Shoulder and Elbow Injuries in National Basketball Association Athletes and Their Effects on Player Performance

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Background: Shoulder and elbow function is essential to basic basketball actions. Outside of anterior shoulder instability, injuries in these joints are not well characterized in National Basketball Association (NBA) players.

Purpose: To describe the epidemiology and associated risk factors of shoulder and elbow injuries in NBA players and identify factors that influence player performance upon return to play.

Study Design: Descriptive epidemiology study.

Methods: Historical injury data from the 2015-2020 NBA seasons were retrieved from Pro Sports Transactions, a public online database. An injury was defined as a health-related concern resulting in an absence of $\geq$1 NBA games. Primary measures included pre- and postinjury player efficiency rating (PER) and true shooting percentage (TS%) with interquartile ranges (IQRs), stratified by extremity dominance. Multivariate logistic regression analyses with stepwise regression were performed to identify risk factors associated with return-to-play performance.

Results: A total of 192 shoulder and elbow injuries were sustained among 126 NBA athletes, with incidence rates of 1.11 per 1000 game exposures (GEs) and 0.30 per 1000 GEs, respectively. Sprain/strain and general soreness were the most common injury types in both the shoulder and the elbow. In the 2 years after injury, baseline PER was achieved in all groups, except for players with dominant shoulder injuries (baseline PER, 16 [IQR, 14-18] vs 2-year PER, 13 [IQR 11-16]; *P* = .012). Younger age was associated with quicker return to baseline PER (odds ratio, 0.77 [95% CI, 0.67-0.88]). Shoulder and elbow injuries did not negatively influence TS% upon return to play (baseline TS%, 0.55% [IQR, 0.51%-0.58%] vs 1-year TS%, 0.55% [IQR, 0.52%-0.58%]; *P* = .13).

Conclusion: Dominant shoulder injuries negatively influenced PER during the first 2 seasons upon return to play in NBA players. Therefore, expectations that players with this type of injury immediately achieve baseline statistical production should be tempered. Shooting accuracy appears to remain unaffected after shoulder or elbow injury.

Keywords: elbow; injury; National Basketball Association; player performance; shoulder

Shoulder and elbow injuries are common in basketball players, with an estimated incidence of 0.82 per 1000 athlete game exposures (GEs).[20] Most notably, anterior shoulder instability is associated with basketball players, with an incidence second only to football players among major sports.[17] Basketball players attempting to shoot and rebound often extend their arms overhead, leaving the glenohumeral joint in a vulnerable position with decreased dynamic stabilization against external forces. Potential instability injuries range from isolated soft tissue Bankart lesions to Hill-Sachs lesions and bony Bankart lesions.[15,19,28] Beyond direct contact mechanisms, basketball-related injuries may also present chronically as the result of overuse secondary to repetitive shooting, passing, and rebounding motions. These types of pathologies include bursitis, rotator cuff disease,[6,8] impingement,[11] and scapular dyskinesia.[26]

The kinetic chain of basketball players requires functional shoulder and elbow joints. Slight changes in angular velocities of either joint during the shooting motion can significantly influence ball release and trajectory.[24] At release specifically, shoulder rotation will increase ball release velocity, while elbow rotation facilitates backspin. [24] Any

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pathological disruption to these structures may compromise the abilities of National Basketball Association (NBA) athletes, consequently affecting their statistical performance. Over 72% of NBA players sustaining shoulder injuries have reported lingering issues until retirement, while 24% believed that they did not achieve the same level of play after returning from their initial shoulder injury.[12]

The epidemiology of upper extremity injuries using league-wide national data has been well studied in other professional organizations, including the National Football League[1,3] and Major League Baseball.[9,10] Despite the significance of the shoulder and elbow in the kinetic chain of NBA athletes, the majority of studies on this population focus on lower extremity injuries. Although there is literature on the clinical results of nonoperative[16] or operative treatment[15,18] of anterior shoulder instability, there is limited information on the various types of upper extremity injuries in NBA players.

The primary purpose of this study was to comprehensively characterize shoulder and elbow injuries in NBA players using epidemiological data over 5 seasons. The secondary analysis focused on identifying risk factors affecting player performance upon return to play from these injuries. We hypothesized that increasing age and number of games missed would be correlated with decreased statistical performance after returning from a shoulder injury.

