

Incidence of Elbow Ulnar Collateral Ligament Surgery in Collegiate Baseball Players

Marcus A. Rothermich,^{*†} MD, Stan A. Conte,[‡] PT, DPT, ATC, Kyle T. Aune,[†] MPH, Glenn S. Fleisig,[†] PhD, E. Lyle Cain Jr,[†] MD, and Jeffrey R. Dugas,[†] MD

Investigation performed at the American Sports Medicine Institute, Birmingham, Alabama, USA

Background: Recent reports have highlighted the progressive increase in the incidence of ulnar collateral ligament (UCL) injuries to the elbow in baseball players of all levels. However, knowledge of the incidence and other epidemiological factors regarding UCL injuries, specifically in college baseball players, is currently lacking.

Purpose: To evaluate, over a period of 1 year, the incidence of UCL injuries requiring surgery in National Collegiate Athletic Association (NCAA) Division I baseball programs.

Study Design: Descriptive epidemiology study.

Methods: A total of 155 Division I collegiate baseball programs agreed to participate in the study. Demographics (position, year, background [location of high school]) for all players on these rosters were obtained from public websites. At the conclusion of the 2017 collegiate baseball season, the athletic trainer for each program entered anonymous, detailed information on injured players through an electronic survey into a secured database.

Results: All 155 teams enrolled in the study completed the electronic survey. Of the 5295 collegiate baseball players on these rosters, 134 underwent surgery for an injured UCL (2.5% of all eligible athletes), resulting in a team surgery rate of 0.86 per program for 1 year. These 134 players came from 88 teams, thus 56.8% of the study teams underwent at least 1 surgery during the year. The surgery rate was 2.5 per 100 player-seasons for all players and was significantly higher among pitchers (4.4/100 player-seasons) than nonpitchers (0.7/100 player-seasons). The surgery rate was also significantly higher in underclassmen (3.1/100 player-seasons among freshmen and sophomores) than upperclassmen (1.9/100 player-seasons among juniors and seniors) (incidence rate ratio, 1.7; 95% CI, 1.1-2.4). Players from traditionally warm-weather states did not undergo UCL surgery at a significantly different rate from players from traditionally cold-weather states (2.7/100 player-seasons vs 2.1/100 player-seasons, respectively). Nearly half of surgeries (48.5%) were performed during the baseball season.

Conclusion: The incidence of UCL surgeries in NCAA Division I collegiate baseball players represents substantial morbidity to this young athletic population. Risk factors for injuries requiring surgery include being a pitcher and an underclassman. Awareness of these factors should be considered in injury prevention programs. Furthermore, this initial study can serve as a foundation for tracking these surgical injuries in future years and then identifying trends over time.

Keywords: epidemiology; sports medicine; overhead athlete; UCL; Tommy John surgery

*Address correspondence to Marcus A. Rothermich, MD, American Sports Medicine Institute, 833 St Vincent's Drive, Suite 205, Birmingham, AL 35205, USA (email: marcusrothermich@gmail.com).

[†]American Sports Medicine Institute, Birmingham, Alabama, USA.

[‡]Santa Clara University, Santa Clara, California, USA.

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Injuries to the medial ulnar collateral ligament (UCL) have been identified as a cause of substantial morbidity in overhead athletes for decades. There has recently been a well-documented elevation in the incidence of injuries to the UCL in baseball players at the high school, collegiate, and professional levels of play.^{2,4-8,14,15,17,22,27,31} Likewise, the number of young baseball players undergoing UCL reconstruction or repair continues to rise.^{11,18} Despite the awareness of this general trend, little is known regarding the incidence of UCL injuries in collegiate baseball players.

Recent research has explored the incidence of UCL injuries to the elbow at various levels of competition.^{6,7,29} Although these reports have added significant information to the historical literature on the subject of UCL injuries in baseball players,^{1,20} there remains a significant lack of

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knowledge regarding both the incidence and common treatment courses chosen by collegiate baseball players sustaining UCL injuries.

With the rapid increase in the number of professional baseball players undergoing UCL reconstruction and the associated millions of dollars lost annually to these morbid injuries, focus has recently shifted to the prevention of damage to the UCL in high school and collegiate baseball players.^{12,13,23,24,27,28,30} This interest in preventing UCL injuries makes the need for epidemiological and treatment information increasingly relevant for young baseball players.

