

Determining the True Incidence of Glenohumeral Instability Among Players in the National Football League

An Epidemiological Study of Non-Missed Time Shoulder Instability Injuries

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Background: Shoulder instability encompasses a spectrum of glenohumeral pathology ranging from subluxation to dislocation. While dislocation frequently leads to removal from play, athletes are often able to play through subluxation. Previous research on glenohumeral instability among athletes has largely focused on missed-time injuries, which has likely disproportionately excluded subluxation injuries and underestimated the overall incidence of shoulder instability.

Purpose: To describe the epidemiology of shoulder instability injuries resulting in no missed time beyond the date of injury (non-missed time injuries) among athletes in the National Football League (NFL).

Study Design: Descriptive epidemiology study.

Methods: The NFL's electronic medical record was retrospectively reviewed to identify non-missed time shoulder instability injuries during the 2015 through 2019 seasons. For each injury, player age, player position, shoulder laterality, instability type, instability direction, injury timing, injury setting, and injury mechanism were recorded. For injuries that occurred during games, incidence rates were calculated based on time during the season as well as player position. The influence of player position on instability direction was also investigated.

Results: Of the 546 shoulder instability injuries documented during the study period, 162 were non-missed time injuries. The majority of non-missed time injuries were subluxations (97.4%), occurred during games (70.7%), and resulted from a contact mechanism (91.2%). The overall incidence rate of game-related instability was 1.6 injuries per 100,000 player-plays and was highest during the postseason (3.5 per 100,000 player-plays). The greatest proportion of non-missed time injuries occurred in defensive secondary players (28.4%) and offensive linemen (19.8%), while kickers/punters and defensive secondary players had the highest game incidence rates (5.5 and 2.1 per 100,000 player-plays, respectively). In terms of direction, 54.3% of instability events were posterior, 31.9% anterior, 8.5% multidirectional, and 5.3% inferior. Instability events were most often anterior among linebackers and wide receivers (50% and 100%, respectively), while posterior instability was most common in defensive linemen (66.7%), defensive secondary players (58.6%), quarterbacks (100.0%), running backs (55.6%), and tight ends (75.0%).

Conclusion: The majority of non-missed time shoulder instability injuries (97.4%) were subluxations, which were likely excluded from or underreported in previous shoulder instability studies due to the inherent difficulty of detecting and diagnosing shoulder subluxation.

Keywords: shoulder instability; glenohumeral instability; shoulder dislocation; shoulder subluxation; National Football League; professional athletes

Shoulder instability is a common injury in athletes, particularly those who engage in contact and collision sports.^{2,15,17,23} Among collegiate American football players, for instance, shoulder instability accounts for 23.5% of all shoulder and elbow injuries.¹⁵ Much of the existing literature on in-season shoulder instability, however, only considered injuries that required activity restriction for ≥ 1 day.^{8,23} As a result, such studies likely underestimated the true incidence of shoulder instability, as not all instability events lead to removal from play and missed time.⁷ Glenohumeral subluxation in particular, which is less likely to result in missed time compared with dislocation, was likely disproportionately excluded from previous epidemiological studies of shoulder instability.

Interestingly, glenohumeral subluxation has received little attention in the orthopaedic literature overall, despite being more common than dislocation.^{26,27} In general, shoulder subluxation is a difficult pathology to study given the transient nature of the subluxation event. As manual reduction is not required, patients are less inclined to seek medical treatment; for those patients who do, the diagnosis is largely based on patient history and physical examination alone. However, there is increasing evidence that traumatic shoulder subluxations are not benign injuries, with high rates of pathologic changes visible on advanced imaging even after first-time events.^{6,14,21,27,35} It is possible that such pathologic changes may predispose individuals to recurrent instability, risking further damage to the capsulolabral complex, attritional glenoid bone loss, and the eventual development of glenohumeral osteoarthritis.^{11,14,18,22,25} As such, defining the true incidence of shoulder instability, including subluxations and non-missed time events, is essential for identifying risk factors, developing effective preventative measures, and refining treatment algorithms for in-season instability.