METHODS

Data Collection

This was a retrospective review of a publicly available database (Pro Sports Transactions; prosportstransactions.com), and our institutional review board approved an exemption for the study's protocol. This study evaluated 5 complete NBA seasons from 2015-2016 to 2020-2021, with the 2020-2021 season excluded because of the COVID-19 pandemic. Historical injury data between October 2015 and July 2021 were collected from the Pro Sports Transactions database, which tracks injury descriptions, date of injuries, and date of return to play. This source has been cited in previous NBA-related studies.[4,20,23] All injury data were independently verified through official team press releases and media reports. Injury duration was further verified through player game logs on Basketball-Reference.com—a website sourced by the official stats partner of the NBA, Sportradar US (Sportradar).

Shoulder and elbow injuries were classified by the following keywords: soreness; inflammation (bursitis); contusion (bruise); sprain/strain; subluxation/dislocation; labrum tear; ligament tear; and fracture and other (laceration). Structural injuries encompassed all injury events that were nonsoreness related. Similar to the current literature, injury is defined by severity and based on the number of continuous games missed after injury: mild (1 game absence), moderate (2-10 game absences), and severe ($\geq$11 game absences).[22] A GE was defined as the appearance in a regular-season or playoff game, independent of minutes played.

Player characteristics and statistics were queried via Basketball-Reference.com. Minutes per game, points, and games played were calculated by combining all regular season and playoff statistics, whereas player efficiency rating (PER) and true shooting percentage (TS%) were obtained from regular season statistics only. PER, developed by ESPN (ESPN.com), is a numerical representation of the offensive and defensive performance of a player on a per-minute basis. PER is continuously normalized among current NBA players, with a mean PER of 15. TS% represents a player's overall shooting efficiency, accounting for 2-point field goals, 3-point field goals, and free throws. Player baseline, 1-year, and 2-year statistics were gathered from the season before injury, the first season after injury, and the second season after injury, respectively.

Statistical Analysis

NBA player and injury characteristics were assessed through descriptive statistics. Each season, all injury incidences were calculated per 1000 GEs and stratified by injury type and dominance. Statistical significance between subgroup incidences was determined if the 95% CI did not overlap. Confidence intervals were not reported for stratifications in which there were <10 occurrences because of decreased stability and reliability associated with decreased cell frequency.[7,8] Differences between injury severity within an injury type were assessed with chi-square goodness-of-fit tests. The relationship between injury severity and dominance was evaluated with chi-square independence tests. Categorical variable comparisons were not conducted if assumptions were not met. Bivariate analysis was performed to evaluate the association between dominant extremity involvement and PER measured at baseline, 1-year, and 2-year in all players sustaining a shoulder or elbow injury.

The same bivariate analysis was conducted for TS%. To compare continuous variables, Student *t* tests and Mann-Whitney *U* tests were used for parametric and nonparametric data, respectively. A subsequent multivariate analysis was conducted with variables selected via stepwise

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TABLE 1
Characteristics of Structural Shoulder and Elbow Injuries in NBA Players (n = 126 Players)[a]

Variable	Value
Age, y	26 ± 4.2
Height, m	2 ± 0.09
Weight, kg	99 ± 11
BMI, kg/m^2	25 ± 1.6
Years of experience	4 [2-8]
Minutes per game	24 [20-30]
Minutes to injury	898 [481-1326]
Right-handed	115 (91)
Position	
Point guard	28 (22)
Shooting guard	30 (24)
Small forward	17 (14)
Power forward	23 (18)
Center	28 (22)
Baseline performance metrics	
PER	15 [12-18]
TS%	0.55 [0.52-0.58]
Points	4.9 [0-11]

[a]Data are presented as mean ± SD, median [interquartile range], or n (%). BMI, body mass index; NBA, National Basketball Association; PER, player efficiency rating; TS%, true shooting percentage.

regression to identify factors associated with having an equal or greater PER and TS% at 2 years in players sustaining shoulder injuries. Multivariate analysis for elbow injuries was underpowered and therefore not reported. Odds ratios (ORs), 95% CIs, standard errors, and *P* values were reported. Alpha was set at .05.

