

Return to Play and Performance in the Women's National Basketball Association After Anterior Cruciate Ligament Reconstruction

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Background: The incidence of anterior cruciate ligament (ACL) injuries in Women's National Basketball Association (WNBA) athletes continues to increase. There is a paucity of data regarding return-to-play (RTP) rates and performance after ACL reconstruction in these athletes.

Purpose: To quantify RTP rates and performance after ACL reconstruction in WNBA athletes.

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

Methods: All ACL tears sustained in the WNBA from 1997 through 2018 were identified. Body mass index (BMI), age, and position at the time of injury were collected for each player. RTP rates were calculated, and performance data were collected for each player before and after injury to determine changes in playing time and statistical performance. Players who successfully returned to play after ACL reconstruction were compared with a group of healthy controls who were matched by age, years of experience, position, height, and BMI. Statistics at 1 and 3 years after injury were compared to assess acute and longitudinal changes in performance relative to preinjury baseline.

Results: A total of 59 WNBA players sustained ACL tears during the study period, and 41 (69.5%) were able to successfully RTP. Players played a mean of 7.5 ± 12.8 fewer games, played 5.0 ± 9.2 fewer minutes per game, and scored 3.7 ± 5.0 fewer points per game in their first year after RTP compared with the year before injury. Athletes with ACL reconstruction demonstrated significantly decreased performance measures regarding games played, games started, minutes, rebounds, assists, and blocks per game in their first season after RTP compared with control athletes in the same indexed year; however, these differences resolved by year 3 after surgery.

Conclusion: WNBA athletes have a high RTP rate after ACL reconstruction. Players may experience an initial decrease in playing time and performance when returning to play; however, these variables were found to return to baseline over time.

Keywords: knee; ACL; female athlete; basketball

Over the past 20 years, the Women's National Basketball Association (WNBA) has grown into the pinnacle of female professional basketball competition in the United States. Along with its growing popularity, the WNBA has an increasing number of female athletes either entering the league or returning to play after anterior cruciate ligament (ACL) reconstruction.²³ It is well-established in the literature that female athletes are at higher risk of ACL tears than their male counterparts.^{2,3,5,7,31} A recent meta-analysis found that the relative risk of ACL injury in female

basketball players compared with their male counterparts was 3.80, with an overall injury risk of 0.88% per season in females at the high school level.¹¹ Numerous studies have proposed causes for increased injury rates in female players including differences in lower extremity muscle activation,^{6,24} joint laxity,^{25,35} neuromuscular control,^{6,14,15,26} knee anatomic features,^{13,32,33} and hormonal factors.^{16,34}

The incidence of ACL tears and reconstruction continues to rise as athletes seek to return to sport after knee injury.³⁰ Specifically, a history of ACL reconstruction was the most prevalent surgery among female athletes participating in the WNBA draft combine, with 15% of players reporting a history of ACL injury.²³ A comparison between National Basketball Association (NBA) and WNBA players

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found that WNBA players sustained higher rates of lower extremity injury, with a higher incidence of in-game knee injuries, thus highlighting the relatively high risk of ACL injury in female professional basketball players.¹⁰ Return to play (RTP) after ACL reconstruction in the NBA has been reported between 78% and 86%, with trends toward decreased performance after RTP.^{9,12} Similarly, a 78% RTP rate was found in WNBA athletes who sustained an ACL injury before 2008.²⁷

Despite the high rates of ACL injury in female athletes, particularly elite-level basketball players, there is a paucity of recent research examining the effect of ACL reconstruction on RTP and performance in these athletes. The purpose of this investigation was to quantify RTP rates and performance after ACL reconstruction in WNBA athletes.

METHODS

We performed a retrospective review of all ACL tears sustained in the WNBA from its inception in 1997 to 2018. Players who sustained an ACL injury were identified by means of publicly available sources such as WNBA.com, player profiles and team news reports, and injury reports using methods similar to those used in previously published investigations.^{12,17,22,29} Each reported injury was cross-referenced with at least 2 of the above sources to confirm diagnosis of ACL injury and subsequent ACL reconstruction. The above sources were used to further confirm the dates of injury by cross-referencing with statistical pages to verify a gap in statistics during the time away from sport and to verify the documented date of injury and date of RTP for each player. Players were included only if they had participated in a WNBA game before their injury. Athletes were excluded if they sustained an ACL injury in the same knee before entering the WNBA or if they sustained documented concomitant injuries such as cartilage injuries and multiligamentous knee injury. Because the presence of meniscal injuries was not well-documented, this facet was not an exclusion factor.

