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Professional advancement, performance, and injury characteristics of baseball players entering the Major League Baseball draft after treatment for shoulder injuries

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Background: How shoulder injuries treated before the Major League Baseball (MLB) draft affect the player's performance over their career is unclear. The purpose of this study was to determine whether prior shoulder injuries were associated with a difference in the level of performance and advancement of MLB draftees.
Methods: Before entering the draft, 119 professional baseball players from 2004 to 2010 were treated for a shoulder injury (73% treated surgically) as an amateur. A 3:1 matched case-control was performed to players without prior shoulder injuries by age, position, round selected, and signing bonus. Follow-up data were collected in 2016, and professional advancement, disabled list time, and in-game performance statistics for pitchers were analyzed and compared.
Results: Players with a prior shoulder injury had a statistically higher chance to be assigned to the disabled list then controls ($P = .03$), but there was no difference in disabled list time or professional advancement. Pitchers with a prior shoulder injury pitched a statistically lower number of innings per game than controls ($P = .04$). All other in-game performance statistics were not statistically different. The type of treatment did not have any effect on future performance or advancement.
Conclusions: Professional baseball players treated for prior shoulder injuries at the amateur level were more likely to sustain future disability than their matched controls, but it did not affect professional advancement.
Level of evidence: Level III; Retrospective Cohort Design; Prognosis Study

Keywords: shoulder; injuries; Major League Baseball; draft; players; performance; outcomes

The Major League Baseball Medical Committee granted permission to conduct the study, and the study was approved by Scripps Clinic Institutional Review Board (14-6401).

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Due to the dramatic increase in the amount of year-round baseball that youth and adolescents play, there has been a focus on controlling pitch counts, improving throwing mechanics, and understanding the pathophysiology associated with throwing injuries across all levels of play.[8,10,15,17] The

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baseball player's shoulder undergoes significant and repetitive microtrauma over the course of their career, starting at an early age.[13] Adaptive changes to the soft tissue and even bony anatomy can alter the thrower's accuracy, velocity, and endurance.[1,2,6,14] The most common structural lesions and conditions treated in the elite overhead thrower's shoulder include superior labrum anterior-posterior (SLAP) tears, anterior or posterior labral injuries (non-SLAP labral tears), rotator cuff tears (partial or full), internal impingement, and glenohumeral internal rotation deficit. Other pathologic conditions, such as Bennett lesions, or chronic and traumatic instability, are seen less commonly.[4]

Many elite overhead throwers with shoulder pathology can be initially treated with a nonoperative protocol that emphasizes posterior capsular stretching and improvement of scapular and throwing mechanics. However, operative treatment of shoulder pathology, most notably SLAP tears, with or without associated conditions in the elite overhead thrower, has been well studied with a wide range of return to play (RTP).[3,5,9,11,13,16,18-26] In many of these studies, there is a variable level of skill (recreational vs. professional) in the athletes that are studied. This poses a problem when critically evaluating outcomes after surgery. Although excellent outcomes can be reported for the overall cohorts, further subanalyses of elite or professional baseball players, especially pitchers, show a lower RTP, especially when associated with other shoulder conditions.[5,13,20,26] To further evaluate this, a systematic review by Harris et al[12] analyzed 6 studies of only professional baseball pitchers with different shoulder conditions that were treated with surgery and reported a 68% RTP by 1 year (78% RTP overall), with no RTP in 22%.

No studies to date have longitudinally monitored professional baseball draftees with a history of shoulder injuries that were treated before the draft. This is important to evaluate, because the literature has shown consistent results in recreational athletes but variable results in professional baseball players. In this study, a cohort of baseball players selected in the Major League Baseball (MLB) draft who received treatment (surgical or nonoperative) for shoulder injuries before the draft as amateur players were matched to similar players who had no history of shoulder injuries. We then analyzed and compared professional advancement, disabled list (DL) time, and performance metrics between groups.

We hypothesized that players with a history of shoulder injuries treated before the MLB draft would not have a lower rate of professional advancement, more time on the DL, or worse performance metrics than players without a history of predraft shoulder injuries.

Materials and methods

Study information was collected from an MLB database of drafted players. Additional statistical and performance data were also available from MLB and from online resources. To protect all players' privacy, the study data were deidentified, and no names were used during any phase of the study.