RESULTS

A total of 192 shoulder and elbow injuries were sustained among 126 NBA athletes during the study period. Table 1 summarizes the characteristics of the players. The players had a mean age of 26 years, with a mean of 4 years of NBA experience. The mean baseline PER was 15, and the mean TS% was 0.55% .

Table 2 summarizes the 151 reported shoulder injuries sustained by 99 NBA players. Also, 85 (56%) of these injuries were sustained on the player's dominant extremity, and 96 (64%) of shoulder injuries were classified as structural. Sprains/strains were the most common injury type, occurring 0.43 times per 1000 GEs. By comparison, the incidence of subluxations/dislocations was 0.09 per 1000 GEs. Significant differences in severity were observed in soreness ($P < .001$), contusion ($P = .023$), sprain/strain ($P < .001$), and labrum tear ($P = .03$) subgroups in addition to overall injuries ($P < .001$) There was no significant association between injury severity and dominance among all injuries ($P < .001$) or when stratified by injury type. The overall incidence of dominant shoulder injuries (0.62 per 1000 GEs [95% CI, 0.49-0.76]) was comparable to nondominant shoulder injuries (0.48 per 1000 GEs [95% CI, 0.37-0.60]).

Of the 41 total reported elbow injuries sustained in 34 NBA athletes, 28 (68%) injuries occurred on the dominant extremity (Table 3). There were 30 (73%) structural elbow injuries. The most common elbow pathology was sprain/strain, with an incidence of 0.12 per 1000 GEs. There were significant differences between injury severity within the contusion ($P = .031$) and sprain/strain ($P = .046$) subgroups. Regarding sprain/strains, there was a significant increase in the severity of dominant injuries compared with nondominant injuries ($P = .046$). Dominant elbow injuries (0.21 per 1000 GEs [95% CI, 0.13-0.28]) occurred at twice the rate of nondominant elbow injuries (0.10 per 1000 GEs [95% CI, 0.04-0.15]), although this was not determined to be significant.

Risk of Shoulder and Elbow Injuries

The bivariate analysis demonstrated that players sustaining dominant structural shoulder injuries had greater baseline PER (16 [interquartile range (IQR), 14-18]) compared with those with nondominant shoulder injuries (14 [IQR, 11-17]; $P = .029$) (Table 4). In those with dominant shoulder injuries, there were significant declines in PER at 1 year (14 [IQR, 12-16]; $P = .027$) and 2 years (13 [IQR, 11-16]; $P = .012$) after injury. No significant decline in PER was noted in the nondominant shoulder, dominant elbow, or nondominant elbow at 1 or 2 years after injury as compared with baseline. TS% did not decline after injury for either shoulder and elbow injuries regardless of dominance. An increase in TS% was noted in nondominant shoulder injuries at 2 years after injury (0.56% [IQR, 0.53%-0.60%] compared with baseline (0.54% [IQR, 0.50%-0.58%]; $P = .005$).

Multivariable analysis revealed an association between younger age and quicker return to baseline PER after shoulder injury (OR, 0.77 [95% CI, 0.67-0.88]; $P < .001$) (Table 5). This analysis also demonstrated that shoulder injuries on the dominant side compared with the nondominant side did not significantly influence the ability to return to baseline PER (OR, 0.51 [95% CI, 0.22-1.2]; $P = .11$) by 2 years after injury. Return to baseline TS% after shoulder injury was associated with younger age (OR, 0.75 [95% CI, 0.65-0.86]; $P < .001$) and minutes per game (OR, 0.87 [95% CI, 0.80-0.94]; $P < .001$) but not dominant shoulder involvement (OR, 0.45 [95% CI, 0.18-1.1]; $P = .091$).