This study is a follow-up to previous research on missed-time shoulder instability among professional athletes in the National Football League (NFL).² The purpose of the current study was to describe the occurrence of glenohumeral instability injuries not resulting in missed time beyond the date of injury (non-missed time injuries) in the NFL. Secondary objectives were (1) to analyze the risk of non-missed time injuries by player position and (2) to assess the relationship between player position and shoulder instability direction. We hypothesized that a significant proportion of shoulder instability events among athletes in the NFL would not result in missed time and that the majority of non-missed time shoulder instability events would be subluxations. Furthermore, we hypothesized that the incidence rate and direction of non-missed time injuries would vary by player position.

METHODS

The protocol for this study was approved by our institution as well as the NFL Player Scientific and Medical Research Protocol process.¹⁹ Injuries in NFL players are recorded in a leaguewide electronic medical record (EMR), established pursuant to a collective bargaining agreement with the NFL Players Association.¹⁹ When an injury occurs and is reported, the affected individual is promptly evaluated by the team's medical staff, which includes both athletic trainers and sports medicine physicians. Diagnostic imaging is often obtained before the team physician arrives at a final diagnosis. The team's athletic training staff then enters the diagnosis and numerous data points regarding the injury into the NFL's EMR in a timely and standardized manner; the system is regularly reviewed for quality and completeness.¹² Recorded injury data points include the player's roster position at the time of injury, injury timing (preseason, regular season, postseason), injury setting (practice, game, conditioning), injury mechanism (contact, noncontact), findings on diagnostic imaging, treatment, and return to full participation.¹² Each team has ≥ 1 designated athletic trainer(s) who oversee injury data entry, with medical personnel undergoing annual training designed to improve data quality across the league.¹²

For this study, the NFL's EMR was retrospectively reviewed for all non-missed time shoulder instability injuries during the 2015 through 2019 seasons. Shoulder instability injuries were identified based on Clinical Impression (CI) codes, which function similarly to International Classification of Diseases codes. Different CI codes exist to distinguish subluxation from dislocation, specify injury acuity (acute vs chronic), and identify instability direction (anterior, posterior, inferior, multidirectional, unspecified). While the diagnosis of shoulder instability in the NFL is typically based on both physical examination and advanced imaging findings, the exact criteria required for diagnosing shoulder instability are left to the discretion of the teams' medical staff.

For each injury, data were abstracted regarding player age, player roster position, instability type (subluxation vs dislocation), instability direction, shoulder laterality, injury timing, injury setting, and injury mechanism. Shoulder dislocation was defined as an instability event requiring manual reduction by a medical professional, while subluxation was defined as any instability event (based on physical examination and/or diagnostic imaging findings) that did not require reduction. Injury data from the EMR were integrated with data from the NFL Game Statistics and Information System, which documents player participation in games, to calculate game incidence rates.

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Ethical approval for this study was obtained from Columbia University (ref No. IRB-AAAR5640).

TABLE 1
Non-Missed Time Shoulder Instability Injuries, 2015-2019^a

	2015 (n = 28 Players)	2016 (n = 26 Players)	2017 (n = 36 Players)	2018 (n = 32 Players)	2019 (n = 32 Players)	Overall Mean (n = 30.8 Players)
Player age, y, mean ± SD	26.2 ± 3.3	24.9 ± 2.6	25.2 ± 2.6	25.8 ± 3.1	26.7 ± 3.4	25.8 ± 3.0
Shoulders	28	27	38	32	33	31.6
Right	13	13	17	15	9	13.4
Left	15	14	21	17	24	18.2
Instability events	31	27	39	32	33	32.4
Instability type						
Subluxation	10	11	21	17	17	15.2
Dislocation	0	1	1	0	0	0.4
Unspecified	21	15	17	15	16	16.8
Instability direction						
Anterior	7	9	9	1	4	6
Posterior	11	3	11	12	14	10.2
Inferior	1	0	2	0	2	1
Multidirectional	0	1	3	2	2	1.6
Unspecified	12	14	14	17	11	13.6
Injury setting						
Practice	6	8	11	9	4	7.6
Game	18	13	25	18	20	18.8
Other/unspecified	7	6	3	5	9	6.0
Injury mechanism						
Contact	19	19	25	21	19	20.6
Noncontact	2	0	2	1	5	2
Unspecified	10	8	12	10	9	9.8

^aData are reported as absolute values unless otherwise indicated. Some players had instability events across multiple different years.