Descriptive data for each player, including body mass index (BMI), age, and position at the time of injury, were collected from team statistical pages. Successful RTP was defined as any documented WNBA game play after ACL reconstruction. The total number of seasons, games, and minutes played in the WNBA before and after the injury was documented. Performance data were collected for each player including total games played, games started, minutes per game (MPG), points per game, field goals

attempted, field goal percentage (FG%), 3 pointers attempted, 3-point percentage, free throws attempted, free throw percentage (FT%), rebounds per game (RPG), assists per game (APG), steals per game (SPG), and blocks per game (BPG). Overall career data as well as data in the 3 years before and after the date of injury were collected in order to better assess longitudinal changes in performance.

To compare the injured players who successfully returned to play versus a group of healthy controls, we performed a 2:1 control to injury group match based on a previously established method.^{12,17,22,29} Controls were matched to study cases by age at the time of injury, position, years of experience at the time of injury, height, and BMI. Age and years of experience were always within 3 years of the study player, and athletes were not included if they had documented injury within 3 years of the index date. Control players were matched within 3 inches of height and a 5-point range of BMI to the study group. Control players were given an index date that was matched with the study player's date of injury. Performance statistics were collected in an identical manner to the study group.

Statistical Analysis

All continuous data are reported as mean \pm SD, whereas categorical data are reported as counts and percentages. For continuous variables, we performed univariate 2-group comparisons using independent 2-sample *t* tests if the variable was normally distributed and Wilcoxon rank-sum tests if the variable was nonnormally distributed. For categorical variables, we conducted univariate 2-group comparisons using chi-square tests when expected cell counts were >5 and Fisher exact tests when expected cell counts were <5 . Comparisons between pre- and postinjury data were performed using paired *t* tests if the variable was normally distributed and Wilcoxon signed rank tests if the variable was nonnormally distributed, with differences being calculated as (postinjury minus preinjury).

For analysis of variables over time, a repeated-measures analysis was performed and included effects for time, group, and the interaction between time and group. Significant findings for the repeated measures were then analyzed post hoc by use of pairwise comparisons. A Tukey-Kramer *P* value correction was used to adjust for multiple comparisons. Statistical significance was set at $P < .05$. All analyses were performed using SAS Version 9.4 (SAS Institute).

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Ethical approval was not sought for the present study.

TABLE 1

Descriptive Data for Athletes With Anterior Cruciate Ligament Tears Who Did and Did Not Return to Play^a

Variable	No RTP (n = 18)	RTP (n = 41)	P Value
Age at time of injury, y, mean ± SD	25.9 ± 3.5	26.6 ± 3.1	.45
Body mass index at time of injury, mean ± SD	22.3 ± 1.4	23.0 ± 1.6	.12
Position, n (%)			.13
Guard	8 (44)	21 (51)	
Forward	6 (33)	18 (44)	
Center	4 (22)	2 (5)	

^aRTP, return to play.

RESULTS

Descriptive Data

A total of 131 WNBA players had a documented history of ACL reconstruction; 72 of these players underwent ACL reconstruction before their WNBA career and were thereby excluded. Of the remaining 59 WNBA players who sustained an ACL tear during the study period, 41 (69.5%) were able to successfully RTP in the WNBA after ACL reconstruction. No significant difference in demographic variables was found between those who were and were not able to return to play (Table 1). In total, 4 athletes sustained re-tears of the same ACL after RTP; 2 of these ruptures occurred <1 year after RTP whereas the other 2 ruptures occurred >2 years after reconstruction.

WNBA athletes who were able to successfully RTP were compared with 82 matched controls who did not have an ACL injury. No difference was seen in demographic variables or performance before injury between the study group and matched controls (Table 2).