DISCUSSION

The key finding of this study was that players sustaining shoulder injuries on their dominant side were not able to return to baseline PER within the first 2 years after injury (baseline vs 2-year postinjury PER, 16 vs 13; $P = .012$). In contrast, baseline PER was achieved by 1-year postinjury in players with a nondominant shoulder injury (baseline vs 1-year postinjury PER: 14 vs 13; $P = .12$), dominant

TABLE 2
Number, Incidence, and Severity of Shoulder Injuries in NBA Players (n = 99 Players)[a]

Injury Type	Injuries, n	Injury Incidence (95% CI)[b]	Injury Severity, n			*P* Value
			Mild	Moderate	Severe	
Soreness	55	0.40 (0.30-0.51)	33	20	2	**<.001**
Dominant	38	0.28 (0.19-0.37)	24	12	2	.392[c]
Nondominant	17	0.12 (0.07-0.18)	9	8	0	
Inflammation	4	0.03	2	2	0	.369
Dominant	1	0.01	1	0	0	—[c]
Nondominant	3	0.02	1	2	0	
Contusion	13	0.10 (0.04-0.15)	2	9	2	**.023**
Dominant	7	0.05	1	4	2	.778[c]
Nondominant	6	0.04	1	5	0	
Sprain/strain	59	0.43 (0.32-0.54)	13	37	9	**<.001**
Dominant	29	0.21 (0.14-0.29)	8	17	4	.847[c]
Nondominant	30	0.22 (0.14-0.30)	5	20	5	
Subluxation/dislocation	12	0.09 (0.04-0.14)	1	4	7	.105
Dominant	4	0.03	0	1	3	.644[c]
Nondominant	8	0.06	1	3	4	
Labrum tear	6	0.04	0	1	5	**.030**
Dominant	4	0.03	0	0	4	—[c]
Nondominant	2	0.01	0	1	1	
Other	2	0.01	2	0	0	.137
Dominant	2	0.01	2	0	0	—[c]
Nondominant	0	0	0	0	0	
Total	151	1.11 (0.93-1.28)	53	73	25	**<.001**
Dominant	85	0.62 (0.49-0.76)	36	34	15	.052[c]
Nondominant	66	0.48 (0.37-0.60)	17	39	10	
Total, structural only[d]	96	0.70 (0.56-0.84)	20	53	23	**<.001**

[a]Bold *P* values indicate statistically significant differences between comparisons as indicated ($P < .05$). NBA, National Basketball Association.
[b]Calculated per 1000 game exposures. 95% CIs reported if n >10 injuries.
[c]Comparisons of dominant versus nondominant injuries by severity. Dashes indicate underpowered comparisons in which no *P* values were reported.
[d]All injury types except for soreness.

elbow injury (16 vs 16; *P* = .42), and nondominant elbow injury (16 vs 12; *P* = .11). Interestingly, our multivariable analysis suggests that the involvement of the dominant shoulder does not influence one's ability to return to baseline PER by 2 years postinjury (OR, 0.51; *P* = .11). However, the mean PER did steadily decrease from 16 to 13 between baseline and 2 years postinjury in the dominant shoulder cohort, whereas the mean PER increased from 14 to 15 over the same time frame in the nondominant shoulder cohort. Therefore, with greater power, this comparison may have reached statistical significance.

PER is an unabridged statistical representation of player performance, accounting for 2-point field goals, 3-point field goals, free throws, rebounds, assists, blocks, steals, turnovers, and personal fouls. Interestingly, evaluation of TS%—which isolates 2-point field goals, 3-point field goals, and free throws—in these players over the same time frame revealed no decline in shooting performance. The combination of these findings suggests that non-TS% components of PER such as rebounds, blocks, and assists likely account for the decline in PER after sustaining a dominant shoulder injury. Rebounding and blocking in particular are associated with overhead movements requiring significant shoulder flexion and abduction with associated internal and external rotation.[2,27] An injury sustained to the shoulder joint may adversely affect the native range of motion in the long term.[12,16] Additionally, there may be psychological apprehension to perform explosive overhead movements in the same manner as preinjury. Collectively, these limitations may contribute to the decrease in PER observed in the dominant shoulder group.