In the MLB drafts from 2004 to 2010, 2789 draftee medical records were submitted. From these, we identified 144 players who had shoulder injuries before entering the draft, and 119 of them proceeded to play professional baseball and were included in the study. Of the 119 included players, 87 were treated surgically and 32 were treated nonoperatively. For each study player (case), 3 players (controls) with no history of shoulder injuries were matched by age, position (pitchers or position players with same throwing handedness), round selected (within 30 draft picks), and signing bonus. The surgically treated players were further subdivided by the procedure performed, which included arthroscopic débridement (labral or rotator cuff), SLAP repair, non-SLAP labral repair (anterior/posterior repairs), labral + SLAP repair, rotator cuff repair, and distal clavicle excision. The nonoperatively treated players were divided by pathology, which included rotator cuff tendinitis/internal impingement, SLAP tears, and non-SLAP labral tears (anterior/posterior repairs).

Data after the draft were collected in 2016, which allowed for follow-up of 6 to 12 years. The difference between the players' highest level of professional advancement as well as the number of times and total number of days spent on the DL were determined. For the highest level of professional advancement, the player must have had 10 plate appearances or pitched 10 innings at that level to register for advancing to that level. The highest level of professional advancement was divided into 5 categories for comparison purposes (Table I). To assess the future injury risk of having predraft shoulder pathologies, treated surgically or nonsurgically, we analyzed only the number of days on the DL due to shoulder injuries.

Performance data were collected for all pitchers, including total innings, games played, games started, earned run average, and walks and hits per inning pitched and compared with the matched controls. The performance statistics were obtained from minor league performance data only, because most players do not advance to playing at the major league level.[7] Therefore, if performance statistics were available from major league games, they were not included in this analysis to reduce the bias of this data.

Statistical analysis was performed using SPSS 12 software (IBM, Armonk, NY, USA), Means and frequencies were calculated to summarize the study data. To compare groups on performance and injury variables, χ^2 tests were used for categoric data, and independent samples *t* tests were used for continuous data. Mann-Whitney *U* tests were used for continuous variables that had non-normal distributions. When differences among the 3 groups (injured players treated surgically, injured players treated non-operatively, and controls) were assessed, χ^2 tests were used for categoric variables and Kruskal-Wallis tests were used for continuous variables that were nonparametric. Significance was set at $P < .05$.

Table I Classification of professional levels including minor and major leagues

Professional Levels
Short A, rookie
A, high A
AA
AAA
Major League Baseball

Table II Demographics of surgical treatment group

Variable	No.	Débridement	Labral repair	SLAP repair	Labral + SLAP repair	RCR	DCE
Pitcher	35	16 (46)	8 (23)	11 (31)	0	0	0
Position	52	9 (17)	25 (48)	13 (25)	3 (6)	1 (2)	1 (2)

SLAP, superior labrum anterior to posterior; *RCR*, rotator cuff repair, *DCE*, distal clavicle excision.
Values are presented as number (%).

Table III Demographics of non-operative treatment group

Variable	No.	Rotator cuff tendinitis/ impingement	Labral tear	SLAP tear
Pitcher	20	8 (40)	7 (35)	5 (25)
Position	12	2 (17)	8 (67)	2 (17)
Overall, %		31	47	22

SLAP, superior labrum anterior to posterior.
Values are presented as number (%) unless indicated otherwise.

Results

Demographics

Between 2004 and 2010, 119 draftees were identified as having shoulder injuries treated before the MLB draft, with 87 players treated surgically and 32 players treated nonoperatively. Within the draft, 357 controls meeting our matching criteria were identified with no history of shoulder pathology. However, 16 controls had incomplete information or performance statistics and were excluded from the comparative analysis, leaving 341 controls.

The average age of all players included in the study (n = 460) was 21.6 ± 1.2 years, with no statistically significant difference in age ($P = .362$) between the surgical (21.7 ± 1.1 years), nonoperative (21.4 ± 1.4 years), and control (21.6 ± 1.2 years) groups. In the surgical cohort, 35 of 87 players (40%) were pitchers and underwent arthroscopic débridements as the most common operation (Table II). In the nonoperative cohort, 20 of 32 players (63%) were pitchers and were most commonly treated for rotator cuff tendinitis or internal impingement (Table III).