Career Player Workload: Before and After ACL Reconstruction

When player workload data were evaluated before and after injury, players showed a decrease in workload in the first season after RTP compared with the season before injury. Players played a mean of 7.54 ± 12.84 fewer games and 5.06 ± 9.19 fewer MPG after RTP compared with the year before injury (Figure 1). These differences were not maintained 3 years after RTP (Figure 2).

Player Workload Compared With Controls

In the first year after RTP, athletes who underwent ACL reconstruction played 7.5 ± 12.84 fewer games, started 5.8 ± 14.29 fewer games, and averaged 5.0 ± 9.19 fewer MPG compared with matched controls. No significant difference in workload was seen between these groups at seasons 2 and 3 after the index injury date (Figure 3).

TABLE 2

Comparison of ACL Group and Control Group Before Index Date of Injury^a

Variable	ACL	Control	P Value
Age, y	26.6 ± 3.1	26.6 ± 3.1	≥.999
Body mass index	23.0 ± 1.6	22.9 ± 1.6	.96
Total games played	69.6 ± 28.3	73.3 ± 26.5	.51
Total games started	42.7 ± 37.3	44.9 ± 34.3	.8
Minutes per game	22.6 ± 8.8	22.7 ± 7.5	.94
Points per game	9.6 ± 5.7	8.4 ± 4.6	.24
Field goals attempted	612.4 ± 440.4	568.9 ± 371.3	.70
Field goal percentage	49.7 ± 57.8	41.0 ± 6.2	.95
3 pointers attempted	164.7 ± 149.0	143.7 ± 156.3	.36
3-point percentage	28.8 ± 14.4	29.0 ± 15.4	.66
Free throws attempted	198.1 ± 167.0	177.7 ± 127.8	.49
Free throw percentage	77.6 ± 11.0	77.1 ± 9.0	.80
Rebounds per game	3.6 ± 2.4	3.5 ± 1.8	.81
Assists per game	1.9 ± 1.3	1.9 ± 1.2	.71
Steals per game	4.5 ± 13.6	1.9 ± 8.4	.24
Blocks per game	0.4 ± 0.4	0.4 ± 0.4	.47

^aData are expressed as mean ± SD. ACL, anterior cruciate ligament.

Player Performance: Before and After ACL Reconstruction

After returning from ACL reconstruction, players scored 3.70 ± 4.99 fewer points per game in their first year. Additionally, a significant reduction was seen in free throws attempted, 3 pointers attempted, FG%, RPG, APG, SPG, and BPG 1 season after ACL tear, as summarized in Table 3.

Player Performance: Compared With Controls

Upon RTP, athletes who had undergone ACL reconstruction demonstrated significantly decreased performance measures in RPG, APG, and BPG in their first season after RTP compared with matched control athletes. These differences were not present past 1 year after return. In the cumulative 3 seasons following RTP, the ACL group had a lower FG% compared with controls (Table 4).

Relative workload percentages were calculated as a percentage of workload in the first year after RTP compared with the year before injury, as well as the first 3 years after RTP compared with the 3 years before injury. Athletes returning from ACL reconstruction were found to have significantly reduced relative workload percentages in their first year after RTP compared with controls in games played, games started, and MPG as well as reduced relative performance in FG%, FT%, RPG, APG, SPG, and BPG. We found no significant differences in relative workload percentages between the 2 groups when comparing 3 years before and after RTP.

DISCUSSION

We found that 69.5% of WNBA athletes who sustained an ACL tear were successfully able to return to competition. Although a significant decrease in overall performance was

