

Is Tommy John Surgery Performed More Frequently in Major League Baseball Pitchers From Warm Weather Areas?

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Background: Medial ulnar collateral ligament (UCL) reconstruction is a common procedure performed on Major League Baseball (MLB) pitchers with symptomatic UCL insufficiency, frequently due to overuse. Warm weather climates afford youth pitchers the opportunity to throw year-round, potentially placing them at risk for overuse elbow injuries.

Purpose/Hypothesis: To determine whether the proportion of MLB pitchers who underwent medial UCL reconstruction and who pitched competitive youth baseball in warm weather areas is higher than those from cold weather areas. The hypothesis was that MLB pitchers from warm weather areas were more likely to undergo UCL reconstruction than pitchers from cold weather areas.

Study Design: Descriptive epidemiological study.

Methods: All MLB pitchers with symptomatic UCL deficiency who underwent UCL reconstruction as of June 1, 2014, were evaluated. The state/country where they played high school baseball was identified from online reference websites. Warm and cold weather areas were defined by latitude distance from the equator and mean annual temperatures. A chi-square test was used to compare the proportion of MLB pitchers from warm versus cold weather areas who underwent UCL reconstruction. The study was 99.6% powered to detect a 100% effect size (eg, 1% vs 2%) and 71.4% powered to detect a 50% effect size (eg, 1% vs 1.5%) with setting $\alpha = .05$.

Results: A total of 247 pitchers were identified who had undergone UCL reconstruction; 139 (56.3%) pitched high school baseball in warm weather areas, 108 (43.7%) pitched in cold weather areas. A significantly higher proportion of pitchers who underwent UCL reconstruction (2.2% [95% CI, 1.9%-2.6%]) were from warm weather areas compared with cold weather areas (0.94% [95% CI, 0.78%-1.1%]) ($P < .0001$). Warm weather pitchers had a mean (\pm SD) age of 27.6 ± 0.6 years and had played 4.0 ± 0.6 seasons in MLB at the time of surgery, while cold weather pitchers were aged 28.4 ± 0.8 years and had played 5.0 ± 0.9 seasons in MLB ($P = .089$ and $P = .047$, respectively).

Conclusion: MLB pitchers who played high school baseball in warm weather climates have undergone medial UCL reconstruction more frequently and earlier in their MLB careers than pitchers who played in cold weather areas.

Keywords: ulnar collateral ligament; Tommy John surgery; Major League Baseball; return to sport; elbow injury; pitching; demographic

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The medial ulnar collateral ligament (UCL), specifically the anterior band, is the primary restraint to valgus stress at the elbow.^{15,21} It plays a pivotal role in pitching mechanics, as well as in elbow mechanics of other sports, including tennis, javelin, and football.^{4,5,12,13,22} Medial UCL reconstruction was first performed by Dr Frank Jobe in 1974 on pitcher Tommy John.¹¹ Since that time, the surgery has become increasingly common, with a significantly greater number of pitchers per year undergoing medial UCL reconstruction since 2000.⁶ This trend is not isolated to MLB pitchers, as high-level adolescent athletes are also undergoing UCL reconstruction at a growing rate in recent years.¹⁹

Despite the increase in the number of UCL reconstructions in athletes, the risk factors for symptomatic UCL insufficiency are not clearly defined. No study to date has

had the primary aim of determining risk factors for undergoing UCL reconstruction in MLB pitchers. Petty et al¹⁹ showed that in 27 high school baseball players, playing baseball year-round was a risk factor for UCL reconstruction as was inadequate warm-up, overuse, throwing more than 80 mph, and throwing breaking pitches. There have also been reports on risk factors for undergoing either shoulder or elbow surgery in adolescents. Pitchers who underwent surgery pitched more innings per game and games per season, threw more warm-up pitches, and often threw more than 100 innings per season.^{9,18} Neither of these studies evaluated geography as a risk factor for UCL reconstruction. Some surgeons believe that pitchers from warm weather areas are able to pitch more competitive innings per year than those from cold weather areas, thereby accumulating higher pitching statistics (more innings pitched, pitches thrown, etc) per year. This added stress on the elbow at a young age could predispose these players to problems later on in their careers, specifically, symptomatic medial UCL insufficiency.