Overall, 92 of 119 injuries (77%) involved the dominant arm. When broken down by treatment group, 79% (69 of 87) in the surgical cohort and 72% (23 of 32) in the nonoperative cohort involved the dominant arm. For the 31 players with SLAP tears overall, 30 (97%) involved the dominant arm, of which 23 of 24 (96%) were in the surgical cohort, and 7 of 7 (100%) were in the nonoperative cohort. In contrast, for non-SLAP labral tears, there was 56% (27 of 48) involvement of the dominant arm. Position players had the highest involvement of the nondominant arm (16 of 33 [48%]) for non-SLAP labral tears in the injury cohort.

Professional advancement

The highest levels of professional advancement achieved are shown in Figs. 1 and 2. Overall, for all 3 groups combined, 21.7% (100 of 460) advanced to MLB. There was no statistically significant difference in professional advancement at the highest level achieved between the injury cohort and controls ($P = .10$) and when analyzing the surgical and

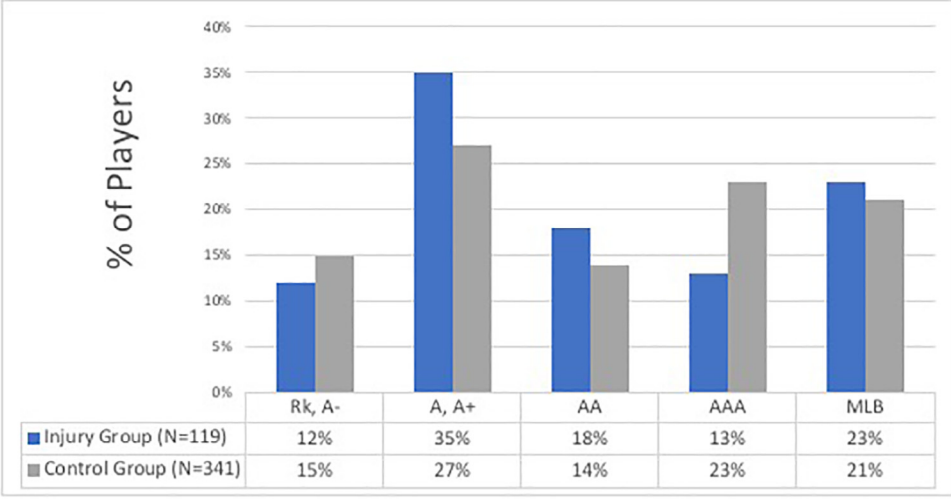

Figure 1 Highest level of professional advancement for injury and control groups. *Rk*, rookie; *MLB*, Major League Baseball.

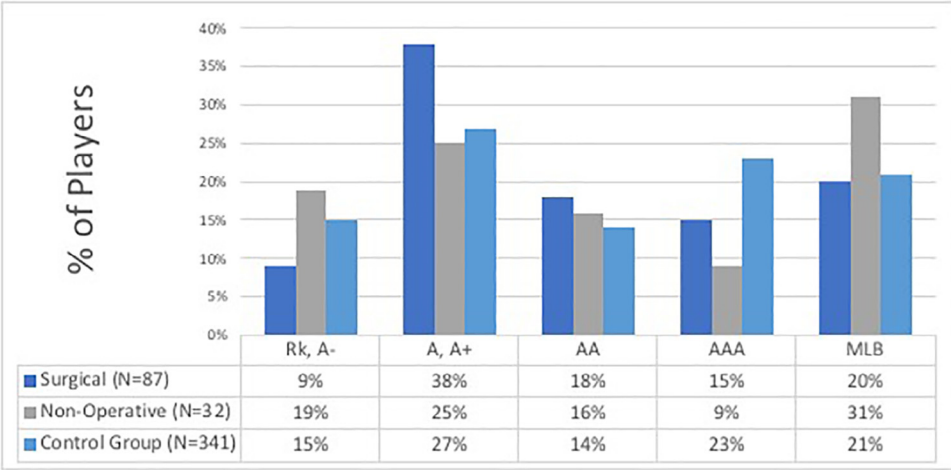

Figure 2 Highest level of professional advancement for surgical, non-operative, and control groups. *Rk*, rookie; *MLB*, Major League Baseball.

nonoperative groups separately to the controls ($P = .13$). There was also no statistically significant difference in advancement to just the MLB level between the entire injury group ($P = .77$) or when analyzing the surgical group and nonoperative group separately to the controls ($P = .36$).