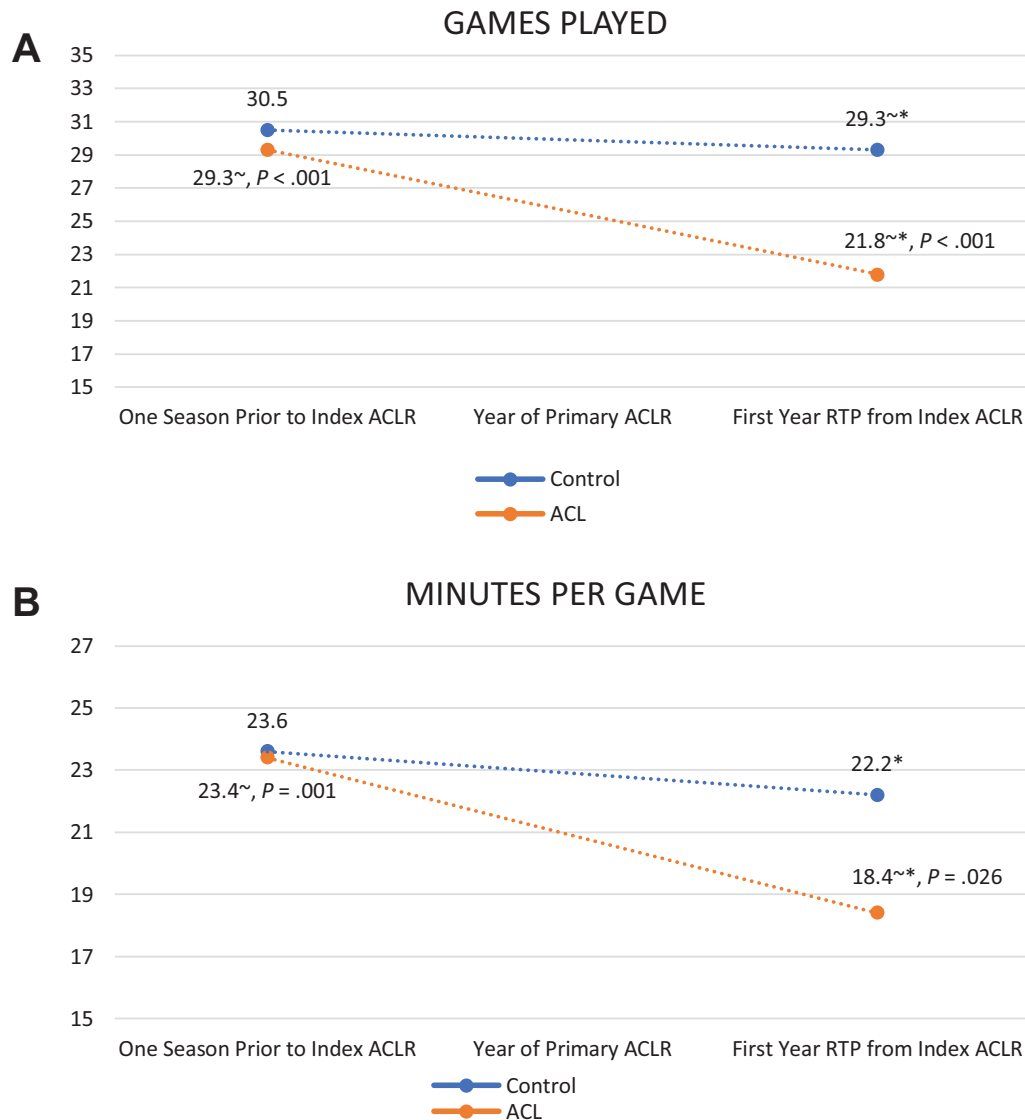


Figure 1. Workload trends in (A) games played and (B) minutes per game comparing 1 season after return to play (RTP) with 1 season before anterior cruciate ligament reconstruction (ACLR). Players with ACL injury significantly decreased their workload after RTP relative to the year before injury ($\sim P < .05$), whereas controls maintained their same workload. Controls significantly maintained a greater workload than ACL players in the year after RTP ($*P < .05$). *Significant differences between groups at a single time point. ~ Significant differences between 2 time points within a single group.

seen compared with controls in the year after injury, this difference was not apparent after 3 years. Additionally, a significant reduction in player workload in the season of RTP was noted. This decrease in workload was found to resolve 3 years after the original injury. Our findings suggest that although WNBA athletes have a high RTP rate after ACL reconstruction, athletes commonly sustain a decrease in workload and performance in the season of return.