Analytic Methods

For each study year, the total number of instability events was subclassified by instability type, instability direction, injury setting, and injury mechanism. As players could have sustained multiple instability events and/or bilateral shoulder instability during the study period, the number of injured players and injured shoulders per year were also tabulated. Descriptive statistics were calculated for these variables across the entire study period. Shoulder instability incidence rates were calculated based on injury timing as well as roster position for game-related injuries, as exposure data were available only for games. A single exposure was defined as 1 athlete participating in 1 offensive, defensive, or special teams play during a game. Last, the relationship between instability direction and player position was examined.

RESULTS

During the 2015 through 2019 NFL seasons, a total of 546 shoulder instability events were documented in the EMR. Of these, 162 injuries (29.7%) were non-missed time injuries (Table 1). In total, 144 individual players accounted for the 162 non-missed time shoulder instability injuries, including 16 players (11.1%) who experienced multiple instability events: 14 players (9.7%) sustained 2 events and 2 players (1.4%) sustained 3 events during the study period. Of the 16 players who sustained multiple non-

missed time instability events, 62.5% (10 players) injured the same shoulder and 37.5% (6 players) experienced bilateral shoulder instability. Overall, the left shoulder was affected more often than the right (n = 93/162 [57.4%] vs n = 69/162 [42.6%], respectively). The number of non-missed time shoulder instability injuries per year was relatively constant throughout the study period, ranging from 27 in 2016 to 39 in 2017 (mean, 32.4 injuries per year). The mean age of affected athletes at the time of injury was 25.8 ± 3.0 years. Excluding unclassified events (n = 84), 97.4% (n = 76) of non-missed time shoulder instability injuries were subluxations and 2.6% (n = 2) were dislocations. More than two-thirds of specified injuries occurred during games (n = 94; 70.7%), and most were the result of a contact mechanism (n = 103; 91.2%).

While the majority of non-missed time shoulder instability injuries occurred during the regular season (n = 102; 63.0%), the incidence rate of game-related injuries was highest during the postseason (3.5 per 100,000 player-plays [95% CI, 0.3-6.8]) (Table 2). The overall incidence rate of game-related shoulder instability was 1.6 injuries per 100,000 player-plays. Defensive secondary (n = 46; 28.4%), offensive linemen (n = 32; 19.8%), and defensive linemen (n = 27; 16.7%) sustained the most non-missed time shoulder instability events, but after accounting for exposures, kickers/punters had the highest incidence rate of game-related injuries at 5.5 per 100,000 player-plays, followed by defensive secondary (2.1) and defensive linemen (1.9) (Table 3).

TABLE 2
Incidence of Game-Related Non-Missed Time Shoulder Instability Injuries by Time During Season, 2015-2019

	Shoulder Instability Events, n	Player-Plays, n	Game Incidence Rate per 100,000 Player-Plays (95% CI)
Total	94	6,018,765	1.6 (1.2-2.0)
Preseason	8	1,161,463	0.7 (0.1-1.2)
Regular season	79	4,657,221	1.7 (1.3-2.1)
Postseason	7	200,081	3.5 (0.3-6.8)

TABLE 3
Incidence of Game-Related Non-Missed Time Shoulder Instability Injuries by Player Roster Position, 2015-2019^a

Player Position	Shoulder Instability Events, n	Player-Plays, n ^b	Game Incidence Rate per 100,000 Player-Plays (95% CI)
Defensive line	16	832,030	1.9 (0.6 to 3.2)
Defensive secondary	29	1,368,232	2.1 (0.9 to 3.4)
Linebacker	11	907,508	1.2 (0.7 to 1.8)
Offensive line	14	1,224,298	1.1 (0.5 to 1.8)
Quarterback	3	229,910	1.3 (-0.8 to 3.4)
Running back	6	344,469	1.7 (0.4 to 3.1)
Kicker/Punter	5	90,413	5.5 (1.2 to 9.8)
Tight end	5	360,059	1.4 (0.3 to 2.5)
Wide receiver	5	661,839	0.8 (-0.1 to 1.6)

^aPlayers who sustained shoulder instability injuries during special teams plays were classified based on roster position.

