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Christopher C Dodson
Rothman Institute, Thomas Jefferson University

Eric S Secrist
Rothman Institute; Sidney Kimmel Medical College, Thomas Jefferson University

Suneel B Bhat
Rothman Institute, Thomas Jefferson University

Daniel P Woods
Rothman Institute, Thomas Jefferson University; Orlin & Cohen Orthopedic Group

Peter F Deluca
Rothman Institute, Thomas Jefferson University

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Anterior Cruciate Ligament Injuries in National Football League Athletes From 2010 to 2013

A Descriptive Epidemiology Study

Christopher C. Dodson,*[†] MD, Eric S. Secrist,[‡] BS, Suneel B. Bhat,[†] MD,
Daniel P. Woods,[§] MD, and Peter F. Deluca,[†] MD
*Investigation performed at the Rothman Institute at Thomas Jefferson University,
Philadelphia, Pennsylvania, USA*

Background: There is a high incidence of anterior cruciate ligament (ACL) injuries among National Football League (NFL) athletes; however, the incidence of reinjury in this population is unknown.

Purpose: This retrospective epidemiological study analyzed all publicly disclosed ACL tears occurring in NFL players between 2010 and 2013 to characterize injury trends and determine the incidence of reinjury.

Study Design: Descriptive epidemiological study.

Methods: A comprehensive online search identified any NFL player who had suffered an ACL injury from 2010 to 2013. Position, playing surface, activity, and date were recorded. Each player was researched for any history of previous ACL injury. The NFL games database from *USA Today* was used to determine the incidence of ACL injuries on artificial turf and grass fields. Databases from Pro Football Focus and Pro Football Reference were used to determine the injury rate for each position.

Results: NFL players suffered 219 ACL injuries between 2010 and 2013. Forty players (18.3%) had a history of previous ACL injury, with 27 (12.3%) retears and 16 (7.3%) tears contralateral to a previous ACL injury. Five players (2.28%) suffered their third ACL tear. Receivers (wide receivers and tight ends) and backs (linebackers, fullbacks, and halfbacks) had significantly greater injury risk than the rest of the NFL players, while perimeter linemen (defensive ends and offensive tackles) had significantly lower injury risk than the rest of the players. Interior linemen (offensive guards, centers, and defensive tackles) had significantly greater injury risk compared with perimeter linemen. ACL injury rates per team games played were 0.050 for grass and 0.053 for turf fields ($P > .05$).

Conclusion: In this retrospective epidemiological study of ACL tears in NFL players, retears and ACL tears contralateral to a previously torn ACL constituted a substantial portion (18.3%) of total ACL injuries. The significant majority of ACL injuries in players with a history of previous ACL injury were retears. Skilled offensive players and linebackers had the greatest injury risk, and significantly more ACL tears occurred among interior linemen than perimeter linemen. The month of August had the highest incidence of ACL injuries, probably because of expanded roster sizes at that point in the NFL season.

Keywords: anterior cruciate ligament; professional sports; epidemiology; football (American)

*Address correspondence to Christopher C. Dodson, MD, Rothman Institute at Thomas Jefferson University, 925 Chestnut Street Philadelphia, PA 19107, USA (email: ccdodson7@gmail.com).
[†]Rothman Institute at Thomas Jefferson University, Philadelphia, Pennsylvania, USA.
[‡]Sidney Kimmel Medical College of Thomas Jefferson University, Philadelphia, Pennsylvania, USA.
[§]Orlin & Cohen Orthopedic Group, Lynbrook, New York, USA.
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An anterior cruciate ligament (ACL) injury is a major injury for any individual, but it can be devastating for the National Football League (NFL) athlete. Between 21% and 37% of NFL athletes who suffer an ACL injury never appear in another NFL game,[5,12] and those who do return to play perform at a lower level on average than they did before injury.[5] The physical demands imposed on NFL athletes also predispose them to a greater injury risk than the general population. Despite the increased risk and increased consequences related to ACL injuries for these athletes, few studies have analyzed the epidemiology of ACL injuries in this population.