ACL tears are major injuries that can compromise a professional athlete's ability to return to elite-level competition.^{9,19,28} Multiple studies have examined RTP rates in male athletes in the NBA and reported RTP rates between 86% to 89%.^{12,18,28} An investigation from 2011 examined 18 ACL tears in female professional basketball players and

found an RTP rate of 78%.²⁷ Our study found a decreased RTP rate (69.5%) when evaluating ACL injuries in WNBA athletes over 20 years. A lower RTP rate in female athletes compared with male counterparts after ACL tear has also been demonstrated in other sports. Ardern et al⁴ completed a meta-analysis of competitive athletes after ACL reconstruction and found that female sex was a risk factor for inability to return to preinjury level of sport across multiple sports, with male athletes 1.5 times more likely to reach the same level of competition after surgery. A multicenter analysis of soccer players also found that female players had significantly lower RTP rates compared with male players.⁸ Although the mechanism for increased risk of ACL rupture has been extensively studied in female athletes, less is

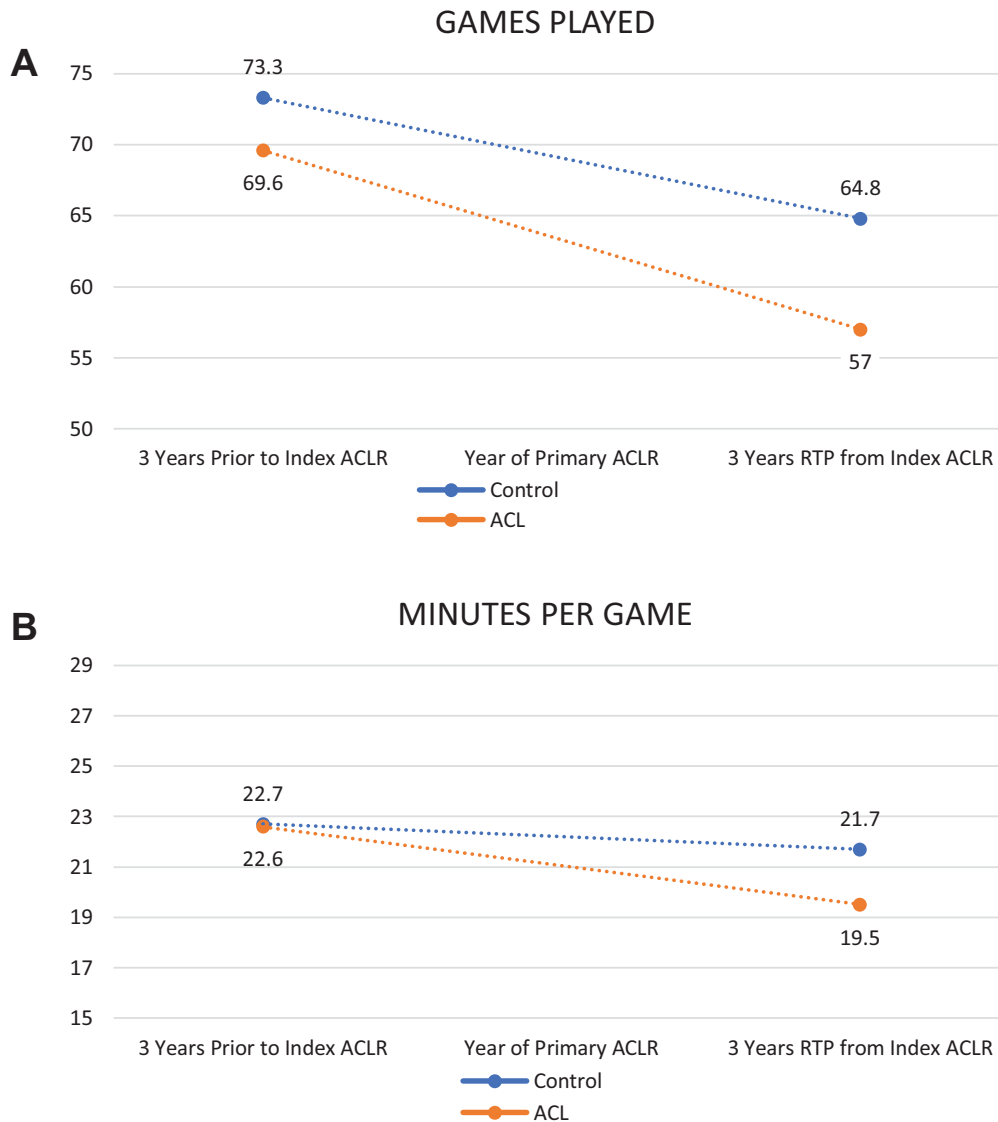


Figure 2. Cumulative workload trends in (A) games played and (B) minutes per game comparing 3 seasons after return to play (RTP) with 3 seasons before anterior cruciate ligament reconstruction (ACLR). Over a 3-year span after RTP compared with a 3-year preinjury baseline, controls and players with ACL injury demonstrated no overall changes in workload.

known regarding the difference in RTP outcomes. Possible explanations for decreased RTP in the WNBA include decreased motivation secondary to lower salaries compared with the NBA, which may influence WNBA athletes to RTP overseas for increased compensation, attain secondary employment, or change careers altogether.