^bSeven player-plays had an unknown roster position and were excluded from this analysis.

Posterior shoulder instability events occurred most often; however, it should be noted that direction was not specified for 42.0% of injuries. After excluding injuries for which direction was unspecified (n = 68), 54.3% of instability events were posterior, 31.9% were anterior, 8.5% were multidirectional, and 5.3% were inferior. Again, excluding unspecified injuries (n = 68), the majority of non-missed time shoulder instability events among linebackers (50.0%) and wide receivers (100.0%) were anterior, while posterior non-missed time shoulder instability injuries were more common in defensive linemen (66.7%), defensive secondary (58.6%), quarterbacks (100.0%), running backs (55.6%), and tight ends (75.0%) (Figure 1). Anterior and posterior events were equally common among offensive linemen and kickers/punters.

DISCUSSION

Over the course of the study period, non-missed time shoulder instability injuries accounted for 29.7% of all reported shoulder instability events in the NFL, suggesting that previous studies of shoulder instability among collision sport athletes likely underestimated the true incidence and prevalence by only including those injuries that led to missed time.²⁷ As hypothesized, the vast majority of instability events in this study were subluxations (97.4% of specified events). Interestingly, posterior non-missed time shoulder instability injuries were more common than anterior (54.3% vs 31.9% of specified events),

and both shoulder instability direction and incidence were found to vary by player position.

Athletic injuries that do not result in immediate removal from play and subsequent missed time are inherently difficult to track, as the diagnosis of these injuries is often dependent upon self-reporting by athletes. As a result, defining the epidemiology and natural history of such injuries represents a challenge for researchers and clinicians. It is well known that some athletes who experience in-season shoulder instability are able to return to full participation immediately, especially those who experience glenohumeral subluxation as opposed to frank dislocation.⁷ Accordingly, most studies of shoulder instability heretofore have focused exclusively or predominantly on missed-time shoulder instability injuries.^{2,23} However, thanks to thorough recording of injuries by NFL team medical staff in addition to frequent audits of the NFL's EMR for quality and completeness, the current study was able to complement the existing shoulder instability literature by providing the first comprehensive overview of non-missed time shoulder instability among professional American football players.

Overall, almost one-third (29.7%) of documented shoulder instability events during the 5-year study period (2015-2019) did not result in missed time (players returned to full participation immediately). This finding differs from other studies in athletes of different competition levels and different sports. Buss et al,⁷ for instance, observed that among 30 high school and collegiate athletes who sustained in-season shoulder instability, only 2 athletes (6.7%) missed zero days of participation. The enhanced

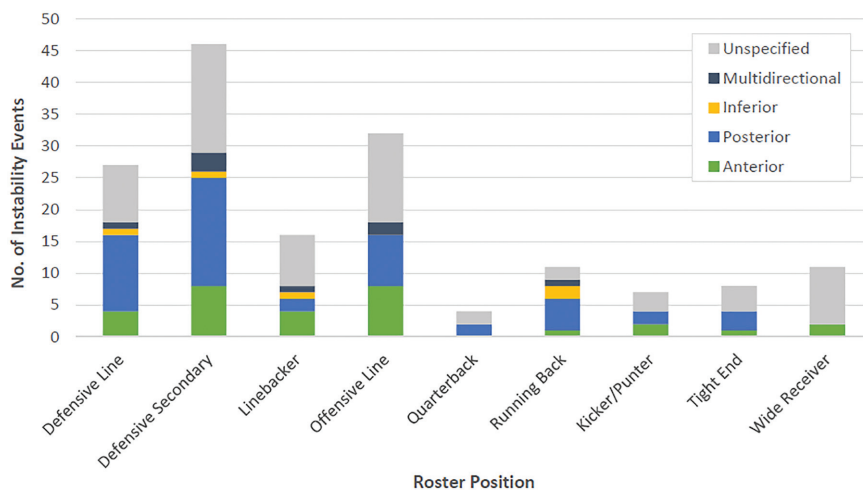


Figure 1. Distribution of non-missed time shoulder instability direction by player roster position, 2015-2019.