The purpose of this study was to determine whether the proportion of MLB pitchers who underwent medial UCL reconstruction who pitched competitive youth baseball in warm weather areas is higher than those from cold weather areas. The study also aimed to determine whether there was a difference in age as well as number of years pitched in MLB at the time of surgery between pitchers from warm versus cold weather areas. We hypothesized that MLB pitchers who grew up in warm weather climates were more likely to undergo UCL reconstruction than were pitchers from cold weather climates and that these pitchers would undergo surgery at younger ages and earlier in their MLB careers.

METHODS

Major League Baseball pitchers with symptomatic medial UCL injury who underwent reconstruction between the first reported case in 1974 and when the search was conducted on June 1, 2014, were evaluated. These pitchers were included if they pitched in at least 1 MLB game prior to the UCL reconstruction, and they were identified through MLB team websites and publicly available Internet-based injury reports. Several studies have used this method of data collection.^{1,3,6-8,10,16,17} Player profiles, biographies, and press releases were cross-referenced with the MLB injury database. The MLB database (HITS;) contains information from 2010 to 2014, and this information was cross-referenced with the publicly available information. An orthopaedic surgery resident and a board-eligible orthopaedic surgeon with sports medicine–fellowship training conducted the search. Once these pitchers were identified, an Internet search was conducted to determine the state or country where each pitcher played high school baseball. The same geographic data were collected for all MLB players over the same time frame using publicly available online information (<http://www.baseball-almanac.com>).²

Prior to conducting the search, warm weather areas were defined as those states/countries that were within the 33rd parallel and closer to the equator in the northern and

southern hemispheres. If a state or country was intersected by the 33rd parallel or fell closer to the equator, it was termed a warm climate, but if the state/country fell outside of this parallel, the region was classified as a cold climate. There were 23 warm weather climatesⁱ and 50 cold weather climatesⁱⁱ (Figure 1).

A chi-square test was used to determine whether a difference existed between the proportion of pitchers from warm weather climates that underwent medial UCL reconstruction and the proportion of pitchers from cold weather climates that underwent medial UCL reconstruction. With the sample size available ($n = 247$) and assuming a 2-tailed test with $\alpha = .05$, we were 99.6% powered to detect a 100% effect size (eg, 1% vs 2%) and 71.4% powered to detect a 50% effect size (eg, 1% vs 1.5%). A chi-square test was used to compare all proportions while a 2-tailed independent Student *t* test was used to compare continuous variables.

RESULTS

In MLB history, 64.5% of all players (11,538) were from cold weather areas, while 35.5% (6359) of all players were from warm weather areas. There were 247 MLB pitchers who underwent UCL reconstruction within the specified dates; 139 of these pitchers (139/247 = 56.3%) were from warm weather areas, and 108 (108/247 = 43.7%) were from cold weather areas (Figures 2 and 3).

A significantly higher proportion of pitchers who underwent UCL reconstruction (139/6359 = 2.2% [95% CI, 1.9%-2.6%]) were from warm weather areas, compared with cold weather areas (108/11,538 = 0.94% [95% CI, 0.78%-1.1%]) ($P < .0001$).

Pitchers from warm weather areas had a mean age (\pm SD) of 27.57 ± 0.61 years at the time of surgery, while those from cold weather areas were aged 28.44 ± 0.83 years ($P = .089$) despite beginning careers in MLB at comparable ages (23.38 ± 0.33 vs 23.16 ± 0.37 ; $P = .380$) (Figure 4A). Pitchers from warm weather areas pitched significantly fewer seasons in MLB prior to UCL reconstruction (mean, 3.98 ± 0.61) compared with pitchers from cold weather areas, who pitched a mean of 5.03 ± 0.85 seasons in MLB prior to surgery ($P = .047$) (Figure 4B).