Of particular interest to this study was the incidence of ACL retears and ACL injuries contralateral to a previously injured ACL among NFL players. Reinjury is uncommon in the general population, as a retrospective study of 17,346 ACL reconstructions found that within 5 years of ACL reconstruction, only 4.9% of patients had needed revision ACL surgery and 4.2% had undergone ACL reconstruction on the contralateral knee.[11] However, high activity levels were identified as a risk factor for retear using data from the Multicenter Orthopaedic Outcomes Network (MOON),[2] and NFL players have particularly high activity levels due to their nearly year-round participation in workouts, practices, and games. Despite this possible increased reinjury risk and the heightened impact of these injuries on the lives of these athletes, no study has analyzed the incidence of ACL reinjury in NFL athletes.

This study utilized an exhaustive review of published news reports describing ACL injuries that occurred in NFL players between the 2010 and 2013 seasons to characterize the epidemiology of ACL injuries in this population. Here we describe the results of this cross-sectional epidemiological study and report the rate of ACL injuries by position, timing, and playing surface as well as the incidence of retears of previously reconstructed ACL tears and ACL tears in players with a history of previous ACL injury in the contralateral knee.

METHODS

A rigorous online search was conducted in an attempt to assemble an exhaustive list of all publicly disclosed ACL injuries occurring in NFL players between 2010 and 2013. A list of ACL injuries from the NFL Injury Surveillance System (NFLISS) was provided by Edgeworth Economics for the years 2004 through 2013. This anonymized list was used as a resource to identify players. No data from the NFLISS were used in our analysis. Searches for "anterior cruciate ligament" and "ACL" were conducted within NFL.com, ESPN.com, Rotoworld.com, each team's published media guide, newspapers covering each team, and websites for each team hosted on SBNation.com. Searches for each year and the words "NFL" and "ACL" or "anterior cruciate ligament" were also conducted on Google.com. This search was designed to identify all athletes who suffered an ACL injury during the indexed seasons. Only players for whom news reports could be obtained confirming the injury were included. All original sources were compiled.

News reports describing the individual ACL injuries were combined with player-specific searches to determine injury dates, previous ACL injuries, and descriptions of the circumstances under which the injury transpired. The number of injuries per season was recorded, with each season defined as beginning the day after the Super Bowl. The number of injuries occurring in each month of the year was also recorded, and the number of ACL injuries per total players was compared between months using a chi-square test. Snap counts were compiled using a database from Pro Football Focus, and these were used to determine the main position of each player who had suffered an ACL injury.

A database of all NFL players from Pro Football Reference was used to calculate the total number of NFL players at each position from 2010 to 2013. Because this database did not include long snappers, it was augmented with a database of NFL long snappers from the website longsnap.com. This was used to calculate the percentage of players suffering an ACL injury at each position. Players in related position groups were combined for analysis and compared with the rest of the NFL using a chi-square test.

Annual team preseason, in-season, and postseason schedules were acquired from the *USA Today* database, and this was used to identify the home team in every game. Notation was made of differing fields for games played at sites other than the home stadiums of each team, specifically stadiums in Toronto and London. Game reports from ESPN.com were analyzed for all in-game injuries to determine where every NFL game during the indexed seasons was played. Team websites were then searched to identify playing surface. This was used to calculate the number of ACL injuries per team game on each playing surface, with each individual NFL game counting as 2 team games. A paired t test was used to compare the incidence of ACL injuries on artificial turf and grass playing surfaces.

RESULTS

Between 2010 and 2013, a total of 219 NFL athletes suffered a torn ACL. In-game injuries were relatively stable across the 4 years studied, with a steady increase in off-season/practice injuries each year (Figure 1).

August had the greatest injury incidence of any month (Figure 2). This corresponds to preseason practices and games in the NFL schedule. During the preseason there are 90 players per NFL team, while during the regular season from 2010 to 2013, there were 61 players per NFL team (53 on the roster and 8 on the practice squad). When roster size was taken into account, the difference in injury incidence between August and the other months of the regular season was not statistically significant ($P > .05$). There were a relatively stable number of injuries during the regular season (September-December) and fewer injuries during the playoffs and off-season.