injury surveillance in the NFL, including the requirement to report all injuries including those that do not result in missed time or require much medical treatment, generally differs from nonelite American football settings.^{8,9,23} Elite athletes also may have close access to medical personnel, leading to increased injury detection, whereas amateur athletes who do not require manual reduction and are able to return to participation immediately after a shoulder instability injury may be less likely to seek out treatment on their own, thereby lowering the reported diagnosis rate of non-missed time shoulder instability in these populations. The high rate of non-missed time instability events observed in this study does, however, suggest that shoulder instability as a spectrum of pathology is likely more common than previously thought. This finding may have important implications for our understanding of the pathogenesis and progression of shoulder instability and warrants further investigation.

Previous investigations of shoulder instability among athletes, including the prior study of missed-time shoulder instability injuries in the NFL,² have largely found incidence rates to be highest during the preseason, a multivariable phenomenon that has been attributed to offseason deconditioning and increased utilization of full-contact drills.^{1,2,10,13,16,23,32} In the current study, the incidence rate of non-missed time shoulder instability was highest in the postseason and lowest in the preseason. This inconsistency is likely attributable to the high proportion of subluxations in the current study (97.4% of specified instability events), whereas prior research predominantly focused on dislocations. Given that shoulder subluxation often arises through repetitive microtrauma, it is reasonable to expect that the incidence rate would increase as the season progresses. Additionally, as the diagnosis of shoulder subluxation essentially relies on self-reporting, it is possible that players who experienced shoulder subluxation early in the season simply continued playing and failed to disclose the injury to medical staff until exit

physicals during the postseason. Alternatively, players who sustain shoulder instability injuries during the postseason may have been more likely to continue playing given the increased stakes (eg, possibility of winning a championship). Finally, although the NFL's EMR records missed days regardless of what time of year the injury occurred (ie, missed-time vs non-missed time designation is based on whether the player would be able to participate fully even if there are no scheduled team activities), it is possible that non-missed time injury incidence rates were highest in the postseason due to the end of the game season, which would limit the need to return to football activity.

Regardless of why an athlete chooses to return to competition immediately after a shoulder instability event, it is important to realize that shoulder instability is likely more common than previously reported, with a significant proportion of athletes playing through injury without seeking medical attention. However, there is increasing evidence that even more minor shoulder subluxation events can lead to pathological changes of the glenohumeral joint.^{6,14,21,27,35} Owens et al²⁷ used magnetic resonance imaging to evaluate 27 patients after a first-time, traumatic, anterior shoulder subluxation event, finding a soft tissue or bony Bankart lesion in 26 patients (96.3%) and a Hill-Sachs lesion in 25 patients (92.6%). The authors concluded that many subluxation events likely involve complete dissociation of the glenohumeral articulation with subsequent spontaneous reduction.²⁷ Although the clinical significance of these findings and overall natural history of shoulder subluxation require further elucidation, given the pathology seen on advanced imaging, there is concern that recurrent subluxation may lead to progressive damage to the capsulolabral complex, attritional glenoid bone loss, and the eventual development of glenohumeral osteoarthritis.^{11,14,18,22,25} As such, we recommend that players seek medical evaluation early.