DISCUSSION

Symptomatic insufficiency of the UCL is a growing problem in MLB pitchers. There has been a significant increase in the number of MLB pitchers who have undergone UCL reconstruction in recent years, and there is no evidence that this number will stop rising.⁶ We sought to determine whether playing high school baseball in warm weather areas led to an increase in the likelihood a pitcher would undergo UCL reconstruction once in MLB and whether it had any effect on the timing of surgery. Our hypothesis was supported, as pitchers who played high school baseball in warm weather climates were more likely to undergo UCL reconstruction than pitchers who played high school baseball in cold weather climates. Also, pitchers from warm

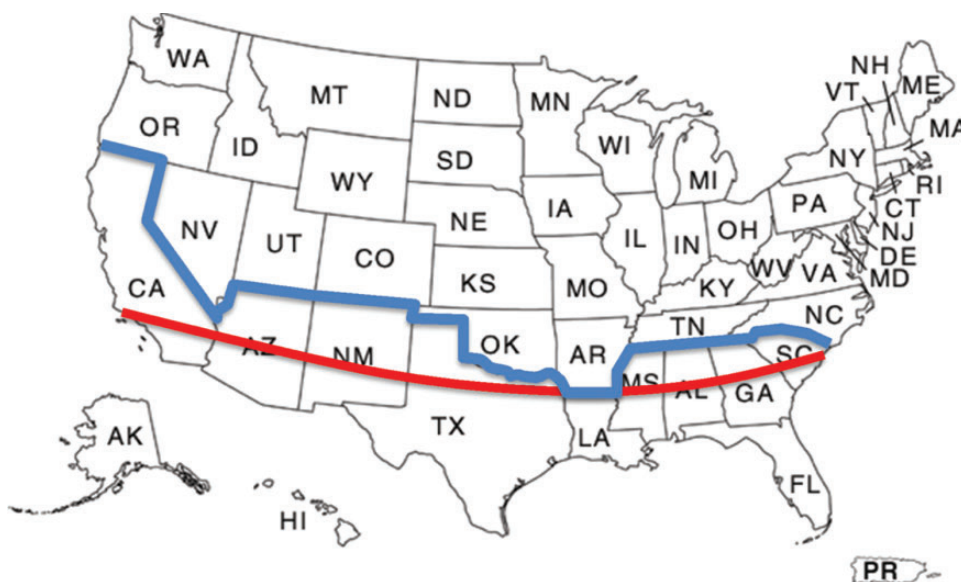


Figure 1. Map of the United States demonstrating the 33rd parallel (red line), which was used to separate the states into warm (south of the 33rd parallel) and cold (north of the 33rd parallel) states; blue line shows the actual state separation into warm (south of the blue line) and cold (north of the blue line).