This study was intended to serve several important roles in advancing the knowledge of UCL injuries. The primary purpose was to identify baseline epidemiological data, including the rate of surgical UCL injuries per team over 1 year and differences in UCL surgical rates by player position, academic level, time of year, and geographic distribution within the United States.

METHODS

This study was designated as nonhuman subjects research by the institutional review board at our institute and therefore did not require formal approval. The recruitment process involved telephone contact with the athletic trainers responsible for the baseball program at each institution. Each of the baseball programs from 15 National Collegiate Athletic Association (NCAA) Division I athletic conferences was contacted by the authors, resulting in 157 of 299 Division I baseball programs²⁵ contacted nationwide (52.5%). These 157 programs represented a selection of 15 out of a possible 30 conferences, with a goal of collecting data on half of the Division I programs nationwide. Our goal in contacting these specific 15 conferences was to invite a majority of Division I programs from diverse geographic locations around the country. After contacting each of these programs, 155 of 157 agreed to participate (98.7%).

An electronic survey compliant with the Health Insurance Portability and Accountability Act (HIPAA) created on SurveyMonkey (<https://www.surveymonkey.com/>) was sent by electronic mail to the athletic trainer at each participating baseball program at the conclusion of the team's season (including postseason play). Importantly, no identifiable personal health information was collected by the electronic survey to allow for anonymous tracking of player data. The identity of the baseball program was not attached to the submitted survey with the anonymous player information but instead separately submitted for independent tracking of institutions responding to the survey. This allowed for the anonymity of the responses while still confirming which programs responded. The trainers were not compensated financially for their participation.

The questions entailed both de-identified personal demographic information and surgical details. Personal demographic data included the player's primary position, age, academic level at the time of surgery, and state in which the player attended high school. Surgical data included hand dominance, additional elbow procedures performed at the time of surgery, any prior shoulder or elbow

surgeries undergone by the player, primary versus revision UCL surgery, type of UCL procedure performed, and time of year of surgery. To protect anonymity, the time of surgery was captured by season instead of exact surgical date. We identified 4 major seasons of the calendar year in relation to the traditional baseball season: "previous post-season" (end of 2016 season to August 31, 2016), "off-season" (September 1 to November 30, 2016), "preseason" (December 1, 2016, to February 14, 2017), and "in-season" (February 15, 2017, to end of 2017 season).

Statistical analysis was performed using SAS 9.4 (SAS Institute). To accurately calculate incidence both overall and within specific subpopulations of athletes, online rosters for all participating schools were reviewed to determine the total risk pool of athletes for the study period (2016-2017 season). Incidence rates were compared among subpopulations (position, academic year, geographic location of high school) using incidence rate ratios (IRRs) with 95% CIs as previously described.³ As the CIs allowed for a more accurate statistical evaluation of significance compared with calculating *P* values, 95% CIs were used to determine statistical significance.

RESULTS

After the conclusion of the 2017 baseball season, all 155 programs that enrolled in the study successfully submitted the completed survey (100.0%). Of the 5295 collegiate baseball players from these 155 programs, 134 underwent surgery for injuries to the UCL. This represents an annual surgical injury rate of 2.53% of total players and 0.86 surgical UCL injuries per team. Figure 1 demonstrates the number of surgeries that were performed over the 2016-2017 season with 67 programs (43.2%) having no surgeries and 88 programs (56.8%) having at least 1 player undergo UCL surgery throughout the year.

Figure 2 shows that the vast majority of injured players were pitchers (115/134; 85.8%). Of these 115 pitchers, 49 were starting pitchers (42.6%), and 66 were relief pitchers (57.4%). Pitchers underwent surgery at a rate 5.9 times higher than that of nonpitchers (95% CI, 3.6-9.6); there was no significant difference in the rate among left- versus right-handed pitchers.

The average age of the player at the time of surgery was 19.7 years. Figure 3 demonstrates that of the 134 players who underwent UCL surgery, 88 (65.7%) were underclassmen (freshmen and sophomores), and 46 (34.3%) were upperclassmen (juniors and seniors). Underclassmen underwent UCL surgery at a rate 1.6 times higher than that of upperclassmen (95% CI, 1.1-2.3). Among pitchers, underclassmen underwent UCL surgery at a significantly higher rate than upperclassmen (3.1/100 vs 1.9/100 player-seasons, respectively; IRR, 1.7 [95% CI, 1.1-2.4]).