Player workload after injury has been evaluated in other leagues. NBA athletes have been found to demonstrate a decrease in participation in the year after ACL reconstruction, with 17.3 fewer games played and 15.5 fewer starts in an 82-game season, relative to the season before injury.¹⁸ Although NBA players may show a decrease in workload in the first year after RTP, this difference was not statistically significant at year 2.²⁸ However, overall career workload was noted to be affected by ACL tear in the NBA, with

athletes who underwent reconstruction showing fewer games played and minutes per game after injury compared with their preinjury state.¹² In our study, WNBA athletes also exhibited a short-term decrease in workload with no significant difference at 3 years or over the remainder of their career compared with controls. These findings are important to set expectations in the first year after ACL reconstruction. Players and coaches should recognize that athletes will likely require more than 1 full year before returning to preinjury workload levels.

Performance after ACL reconstruction has also been evaluated in NBA players. Nwachukwu et al²⁸ evaluated performance in male NBA players after ACL surgery and noted a significant decrease in player efficiency rating in the first season after injury, which was found to improve in

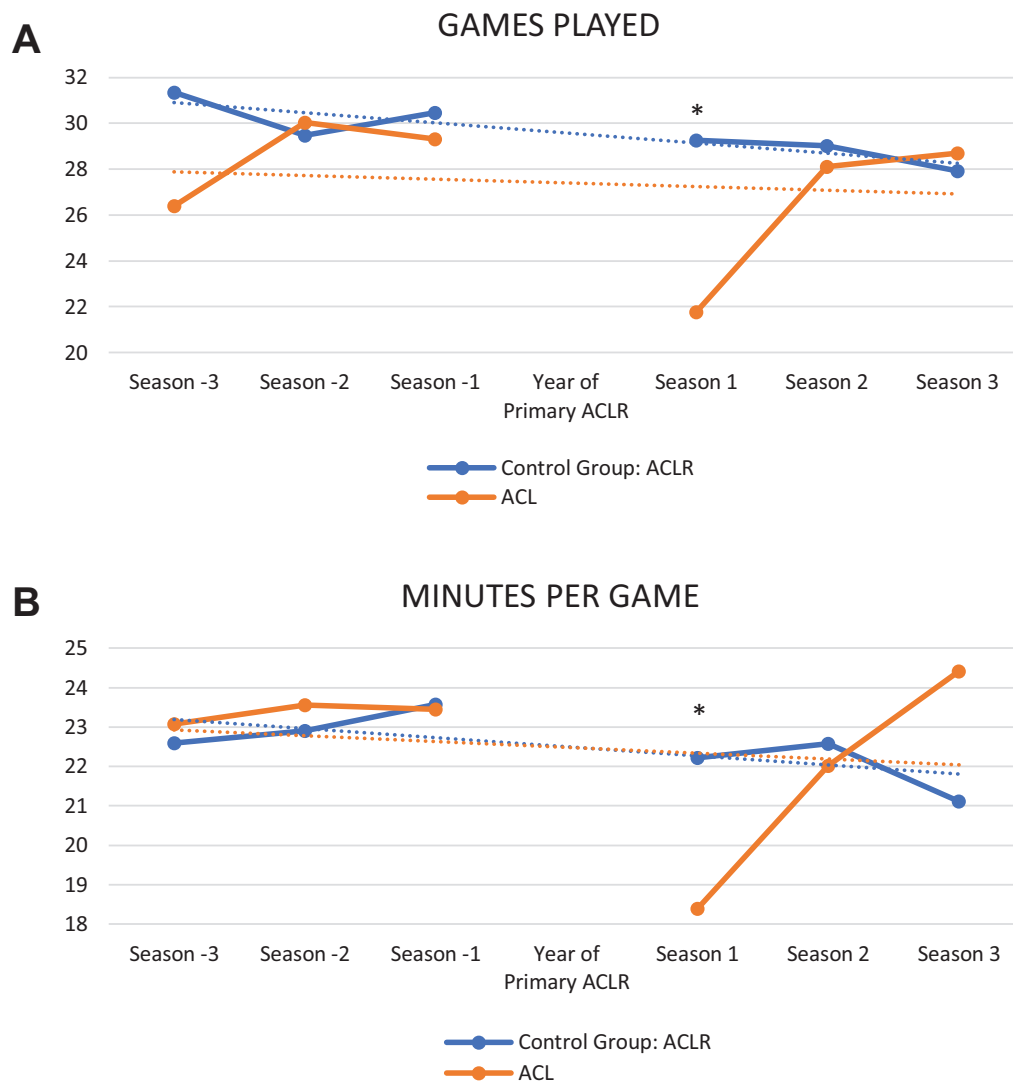


Figure 3. Relative trends in (A) games played and (B) minutes per game for 3 seasons after return to play (RTP) compared with 3 seasons before anterior cruciate ligament reconstruction (ACLR). Control players demonstrated consistent workload from year to year, whereas players with ACL injury demonstrated a reduced workload after RTP relative to baseline, which recovered to baseline values by 3 years. *Statistically significant difference between groups ($P < .05$).

the second season after RTP. A 2017 study examining performance across multiple sports after ACL injury also noted that NBA players had a significant decline in performance, as measured by player efficiency rating, in postinjury year 1 that returned to baseline during years 2 and 3.²¹ A previous study on performance in WNBA players after ACL injury showed a decrease in FG% and SPG, with no other significant differences between the ACL tear group and a matched control group in a 2-year period after injury.