only the developmental leagues. Also, there was no comparison with an age/skill-matched cohort group; this means that it may be unknown whether the return-to-baseline PER is better, worse, or the same as compared with uninjured players with similar skill level and age throughout a career. Despite this, our sample size is comparable to prior studies done on NBA ACL tears.^{3,9} Additionally, analyzing risk factors such as player position is made more difficult by recent trends in the NBA of hybrid-type players (ie, the point forward), making it difficult to classify patients in the more traditional way (forward, guard, center). Also, the calculation of PER may not describe individual player performance independent of team pace and playing style; however, PER does control for this. In this study, each player served as his own control. Player transactions were not investigated, such as trades or change in scheme/usage of a player.

Next, the details of the surgical technique were not available for all players, so we were unable to compare surgical techniques with regard to graft selection, fixation method, and so on. A bone-patellar tendon-bone graft may have affected jumping ability, while a hamstring tendon graft may have affected a player's cutting and quickness. Heterogeneity of the surgeons and their skills also present limitations with regard to possible intraoperative complications. Additionally, the rehabilitation program utilized postoperatively was unavailable. Other limitations include the absence of the surgeons' operative reports for concomitant injuries, such as cartilage injury or meniscal tears, as well as the need for subsequent procedures to address these issues during surgery. Moreover, many reasons unrelated to performance may influence an athlete's decision to not RTP or to play fewer games (eg, contract negotiations, personal factors), and these were not accounted for because of

limitations in the information available. As in any sport, factors outside the players' control, such as roster changes or coaching, may have also affected playing time and performance. For the purposes of this study, the first game on an active roster defined successful RTP, but it is important to consider that this may not define the exact length of recovery. Medical clearance to RTP may predate returning to the court if during the off-season.

CONCLUSION

NBA players have a relatively high rate of RTP after ACLR. However, it may take more than a single season for elite NBA athletes to return to their preinjury performance levels. Younger age and less NBA experience at time of injury correlated with an increased RTP rate but not with time to return.

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