The season in which surgery occurred is shown in Figure 4. As this chart demonstrates, nearly half of the procedures (65/134; 48.5%) occurred during the in-season interval, with the other half spread throughout the previous postseason, off-season, and preseason intervals (69/134; 51.5%).

Figure 5 is a graphic depiction of the state in which the player attended high school, with red states representing

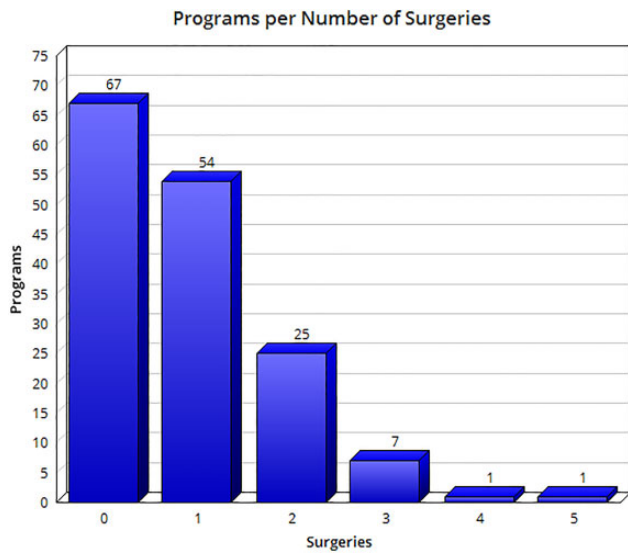


Figure 1. The number of ulnar collateral ligament surgeries that each team experienced during the 2016-2017 season.

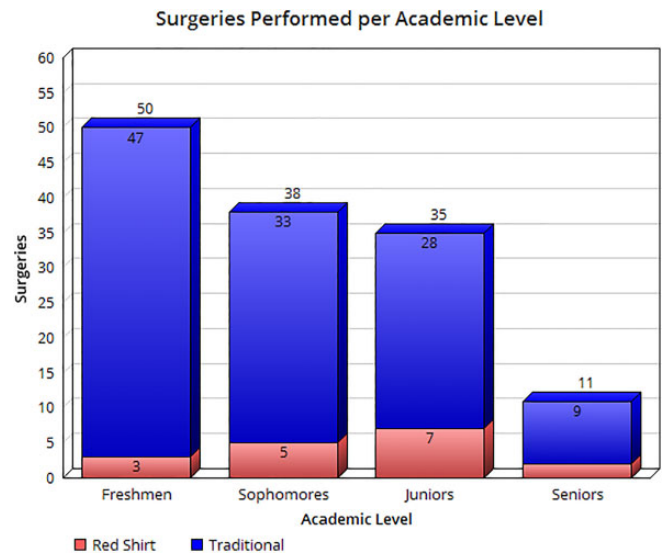


Figure 3. A depiction of academic levels at the time of surgery.

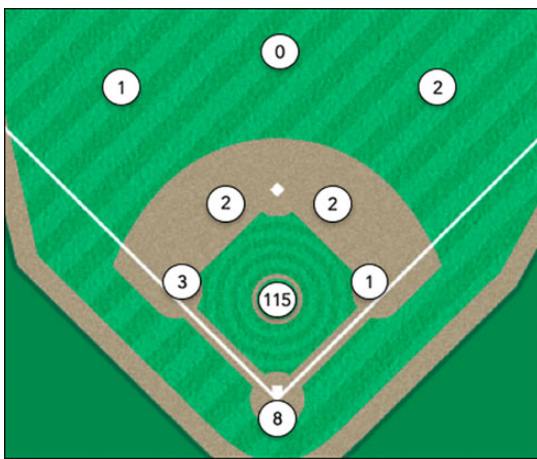


Figure 2. The rate of surgeries for each player position. There were no players listed as multiple position players or designated hitters.

traditionally warm-weather states and blue states representing traditionally cold-weather states, identified as a state with an average annual temperature of $\leq 55^{\circ}\text{F}$ as defined by the National Oceanic and Atmospheric Administration.^{10,19,26,32} Nearly all players were from the United States (132/133; 99.2%), with 1 player from Canada and 1 player unaccounted for as the trainer did not know the state of origin for that player. This figure demonstrates that the 87 players who attended high school in warm-weather states did not undergo UCL surgery at a significantly different rate from the 46 players who attended high school in cold-weather states (IRR, 1.3 [95% CI, 0.9-1.9]). Similarly, among the subgroup of pitchers, those from warm-weather states underwent surgery at a rate higher than that of nonpitchers but not significantly different from