²⁷ Our study found that although performance decreased in WNBA players in their first season after ACL reconstruction compared with controls, this difference diminished throughout the remainder of the athlete's career. Due to the aggressive nature of professional basketball, major knee injuries may take longer than expected to return to a similar level of play. This information is important when

counseling elite athletes returning from ACL reconstruction, as successful return to sport does not equate to return to the same level of performance.

Reduced performance metrics and workload volume in the first year after surgery are not wholly unexpected, as multiple studies have demonstrated significantly less participation in professional basketball games after ACL surgery.^{9,18,28} Successful RTP may be even more difficult in high-level female athletes, as a previous registry study found that women had worse patient-reported outcomes at 1 and 2 years compared with their male counterparts.¹ Lindanger et al²⁰ examined return to pivoting sports in high-level athletes after ACL reconstruction and found that female players were at increased risk for shorter sports careers, less time spent competing at a high level, contralateral ACL injury, and revision ACL surgery compared with

TABLE 3
Performance 1 Year Before Compared With 1 Year After Anterior Cruciate Ligament Reconstruction (n = 41)^a

Variable	Preinjury	Postinjury	Mean Difference	P Value
Minutes per game	23.4 ± 8.6	18.4 ± 9.7	-5.0 ± 9.19	<.01
Points per game	10.2 ± 5.9	6.5 ± 4.7	-3.7 ± 4.99	<.01
Field goals attempted	252.3 ± 148.5	146.7 ± 134.2	-105.6 ± 146.13	<.01
Field goal percentage	41.9 ± 7.3	36.3 ± 12.4	-5.6 ± 13.13	<.01
3 pointers attempted	70.7 ± 59.3	45.1 ± 47.2	-25.6 ± 53.00	<.01
3-point percentage	28.6 ± 14.5	27.7 ± 16.3	-0.9 ± 15.20	.70
Free throws attempted	82.5 ± 62.6	41.9 ± 46.7	-40.6 ± 58.15	<.01
Free throw percentage	78.4 ± 11.9	67.5 ± 28.8	-10.9 ± 29.88	.13
Rebounds per game	3.7 ± 2.4	2.5 ± 1.9	-1.2 ± 1.70	<.01
Assists per game	2.0 ± 1.4	1.4 ± 1.2	-0.6 ± 1.03	<.01
Steals per game	1.0 ± 0.6	0.7 ± 0.5	-0.3 ± 0.55	<.01
Blocks per game	0.4 ± 0.3	0.2 ± 0.4	-0.2 ± 0.32	<.01

^aData are expressed as mean ± SD. Boldface denotes statistically significant value (P < .05).