Of the 219 ACL injuries, 40 (18.3% of total injuries) occurred in players with a history of previous ACL injury (Table 1). There were significantly more players ($P < .05$) who retore a previously injured ACL than players who tore the ACL contralateral to a previously injured ACL. There were 5 players (2.28%) who suffered a third ACL tear, with 2 tearing the same ACL for the third time and 3 retearing the ACL in 1 knee in addition to having previously torn the ACL in the contralateral knee.

The percentage of total players suffering ACL injury at each position is featured in Table 2. When individual positions were compared with the rest of the NFL, wide receivers had a significantly greater injury risk than the rest of the NFL ($P < .05$). However, when related positions were combined into position groups (Table 3), several significant differences were observed. Receivers (wide receivers and tight ends) and backs (running backs, fullbacks, and
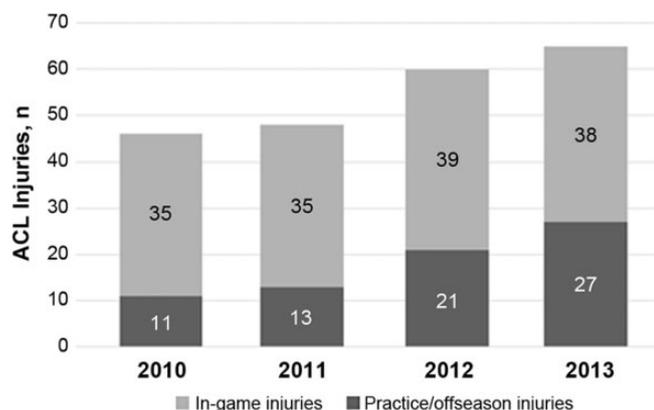
Figure 1. Incidence of in-game and practice/off-season anterior cruciate ligament (ACL) injuries among National Football League players by season, 2010-2013.
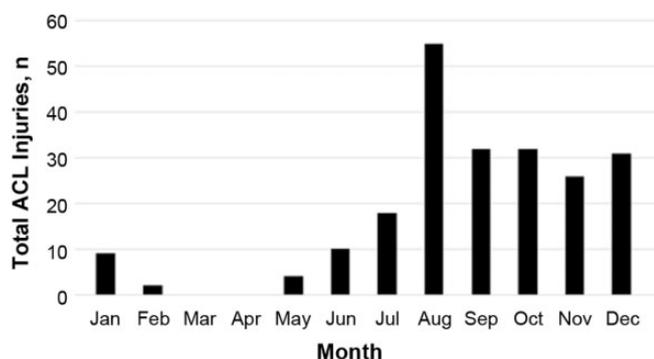

Figure 2. Total anterior cruciate ligament (ACL) injuries among National Football League players by injury month, 2010-2013.

TABLE 1
Incidence of ACL Retears and Tears Contralateral to
a Previously Injured ACL Among NFL Players, 2010-2013[a]

Previous ACL Injury	ACL Injuries, n (% of Total Injuries)
Initial tear	179 (81.7)
Retear	27 (12.3)
Contralateral tear	16 (7.3)

[a]ACL, anterior cruciate ligament; NFL, National Football League.

linebackers) all had significantly greater injury rates than the rest of the NFL. Perimeter linemen (defensive ends and offensive tackles), meanwhile, had significantly lower injury rates than the rest of the NFL. Quarterbacks and specialists (punters and kickers) both had similar injury rates to perimeter linemen, but these differences were not statistically significant as compared with the rest of the NFL.