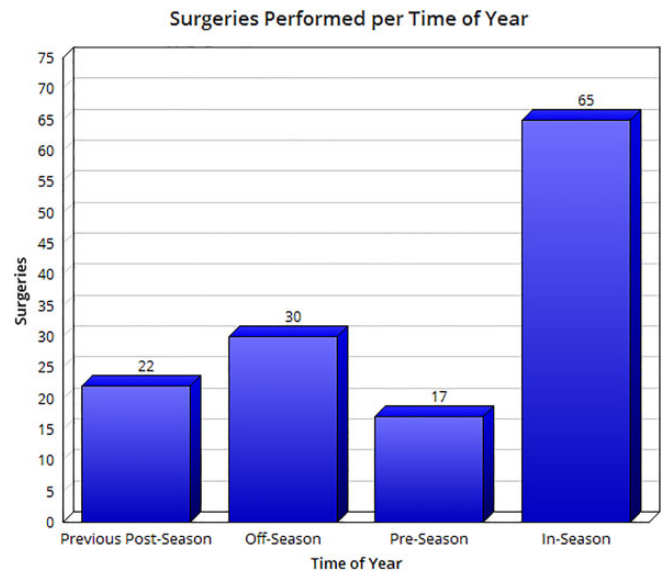


Figure 4. The number of surgeries for each season throughout the year. The previous postseason period was defined as the end of the 2016 baseball season through August 31, 2016, the off-season was September 1, 2016, through November 30, 2016, the preseason was December 1, 2016, through February 14, 2017, and the in-season period was February 15, 2017, through the final game of the 2017 baseball season for each team.

pitchers from cold-weather states (4.5/100 vs 3.6/100 player-seasons, respectively; IRR, 1.2 [95% CI, 0.9-1.8]).

In addition to personal demographic data, the survey also collected surgical data for the 134 players who underwent surgery for UCL injuries to the elbow. Nearly all players underwent surgery on the dominant extremity (133/134; 99.2%). The most common additional procedure

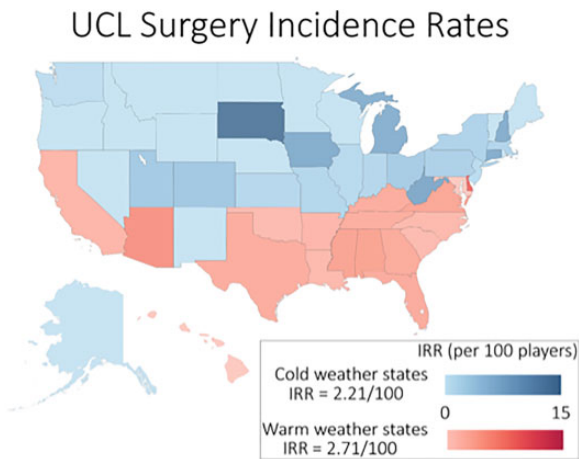


Figure 5. The high school state of origin for each player who underwent surgery. The blue states represent traditionally cold-weather states, and the red states depict traditionally warm-weather states. The overall incidence rate ratio (IRR) was 2.21 for players from cold-weather states and 2.71 for players from warm-weather states. Injury rates are visually indicated by the darkness of each state's image. Not depicted in the figure is 1 player from a Canadian province, who was included in the overall data for players from cold-weather states. UCL, ulnar collateral ligament.

performed at the time of surgery was ulnar nerve transposition, which was performed in 48 of 134 surgeries (35.8%). A small minority of the players had undergone previous surgery to the ipsilateral shoulder and elbow (20/134; 14.9%), and these procedures included shoulder labral repair, prior UCL reconstruction, bone spur removal, ulnar nerve transposition, cervical fusion, and thoracic outlet decompression. For the vast majority of the players who underwent UCL surgery, the operative intervention was the primary surgical procedure to an injured, native UCL of the elbow. Overall, 130 of 134 patients underwent a primary UCL procedure (97.0%) as opposed to 4 of 134 who underwent a revision procedure for a retear of a previous graft (3.0%).