Dominant shoulder injuries appear to be more detrimental to player performance than nondominant shoulder injuries. The dominant and nondominant shoulder muscles of basketball players are exposed to similar isokinetic peak torques during the shooting motion.[14] Therefore, the dominant shoulder is not necessarily predisposed to an increased biomechanical burden. Instead, the decreased performance seen in dominant shoulder injuries may be attributed to a 50% greater incidence of severe injuries in the dominant arm (n = 15) compared with the nondominant arm (n = 10), although no significant association

TABLE 3
Number, Incidence, and Severity of Elbow Injuries in NBA Players (n = 34 Players)[a]

Injury Type	Injuries, n	Injury Incidence (95% CI)[b]	Injury Severity, n			
			Mild	Moderate	Severe	*P* Value[c]
Soreness	11	0.08 (0.03-0.13)	6	4	1	.179
Dominant	9	0.07	4	4	1	.361[c]
Nondominant	2	0.01	2	0	0	
Inflammation	3	0.02	2	1	0	.368
Dominant	2	0.01	1	1	0	—
Nondominant	1	0.01	1	0	0	
Contusion	8	0.06	6	2	0	**.031**
Dominant	2	0.01	2	0	0	—
Nondominant	6	0.04	4	2	0	
Sprain/strain	16	0.12 (0.06-0.17)	6	9	1	**.047**
Dominant	13	0.10 (0.04-0.15)	3	9	1	**.046**[c]
Nondominant	3	0.02	3	0	0	
Ligament tear	1	0.01	0	0	1	.362
Dominant	0	0	0	0	0	—
Nondominant	1	0.01	0	0	1	
Fracture	1	0.01	0	0	1	.362
Dominant	1	0.01	0	0	1	—
Nondominant	0	0	0	0	0	
Other	1	0.01	1	0	0	.362
Dominant	1	0.01	1	0	0	—
Nondominant	0	0	0	0	0	
Total	41	0.30 (0.21-0.40)	21	16	4	**.004**
Dominant	28	0.21 (0.13-0.28)	11	14	3	.072[c]
Nondominant	13	0.10 (0.04-0.15)	10	2	1	
Total, structural only[d]	30	0.22 (0.14-0.30)	15	12	3	**.020**

[a]Bold *P* values indicate statistically significant differences between comparisons as indicated ($P < .05$). NBA, National Basketball Association.
[b]Calculated per 1000 game exposures. 95% CIs reported if n >10 injuries.
[c]Comparisons of dominant versus nondominant injuries by severity. Dashes indicate underpowered comparisons in which no *P* values were reported.
[d]All injury types except for soreness.

was recognized between shoulder dominance and injury severity (*P* = .052) (Table 2). No single structural injury type was associated with dominant-sided injuries as evidenced by comparable injury incidences within each injury type.

The findings in this study also suggest an association between younger age and achievement of baseline PER by 2 years after injury. As hypothesized, increased age did influence the decline in PER for players experiencing dominant shoulder injuries. Older age in NBA players has previously been suggested to result in decreased physical performance including slower average speed and decreased distance covered per game.[13] Although these biometric variables were not evaluated in the present study, aging seems to negatively impact overall player performance.

The majority of the literature evaluating changes in PER after shoulder injuries in NBA athletes has focused on shoulder instability. Four studies found no significant changes in PER in the first 2 seasons after dislocation/subluxation with shoulder stabilization surgery.[15,18,19,21] Li et al[18] identified a significant decrease in PER 1 season after injury for players who elected nonoperative treatment.

Shooting accuracy, as measured by TS%, was not influenced by shoulder or elbow injuries, despite the importance of shoulder and elbow movement in the basketball shooting motion.[5] These findings largely parallel studies of other NBA injuries, in which TS% was largely unaffected after injury.[23] The findings in this study found that younger players who played fewer minutes per game were more likely to return to baseline or improved TS% by 2 years after injury. It remains unclear why a specific improvement in TS% was observed after 2 seasons after nondominant shoulder injury; however, it does suggest that players with this pathology are less likely to have long-lasting implications on performance.