There were 0.050 injuries per team games played on grass fields and 0.053 injuries per team games played on

TABLE 2
Incidence of ACL Injuries by Player Position, 2010-2013[a]

Position	ACL Injuries, n	Total Players, n	ACL Injury Incidence, %
Fullback	5	50	10.0
Guard	16	185	8.6
Wide receiver	38	473	8.0
Tight end	18	230	7.8
Linebacker	36	483	7.5
Running back	19	304	6.3
Center	6	97	6.2
Defensive back	37	651	5.7
Defensive tackle	16	296	5.4
Long snapper	2	44	4.5
Punter	2	55	3.6
Defensive end	11	314	3.5
Kicker	2	61	3.3
Offensive tackle	7	233	3.0
Quarterback	4	162	2.5

[a]ACL, anterior cruciate ligament.

TABLE 3
Percentage of NFL Players Suffering ACL Injuries
by Position Group, 2010-2013[a]

Position Group	ACL Injuries, n	Total Players, n	Percent Injured	P Value (vs Rest of NFL)
Receivers (WR, TE)	56	703	8.0	.004
Backs (LB, HB, FB)	60	837	7.2	.035
Interior linemen (G, DT, C)	38	578	6.6	.312
Defensive backs (CB, S)	37	651	5.7	.995
Specialists (P, K, LS)	6	160	3.8	.282
Perimeter linemen (DE, OT)	18	547	3.3	.009
Quarterbacks	4	162	2.5	.071
All NFL players	219	3638	6.0	

[a]ACL, anterior cruciate ligament; C, center; CB, cornerback; DE, defensive end; DT, defensive tackle; FB, fullback; G, guard; HB, halfback; K, kicker; LB, linebacker; LS, long snapper; NFL, National Football League; OT, offensive tackle; P, punter; S, safety; TE, tight end; WR, wide receiver.

TABLE 4
ACL Injuries Occurring During NFL Games
by Playing Surface, 2010-2013[a]

	In-Game ACL Injuries, n	Team Games Played, n	Injury Rate
Grass	74	1478	.050
Artificial turf	63	1178	.053

[a]ACL, anterior cruciate ligament; NFL, National Football League.

turf fields (Table 4). FieldTurf had a rate of 0.048 ACL injuries per team games played. None of these differences were statistically significant.

DISCUSSION

Previous studies have documented that patients in the general population have decreased activity levels as compared with preinjury levels[1] and a low incidence of retears after ACL reconstruction.[11] High activity levels have been linked to an increase in ACL reinjury rate,[9] however, and NFL athletes who return to play after ACL reconstruction have particularly high activity levels, meaning reinjury may be more common in this population. This is the first study to analyze the incidence of reinjury in NFL athletes. We demonstrate that reinjuries comprise a substantial portion of total ACL injuries among NFL athletes, as 12.3% of total ACL injuries occurred in a previously reconstructed knee and significantly more retears than contralateral tears occurred among players with a history of previous ACL injury. This indicates that it is possible that the risk of suffering a knee injury may be greater in elite athletes returning from ACL reconstruction than it is in elite players with a native knee. However, we were not able to address the relative risk of ACL injury for players with a previously reconstructed ACL as compared with the rest of the NFL in this study, and this warrants further investigation.

Analysis of the injury histories of 332 college athletes at the 2005 NFL Combine found that 12% of players had a history of ACL injury, and these were most common among tight ends, wide receivers, and running backs.[3] Bradley et al[4] reported that running backs and offensive linemen were the most frequently injured offensive NFL players, while defensive linemen and defensive secondary players were the most frequently injured defensive players. We report a more detailed analysis of ACL injuries than these studies, with more recent results, more specific position categories, and rates stratified based on the total number of NFL players at each position. Our analysis accounts for differences in the number of NFL players at each position, yielding a more precise statistic than the absolute number of ACL injuries that occurred at each position.