Surgical information was also collected on the type of surgical procedure performed on the injured elbow. There were 35 surgeries documented with an "unknown" procedure type, leaving 99 procedures in which the surgical technique was documented. Of these, most players underwent a reconstructive procedure with a graft (83/99; 83.8%). The remainder of the players (16/99; 16.2%) underwent the recently described UCL repair with internal brace augmentation.⁹

DISCUSSION

As the incidence of UCL injuries in young baseball players continues to rise at an unprecedented rate, the description of epidemiological data at the collegiate level is critical to establishing baseline knowledge of their incidence and to examining trends in future years. Professional baseball has suffered because of the increasing prevalence of UCL

injuries in recent decades, prompting a collective focus on injury prevention in young players.^{6,7,12-15} An informed prevention strategy requires knowledge about the incidence of UCL surgery at all levels of play, including the injuries related to collegiate baseball. The enthusiastic response that was apparent among collegiate baseball athletic trainers to collect and distribute this epidemiological information underscores the necessity for more research into the cause of this common injury. This study establishes the baseline incidence rate of surgical UCL injuries over the course of 1 year to be 0.86 per team. Additional findings demonstrating that underclassmen and pitchers are at a higher risk of surgical injuries contribute to an epidemiological foundation established by this study. Longer term data and surgical trends from the continuation of this study will build upon these baseline data.

At the core of this study was the goal to establish the incidence of surgical UCL injuries in collegiate baseball throughout the course of 1 year. This information was previously unknown, and the understanding of UCL injuries at the collegiate level will provide a significant contribution to the treatment of these injured players, with the goal of ultimately identifying prevention strategies for these common injuries. Among the important findings was the raw number of 134 surgeries throughout 1 year from the 155 schools, representing an average surgery rate of 0.86 per year for each school. This is substantially higher than the only other published incidence rate of 0.38 in a longitudinal study of programs from 2 conferences over several seasons.³² Although many schools had no UCL surgeries (67/155; 43.2%), Figure 1 demonstrates that 54 schools (34.8%) had 1 surgery and 34 schools (21.9%) had multiple players lost to UCL surgery during the 2016-2017 year.

The strong predominance of pitchers undergoing UCL surgery (85.8%) compared with nonpitchers (14.2%), as represented in Figure 2, is consistent with previous literature on UCL injury epidemiology across all levels of play.^{6,7,29} Biomechanical analysis has demonstrated that the pitching motion creates 70 N·m of varus torque about the elbow for collegiate pitchers.¹⁶ However, in vitro research of young male cadaveric elbows with muscles removed has shown an ultimate failure torque of 34 N·m.² These data demonstrate that muscular dynamic forces about the elbow are required to allow the UCL to withstand the biomechanical demands of the pitching mechanism.¹⁴ Therefore, the high rate of UCL injuries among collegiate pitchers is to be expected.

Based on the data collected in this study and represented in Figure 3, a majority of the athletes who underwent UCL surgery were underclassmen (IRR, 3.1/100 player-seasons in underclassmen vs 1.9/100 player-seasons in upperclassmen). This finding seems in contrast with the prevalence patterns in Minor League Baseball, where 6% of Minor League pitchers aged ≤ 20 years have a history of UCL surgery, but 14% of Minor League pitchers aged 21 to 25 years have undergone UCL surgery.⁷ Although intuition suggests that older players with more cumulative innings pitched would be more likely to sustain an injury to the UCL requiring surgery, the large number of freshmen who underwent surgery (37.3%) implies that they may have

enrolled in a collegiate program with a pre-existing elbow injury from high school that required operative intervention during their freshman season. The upperclassmen population of this study may have also been susceptible to survival bias; those who remained active collegiate players as juniors and seniors may have been healthier than others who became injured and dropped out of baseball earlier in their collegiate or high school career. Additionally, players throwing at a higher velocity could have potentially been drafted after their junior year and left collegiate baseball early. Also, the pitching mechanics of incoming freshmen are likely to be widely variable, and this could make the younger pitchers more vulnerable to injuries. Finally, the decision to proceed with surgical intervention could potentially be made earlier in a collegiate career with the knowledge of multiple more years of eligibility, as reflected in the high number of freshmen undergoing surgery (37.3%) compared with the low number of seniors undergoing UCL reconstruction or repair (8.2%). This intent to be at optimal health during the later collegiate years of eligibility could potentially bias athletes toward pursuing surgery at a younger age. Also, seniors may have elected to forgo surgery if they did not intend to pursue competitive baseball after their senior collegiate season.