Overall, the incidence of shoulder and elbow injuries was 1.11 per 1000 GEs and 0.30 per 1000 GEs, respectively. This was consistent with historical NBA injury data from 1988 to 2005, which demonstrated shoulder and elbow injury incidence rates of between 0.70 and

TABLE 4
Results of Bivariate Analysis of Shoulder and Elbow Injuries in the Dominant and Nondominant Sides Among NBA Players[a]

	n	Timepoint: Baseline (n = 175)	Timepoint: 1 Year Postinjury (n = 144)	Timepoint: 2 Years Postinjury (n = 128)	P Value: 1 Year vs Baseline	P Value: 2 Years vs Baseline
PER						
All injuries	192	15 [12-18]	14 [12-17]	14 [12-17]	**.002**	**.011**
Dominant shoulder	85	16 [14-18]	14 [12-16]	13 [11-16]	**.027**	**.012**
Nondominant shoulder	66	14 [11-17]	13 [11-16]	15 [13-17]	.12	.79
Dominant elbow	28	16 [12-19]	16 [14-20]	16 [14-20]	.42	.093
Nondominant elbow	13	16 [11-16]	12 [12-14]	12 [9.2-15]	.17	.17
P Value						
Shoulder		.029	.52	.093		
Elbow		.38	.069	.055		
TS%						
All injuries	192	0.55 [0.51-0.58]	0.55 [0.52-0.58]	0.55 [0.52-0.60]	.13	**.015**
Dominant shoulder	85	0.55 [0.52-0.58]	0.54 [0.53-0.58]	0.55 [0.52-0.60]	.79	.38
Nondominant shoulder	66	0.54 [0.50-0.58]	0.54 [0.51-0.59]	0.56 [0.53-0.60]	.41	**.005**
Dominant elbow	28	0.54 [0.53-0.58]	0.55 [0.52-0.58]	0.55 [0.54-0.59]	.34	.44
Nondominant elbow	13	0.53 [0.53-0.57]	0.58 [0.56-0.58]	0.51 [0.46-0.58]	.061	.50
P Value						
Shoulder		.31	.61	.39		
Elbow		.82	.34	.22		

[a]Continuous variables are presented as median [interquartile range]. Bold *P* values indicate statistically significant differences between comparisons as indicated ($P < .05$). NBA, National Basketball Association; PER, player efficiency rating; TS%, true shooting percentage.

TABLE 5
Results of Multivariable Logistic Regression Analysis of Factors Associated With Equal or Higher PER and TS% at 2 Years Versus Baseline Among NBA Players With Shoulder Injuries[a]

	OR (95% CI)	SE	*P* Value	Pseudo R^2
PER				0.15
Age, y	0.77 (0.67-0.88)	0.052	**<.001**	
Dominant side	0.51 (0.22-1.2)	0.21	.11	
TS%				0.25
Age, y	0.75 (0.65-0.86)	0.053	**<.001**	
Minutes per game	0.87 (0.80-0.94)	0.035	**<.001**	
Dominant side	0.45 (0.18-1.1)	0.21	.091	

[a]Variables were selected using backward stepwise regression to create a parsimonious model. Bold *P* values indicate statistical significance ($P < .05$). NBA, National Basketball Association; OR, odds ratio; PER, player efficiency rating; TS%, true shooting percentage.

0.90 per 1000 GEs and 0.40 and 0.50 per 1000 GEs respectively.[7,8,25] Elbow injuries are relatively rare in basketball players, and there is limited literature regarding the topic.[4] This study found that only 10% of elbow injuries were severe, requiring players to miss 11 or more consecutive games. With larger sample sizes, future studies may aim to identify factors influencing return-to-play performance after sustaining elbow injuries.

Limitations

There are several limitations to this retrospective study. First, injury data were queried and verified through a public database and media outlets. Despite the use of these resources in other literature, discrepancies in this injury data may exist compared with official team records. Second, this study did not report the type of treatment, including operative interventions, which may provide more insight into the return-to-play measures that were evaluated. This was an inherent limitation because of a lack of access to team records. Third, information on subclinical injuries and injuries sustained during the offseason or practices was not publicly available and therefore may have led to an underreporting of shoulder/elbow injuries in NBA players. Players may have played through injuries, a common occurrence in the playoffs, which furthers the possibility of underreporting.

CONCLUSION

A significant decline in PER was discovered in the 2 seasons after dominant shoulder injuries sustained by NBA players, with increased age identified as a risk factor for this performance-related trend. Players with elbow or nondominant shoulder injuries did not experience any change in PER. Shooting accuracy remained unaffected upon return to play after all types of shoulder and elbow injuries. These findings suggest that most NBA players with shoulder or elbow injuries should expect a return to their preinjury statistical performance unless their injury is sustained to their dominant shoulder.

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