Warm Weather Areas

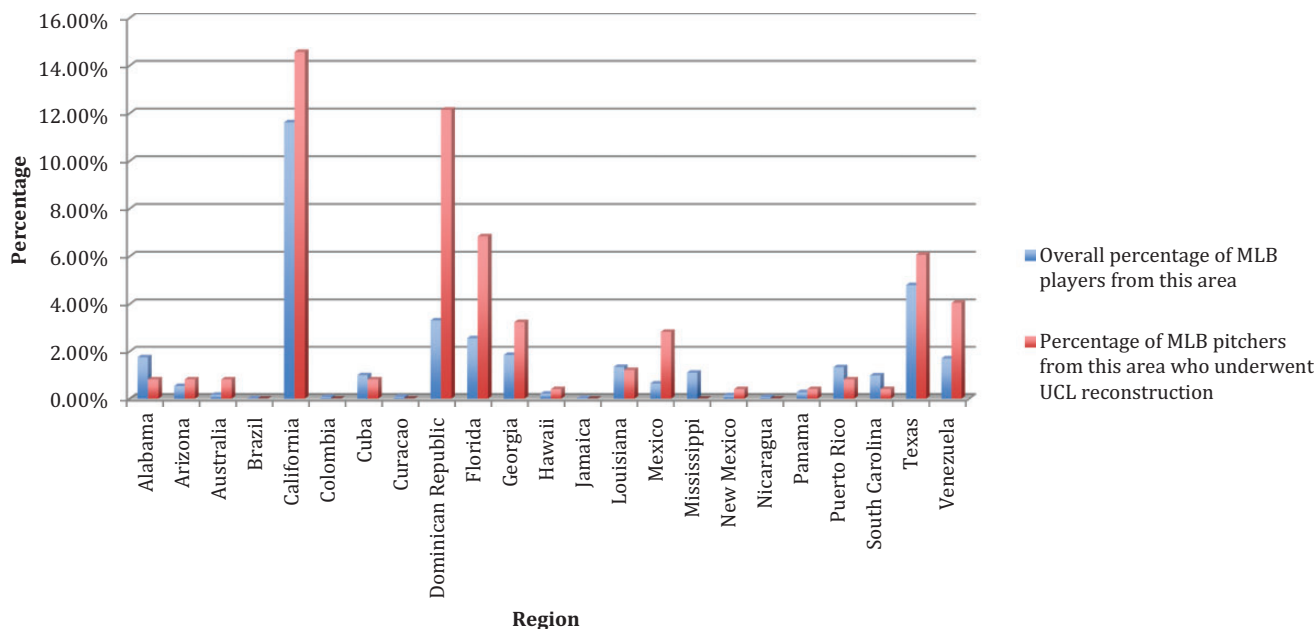


Figure 2. The percentage of Major League Baseball (MLB) players from each warm climate area (blue) versus the percentage of all 247 MLB pitchers who underwent ulnar collateral ligament (UCL) reconstruction who were from this area (red).

weather areas underwent UCL reconstruction after having pitched significantly fewer seasons in MLB and showed a trend to undergo surgery at an earlier age than did pitchers from cold weather areas.

The warm and cold weather climates were delineated based on their relation to latitude 33°, both north and south

of the equator. The goal was to group the areas where pitchers would be able to pitch competitively year-round, thereby increasing the number of games, innings, and pitches per year. This latitude was chosen as the lowest average daily temperature in the areas at the northern and southern ends of the 33rd parallel was above freezing in