TABLE 4
Comparison Between ACL and Control Group at 1 Year and Cumulative 3 Years After Index Injury Year^a

Variable	Index Year +1			Cumulative Years +1 to +3		
	ACL	Control	P Value	ACL	Control	P Value
Total games played	21.8 ± 10.3	29.3 ± 7.4	<.01	57.0 ± 32.3	64.8 ± 28.5	.18
Total games started	11.6 ± 13.0	17.4 ± 14.2	<.01	36.9 ± 34.9	39.9 ± 33.1	.64
Minutes per game	18.4 ± 9.7	22.2 ± 8.4	.03	19.5 ± 8.9	21.7 ± 7.6	.16
Points per game	6.5 ± 4.7	8.2 ± 5.1	.07	7.0 ± 4.7	7.9 ± 4.8	.30
Field goals attempted	146.7 ± 134.2	222.8 ± 140.7	.01	176.9 ± 126.8	216.3 ± 128.2	.11
Field goal percentage	36.3 ± 12.4	39.7 ± 6.7	.31	36.1 ± 11.0	40.1 ± 7.3	.04
3 pointers attempted	45.1 ± 47.2	59.3 ± 56.0	.25	52.8 ± 45.7	59.1 ± 53.7	.52
3-point percentage	27.7 ± 16.3	25.6 ± 14.7	.35	26.4 ± 15.4	25.2 ± 14.2	.65
Free throws attempted	41.9 ± 46.7	63.4 ± 50.9	<.01	50.3 ± 44.9	58.9 ± 42.5	.30
Free throw percentage	67.5 ± 28.8	78.5 ± 11.6	.07	68.5 ± 24.5	76.8 ± 11.2	.05
Rebounds per game	2.5 ± 1.9	3.4 ± 2.0	.02	2.8 ± 2.0	3.2 ± 1.7	.17
Assists per game	1.4 ± 1.2	1.9 ± 1.3	.04	1.7 ± 1.2	1.9 ± 1.3	.33
Steals per game	0.7 ± 0.5	0.9 ± 0.5	.06	0.8 ± 0.5	0.8 ± 0.4	.46
Blocks per game	0.2 ± 0.4	0.3 ± 0.4	.04	0.3 ± 0.4	0.3 ± 0.4	.68

^aData are expressed as mean ± SD. Boldface denotes statistically significant value (P < .05). ACL, anterior cruciate ligament.

their male counterparts. Nevertheless, our findings are promising, as WNBA players performed equivalent to controls throughout the remainder of their careers. Athletes and coaches should remain cognizant of this phenomenon, as it may have psychological and economic implications.

This investigation is not without limitations. All data were retrieved from publicly available sources, which can be susceptible to reporting bias and inaccuracies. As in previous investigations, all data were cross-referenced with more than 1 available source.^{12,17,22,29} Although we are confident that the majority of ACL tears were captured, there is a chance that not every tear was counted. It is also difficult to determine whether concomitant injuries such as meniscal tears and cartilage damage were accurately reported in the public sources, and these may be underreported in our investigation. We did not account for timing of injury in relation to the WNBA season; thus, RTP and performance the next year may be influenced by when an athlete sustained an ACL tear. Additionally, there were likely differences in how each

team handled a player's RTP program and overall perioperative treatment plan. No information was available regarding surgical factors such as timing of surgery, graft type, and technique used. Ability to RTP is multifactorial, and we are unable to conclude whether the ACL tear was the primary reason for failure to RTP or whether it could be based on skill level before injury or if the player resumed play in another league outside the WNBA, such as internationally. Finally, although a history of ACL reconstruction before the WNBA was an exclusion factor, the majority of these instances were identified during collegiate careers, and the possibility exists that an adolescent injury was not identified in athletes in our cohort.

CONCLUSION

We found that WNBA athletes have a high RTP rate after ACL reconstruction. Players may experience an initial

decrease in playing time and performance when returning to play; however, these variables were found to return to baseline over time.

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