In terms of instability direction, much of the existing literature on in-season shoulder instability has focused on anterior instability, which was purported to account for 82% to 90% of all instability injuries.^{18,24,26} It should be noted, however, that prior epidemiological research on shoulder instability among athletes was largely based on cadets at the United States Military Academy, who have unique risk factors for specific types of instability.^{18,24,26} For instance, Owens et al²⁶ found that boxing, a mandatory physical education class for all male students, accounted for 16% of shoulder instability events among cadets. Approximately 47% of these injuries occurred via a missed punch, all of which resulted in anterior shoulder subluxation.²⁶ The results of the current study and the previous study² on missed-time shoulder instability injuries in the NFL suggest that posterior instability is much more common among professional American football players, accounting for 43.6% of all instability events across the 2 studies vs 46.1% for anterior. Similarly, Lanzi et al¹⁸ found that intercollegiate wrestlers, American football players, and rugby players were at increased risk for posterior instability compared with other sports. Moreover, instability direction appears to vary by instability type, with the majority of dislocations in NFL players being anterior (76.1% across the 2 studies), while subluxations were more often posterior (52.1% across the 2 studies).²

The observed variation in instability direction by instability type is likely attributable to injury mechanism. Dislocations typically arise from an acute traumatic event, whereas glenohumeral subluxation often results from the accumulation of microtrauma to the capsulolabral complex.^{28,29,31,33} Certain sport-specific and position-specific maneuvers, such as pass blocking and throwing in American football, involve posterior loading of the shoulder.^{3-5,20,29,30,34,36} Over time, such repetitive loading leads to attenuation, tearing, laxity, and detachment of the posterior capsulolabral complex, which then allows for posterior subluxation of the humeral head.^{3-5,20,29,30,34,36} This theory is supported by the differences in instability direction by player position, with anterior instability being more common among linebackers and wide receivers, while posterior instability was more common in quarterbacks, defensive linemen, defensive secondary, running backs, and tight ends. Interestingly, anterior and posterior instability were equally common among offensive linemen, a position that has long been associated with posterior shoulder instability due to repetitive posterior loading of a flexed, adducted, and internally rotated shoulder involved in pass blocking. However, among offensive linemen, direction was unspecified for 43.8% ($n = 14$) of instability events. In the prior study of missed-time instability injuries in the NFL, 73% of specified shoulder instability injuries among offensive linemen were posterior.²

Limitations

This study has several limitations. First, as each NFL team has its own medical staff, there was likely variability

in the criteria for diagnosing shoulder instability and/or reporting of less severe subluxation events. Although the NFL employs numerous measures to standardize injury data entry across all 32 teams, as well as safeguards designed to improve data quality, variability in reporting patterns and under-ascertainment of non-missed time or less severe injuries is a limitation inherent to all injury surveillance studies. Moreover, players who experience recurrent shoulder instability may have a single record entered into the EMR for the chronic injury, but the total number of instability events may be underreported. Additionally, first-time instability events were not differentiated from recurrent instability events in this study, which may have obscured important differences in injury characteristics.

Another limitation was that there were relatively few injuries for several player positions, which obfuscated our analysis of instability incidence and direction by position. As such, the high incidence rate of shoulder instability observed among kickers/punters may be attributable to reduced exposures (player-plays) compared with other positions rather than actual increased risk of injury. A high proportion of instability events were unspecified in terms of type, direction, injury setting, and injury mechanism. It is possible that this limitation of the data set may have influenced our subanalysis of instability events by injury characteristics. In addition, while we demonstrated that roughly one-third of shoulder instability injuries in the NFL do not result in missed time, the different rehabilitation protocols were not assessed, and it was not possible to ascertain what proportion of players eventually went on to require surgical treatment. Such data are vital for counseling athletes who sustain in-season shoulder instability and warrant further investigation. We also could not ascertain the overall rate of recurrent instability based on the data presented in this study, as missed-time instability events were excluded. Last, professional athletes represent a unique patient population in that they often have unlimited access to comprehensive treatment modalities and contractual considerations tied to performance, factors that can influence missed time after injury. Nonetheless, we believe this study's findings may have important implications for players of American football at all levels.

CONCLUSION

The majority of the documented shoulder instability injuries in the NFL are posterior subluxations, and a sizable proportion of these injuries do not result in missed time. Based on these findings, it is likely that previous investigations of glenohumeral instability among collision sport athletes that only considered missed-time injuries disproportionately excluded subluxations and underestimated the overall incidence of athletes experiencing shoulder instability. Additional research is warranted to further elucidate the epidemiology, natural history, and risk factors for the many subtypes of shoulder instability in athletes, which will allow for the development of more nuanced preventative measures and treatments.

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