Future injury

There was a statistically higher representation of players in the injury cohort (36 of 119 [30%]) placed on the DL at some point in their career for a future shoulder injury compared with the players in the control group being placed on the DL (69 of 341 [20%]; $P = .03$) for a shoulder injury. Most of the players from the injury cohort who were placed on the DL in the future (36 players) for a shoulder injury were from the surgical group (27 of 36 [75%]). However, when the surgical, nonoperative, and control groups were compared for future shoulder injury, the difference between the groups was not statistically significant ($P = .08$). For those requiring DL assignment for a future shoulder injury, there was no significant difference in the number of days that they spent on the DL. These results are summarized in Table IV and Table V.

Table IV Future disabled list assignment for shoulder injury and matched control groups

Group	No.	Was placed on DL	*P*	Days on DL	*P*
		No. (%)		Average ± SD	
Injury group	119	36 (30)		76 ± 65	
Control group	341	69 (20)	.03	62 ± 66	.24

DL, disabled list; *SD*, standard deviation.
P <.05 is deemed statistically significant.

Table V Future disabled list assignment for surgical, nonoperative, and matched control groups

Variable	No.	Was placed on DL	*P* value	Days on DL	*P* value
		No. (%)		Average ± SD	
Surgical group	87	27 (31)		67 ± 61	
Nonoperative group	32	9 (28)		101 ± 74	
Control group	341	69 (20)	.08	62 ± 66	.27

DL, disabled list; *SD*, standard deviation.
P < .05 is deemed statistically significant.

Performance

Performance metrics for pitchers were analyzed and showed a statistically lower number of innings played per game for the entire injury group (2.3) compared with controls (2.8; $P = .04$). The remaining performance metrics were not statistically significant from each other and are summarized in Table VI. When the surgical and nonsurgical groups were analyzed separately to the controls, no statistically significant differences were identified between groups (Table VII). Of note, the pitchers represent players at all professional designations, level of play, and multiple in-game roles (reliever, starter, both).

Discussion

Shoulder injuries are common in professional baseball players and can have varying long-term effects on the careers of these athletes. How shoulder injuries can affect the career

Table VI Pitcher performance of injury and control groups

Group	No.	Inning pitched	Games played	Games started	Innings played per game	ERA	WHIP
Injury	54	258 ± 224	106 ± 106	28 ± 40	2.3 ± 1.2	4.09 ± 1.13	1.42 ± 0.156
Control	150	300 ± 280	101 ± 71	40 ± 49	2.8 ± 1.4	4.55 ± 4.23	1.46 ± 0.486
P value		.63	.47	.34	.04	.46	.54

ERA, earned run average; *WHIP*, walks plus hits per inning pitched.
P < .05 is deemed statistically significant. All performance values are reported as number ± standard deviation.

Table VII Pitcher performance of surgical, nonoperative, and control groups

Group	No.	Innings pitched	Games played	Games started	Innings played per game	ERA	WHIP
Surgical	34	243 ± 204	108 ± 75	23 ± 34	2.2 ± 1.0	4.17 ± 1.26	1.42 ± 0.170
Nonoperative	20	282 ± 257	102 ± 64	37 ± 48	2.6 ± 1.4	3.94 ± 0.877	1.40 ± 0.03
Control	150	300 ± 280	101 ± 77	40 ± 49	2.8 ± 1.4	4.55 ± 4.23	1.46 ± 0.04
P value		.86	.77	.46	.10	.48	.75

ERA, earned run average; *WHIP*, walks plus hits per inning pitched.
P < .05 is deemed statistically significant. All performance values are reported as number ± standard deviation.

progression and performance of baseball players entering the MLB draft has not been evaluated. A recent article by Wymore et al[27] evaluated the professional advancement and performance of 38 drafted players who had elbow ulnar collateral ligament reconstructions before the draft and matched them to players who did not. Data were collected after the draft in 2014, with up to 4 to 8 years of follow-up, and they found an increased risk of DL assignment for the elbow but no other statistically significant differences between the cohorts in terms of statistical performance.[27] Similarly, in our study, players who had a shoulder injury, regardless of treatment, had a statistically higher risk (30%) of being placed on the DL than controls (20%). When the injury cohort was analyzed further, 75% of the players who were assigned to the DL were previously treated with surgery.

In our study, the dominant shoulder was affected in most of the injuries except cases of non-SLAP labral tears (anterior or posterior labral tears). However, position players had the highest number of non-SLAP labral tears in their nondominant arm. A potential explanation for this can be attributed to the glove arm being repetitively extended during catching or diving.