Another interesting element of the data collected was the time of year in which surgery was performed. Nearly half of the players underwent surgery during the active season (65/134; 48.5%), likely to maximize rehabilitation time before the following season. Interestingly, a small spike was noted in the off-season months of September to November (30/134; 22.4%), which may represent players who were injured in a summer baseball league or who failed nonoperative management that was initially pursued after the previous collegiate season. The 2 seasons with the smallest incidence of surgery (previous postseason and preseason) likely identified players who had an injury late in the previous season or players who attempted nonoperative management until they resumed conditioning and full-speed throwing in the preseason months.

Previous literature has described the effect of average annual temperature on the rate of UCL injuries in collegiate baseball players, reporting in these studies that the availability of year-round play due to warmer climates may contribute to a higher incidence of surgical UCL injuries in warm-weather states.^{10,19,26,32} To effectively determine potential damage done to the UCL in players entering and actively playing collegiate baseball, we elected to collect information on the state in which the player attended high school. It is conceivable that a player could play for a college team in a warm-weather state but have played several seasons of youth league and high school baseball in a cold-weather state and vice versa, so we determined that high school origin would define the location where the majority of cumulative time was spent pitching throughout the player's career. Athletes who played high school baseball in warm-weather states underwent UCL surgery at a slightly, although not significantly, higher rate (IRR, 1.3 [95% CI, 0.9-1.9]). Knowledge of this information is valuable but does not suggest causation related to high school origin. Our conclusion that geographic location does not

have a significant impact on the rate of surgical UCL injuries may be reflected in the recent trend of athletes playing a single sport year-round despite geographic location.^{12,13} The disappearance of the multisport athlete may well be related to the elimination of geographic influence on the UCL surgical injury rate.

As reflected in the data set collected, nearly all of the UCL surgeries performed on collegiate baseball players during 2016-2017 were primary surgical procedures to the UCL (97.0%). A small minority underwent revision procedures (3.0%), representing a smaller incidence of revision procedures at the collegiate level than the 13.2% revision rate published in a recent study of professional baseball players.²¹ This lower revision rate is logical with the younger cohort at the collegiate level, and all revision procedures included revision UCL reconstruction in these collegiate athletes.

A recent debate regarding the management of UCL injuries in throwing athletes has centered around the most appropriate surgical treatment for different types of UCL injuries. In patients with chronic, attritional damage to the UCL and secondary damage to elbow joint stability, reconstruction with a graft remains the most common surgical intervention.⁴⁻⁷ However, with the exponential rise in the incidence of UCL injuries, a proportion of these injuries occur in athletes with maintained joint stability and high-quality native ligament tissue. It has been proposed that these patients are the ideal candidates for successful treatment with UCL repair.⁹ As noted in this data set, 83.8% of collegiate baseball players treated surgically for a UCL injury with a known procedure type had their native ligament reconstructed, whereas 16.2% underwent UCL repair with a tape augmentation procedure performed. This discrepancy will likely narrow as the indications and outcomes for the UCL repair procedure are better understood in the future.

Limitations

This study had several limitations. It represents data on surgical UCL injuries over a single year, and an ongoing longitudinal study of multiple seasons with epidemiological trends will include much more data and player-years. Also, as the epidemiological data were entered and submitted by the individual athletic training staff members at each NCAA Division I baseball program, including by the head athletic trainer, baseball athletic trainer, or graduate assistant baseball trainer at the various institutions, the accuracy of the data relied on the local training staff. As player information was de-identified, its accuracy could not be independently verified by investigators, and outcomes could not be assessed.

This data set does not account for players who had potentially previously played at the junior collegiate level and also could misrepresent the data on those few who may have changed geographic locations during high school. The 155 enrolled institutions represented 51.8% of all Division I collegiate baseball programs nationwide; however, this sample size allowed us to measure the incidence of UCL surgeries in NCAA Division I baseball with 95% confidence

and a margin of error of $\pm 5\%$. Player data from the 2 programs that declined participation and the 142 programs not contacted to participate in this study are unknown. A complete data set would include responses from all 299 Division I programs, and the extrapolation of only the received epidemiological data represents a possibility of spectrum biases in the results of this study.

CONCLUSION

The average rate of UCL surgeries in the 155 Division I collegiate baseball programs enrolled for the 2016-2017 year was 0.86 per program. The risk of a surgical injury was much higher for pitchers, as 4.4% of all pitchers underwent UCL surgery during the 1-year period. Pitchers who were underclassmen were at an increased risk of an injury requiring surgery. Awareness of these factors should be considered in injury prevention.

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