This analysis of relative injury risk for each position demonstrated that certain skilled players, specifically wide receivers, tight ends, linebackers, running backs, and fullbacks, faced significantly greater ACL injury risk than the rest of the NFL in the seasons studied. These players are involved in the majority of tackles, which exposes them to high-speed collisions, possibly increasing their risk of contact ACL injuries. These players also make up a significant portion of special teams units, and special teams plays accounted for 20.4% of in-game ACL injuries according to a previous analysis by Bradley et al.[4] Interestingly, the risk of ACL injury in defensive backs, especially safeties, was lower than other skilled positions, although this difference was not statistically significant. Guards, centers, and defensive tackles, who play in the interior portion of the offensive and defensive lines, carried a significantly greater risk of ACL injury than perimeter linemen (defensive ends and offensive tackles). Offensive linemen are the heaviest players on the field at any given time,[10] and offensive guards have the greatest mean body mass index of any position in football based on an analysis of NFL rosters

published online.[7] Both increased body mass index and increased weight are risk factors for ACL injuries.[13] These athletes also play in the most congested portion of the field, which increases the frequency with which they contact multiple opponents while blocking, possibly increasing the risk of suffering a contact ACL injury. Quarterbacks and specialists (punters and kickers) had low ACL injury risks. These differences were not statistically significant when compared with the rest of the NFL, most likely due to this comparison being underpowered. NFL rules limit the amount of contact these players are exposed to, and this provides a possible explanation for the lower injury risk of these players.

There were more in-game injuries than off-season/ practice injuries in every season studied, and the most injuries occurred during the month of August. Other work by Feeley et al[6] analyzing results from the training camps of 1 NFL team indicated that games carried a significantly greater risk of injury than practices and the highest risk practices were the ones conducted early in training camp. This aligns with the data presented here. It should be noted that because rosters were cut from 90 to 61 players (53 on the roster and 8 on the practice squad) at the end of August, there were more total NFL players participating in games and practices in August than in any other month when NFL teams hold full-contact practices and games. This larger pool of total athletes provides a likely explanation for the increased incidence of injuries in this month, and the increase was not statistically significant when the increased number of total players was factored into the analysis.

Analysis of NFLISS data from the 2000 to 2009 seasons found an injury rate of 0.041 ACL sprains per game for grass fields and 0.069 ACL sprains per game for FieldTurf. This 67% higher incidence for FieldTurf ($P < .001$) was statistically significant.[8] Analysis of this cohort revealed no correlation between playing surfaces and ACL injury rates. While our results do not corroborate the findings of the previous study, it was conducted on a smaller sample size. The only other epidemiological study of ACL injuries in NFL players likewise found no correlation between playing surface and ACL injury rate, although that study was conducted on injuries between 1994 and 1998 when AstroTurf was the most popular artificial playing surface rather than FieldTurf.[4]

Limitations

The present study was based on publicly available data, and this was aided by the NFL's policy of requiring all teams to report injuries occurring to their players. While every effort was made to identify all players who had suffered an ACL injury, it is certainly possible that this sample does not represent all ACL injuries that occurred during the seasons studied and it likely underreports the incidence of off-season injuries as well as ACL reinjuries. Additionally, we report here the incidence of ACL reinjuries rather than a reinjury rate. To report a reinjury rate we would have had to have known the total number of players in the NFL with a reconstructed ACL. These data were not

available to us, so we can only report the percentage of total acute ACL injuries that were reinjuries. Our use of publicly available online data could also have introduced a bias toward more recent injuries, as more recent news stories are featured most prominently in online searches. Because of this, we do not view the increase in off-season ACL injuries per season as a key finding, as it is more likely that injuries occurring in 2010 were missed than injuries that occurred in 2013. Finally, our analysis of positional differences was limited by the categories themselves. Players such as pass-rushing linebackers, nickelbacks, defensive players who play fullback in goal-line situations, running backs who frequently line up as a slot receiver, and tight ends who frequently play wide out do not fit neatly into any specific position, and this makes positional definitions less than ideal.

CONCLUSION

In this retrospective epidemiological study of ACL tears in NFL players, retears and ACL tears contralateral to a previously torn ACL comprised a substantial portion (18.3%) of total ACL injuries. Roughly two-thirds of ACL injuries in players with a history of previous ACL injury were retears. Skilled offensive players and linebackers had the greatest ACL injury risk, and significantly more ACL tears occurred among interior linemen than perimeter linemen. The month of August had the greatest incidence of ACL injuries, probably because of the expanded roster sizes at this point in the NFL season.

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