When professional advancement was evaluated, especially to MLB, there was no statistical difference between players with prior shoulder injuries and their matched controls. There was also no difference between those treated with surgery or treated nonoperatively in the injury cohort. Overall, for all 3 groups combined, the advancement to MLB was 21.7% (100 of 460). This is similar to an analytics report by Baseball America, where they calculated that 17.2% (~1 of 6) of signed draftees from 1987 to 2008 advanced to play at least 1 game in MLB.[7] Wymore et al[27] reported a 34% advancement rate to MLB for pitchers with ulnar collateral ligament reconstruction before the draft vs. 26% for their matched controls, but this was not statistically significant.

In pitchers, we found a statistically lower number of innings played per game in our injury cohort (2.33), regardless of treatment regimen, compared with the controls (2.81). The difference of 0.48 inning may not be clinically important for starters, because a half inning does not equate to a significant portion of the game over a pitcher's career, but it may be significant for players who pitch in relief.

Because there are no published data on professional baseball players with a history of shoulder injuries before the draft, we have to carefully evaluate the literature on studies that have focused only on elite or professional baseball pitchers who underwent treatment for shoulder injuries. Harris et al,[12] in their systematic review of elite-level baseball pitchers, evaluated 6 studies with 287 shoulders that underwent treatment for full-thickness or partial-thickness rotator cuff tears, labral tears, type II SLAP tears, and internal impingement. However, only 1 of those studies evaluated an isolated injury (labral tears).[24] The rest of the studies reported multiple concomitant shoulder lesions that were surgically treated.[12] Overall, Harris et al[12] reported a RTP of 68% by 1 year after surgery and 78% overall.

In both the surgical and nonoperative cohorts, SLAP tears and labral tears were the most commonly treated pathology in pitchers and position players. There has been increasing evidence in recent studies to suggest that elite pitchers may not benefit greatly from SLAP repairs.[9,20,21] Only 3 position players in our surgical cohort had a combined SLAP and labral repair. But, given that this was a study of players who were injured at the amateur level, we did not expect many players to have multiple lesions that needed to be concomitantly addressed at the time of their operation.

The strengths of this study are that it focuses on an isolated population of elite-level baseball players who were drafted to MLB, which controls for selection bias. To improve the power of the study, a 3:1 matched-control was

performed to identify players who were similar in age, skill level, and position. There was a minimum of 6 years up to 11 years of longitudinal follow-up, which should allow enough time to determine what effect any pre-existing shoulder injuries that were treated would have on the long-term potential of drafted baseball players. This study also provides a baseline knowledge of various outcomes and metrics that are useful to players and respective teams in understanding how shoulder injuries can potentially affect a player's career.

Limitations of our study include that it is a retrospective review with data acquired through a large database. Multiple diagnoses were treated nonoperatively and surgically, which creates heterogeneity within our "injury cohort." The severity of the injuries also varied between the surgical and nonoperative groups and was difficult to control for in our analysis. Therefore, even though there seems to be a selection bias based on varying degrees of injury and conditions treated, the players all passed a predraft evaluation for their overall health and ability to play baseball at an elite level before they were drafted.

Although our data collection from MLB after the draft allowed for a follow-up time between 6 and 12 years, many drafted players take years to advance, and some players may have advanced beyond our final follow-up who were not accounted for. DL assessment may not be the most comprehensive measurement for injury; however, this was universally used for the injury and control groups to allow for an equal comparison. Our matching criteria used age, position, draft pick, and signing bonus. We felt this allowed us to best identify players who could be compared with our cases as closely as possible; however, other criteria (e.g. performance data) also have been used.

Finally, a player's draft pick may theoretically be affected by a history of previous surgery. However, based on our results, we did not see a difference in professional advancement between players who did or did not undergo surgery for their shoulder injuries. Some players who are drafted higher may not advance as far as some players drafted in lower rounds, although, it is more likely that the higher drafted players have a higher likelihood of advancing to MLB.

Conclusion

Our study showed that professional baseball players with a history of shoulder injuries treated before the MLB draft were more likely to be assigned to the DL for a future shoulder injury than their matched controls without a history of a shoulder injury. Also, there was no difference in professional advancement and performance whether they were treated nonoperatively or surgically. For pitchers who were drafted with a history of prior shoulder injury, they pitched a significantly lower number of innings per game compared with matched controls.

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