Cold Weather Areas

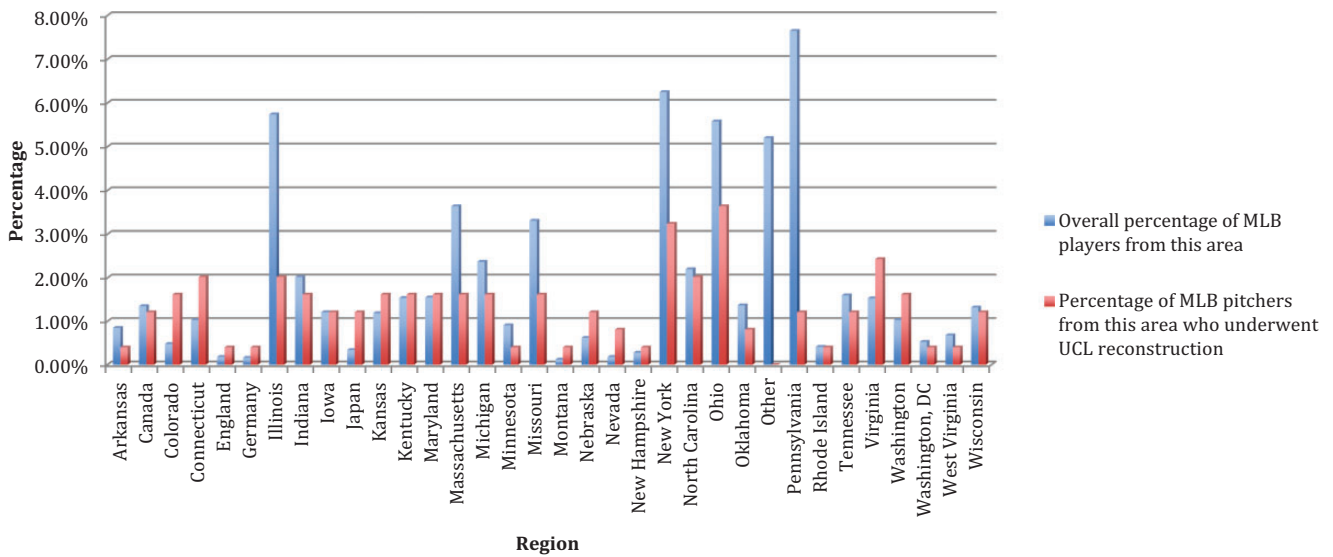


Figure 3. The percentage of Major League Baseball (MLB) players from each cold climate area (blue) versus the percentage of all 247 MLB pitchers who underwent ulnar collateral ligament (UCL) reconstruction who were from this area (red).

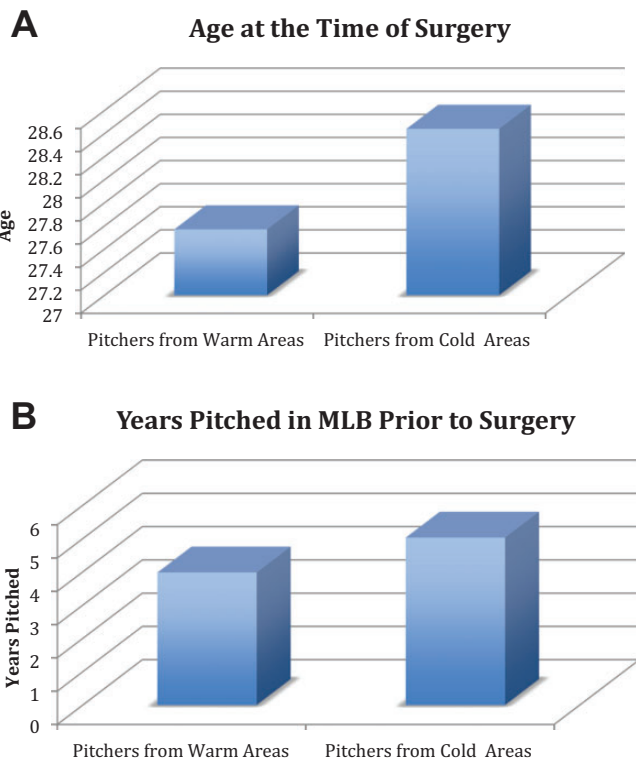


Figure 4. (A) Age at the time of ulnar collateral ligament reconstruction (UCL) in warm versus cold weather pitchers. (B) Number of years pitched in Major League Baseball (MLB) prior to UCL reconstruction in warm versus cold weather pitchers.

January, thereby making all areas deemed “warm weather” as places where the temperature was above freezing in January.²⁰ When the regions were grouped in this fashion, there were a total of 23 warm weather areas and 50 cold weather areas. Using this latitude, 64.5% of all MLB players were from cold weather areas, while 35.5% were from warm weather areas. Despite more players being from cold weather areas, a majority of pitchers who underwent UCL reconstruction were from warm weather climates (56.3%).

The current literature regarding risk factors for UCL reconstruction in elite athletes is limited. While recent studies have evaluated the performance of MLB pitchers before and after UCL reconstruction and have reported on the incidence of this surgery, no studies to date have discerned risk factors for symptomatic UCL insufficiency.^{6,14} There have been several studies in adolescent pitchers that have attempted to elucidate risk factors for shoulder and elbow surgery in general.^{9,18} Fleisig et al⁹ followed 481 youth pitchers for 10 years and determined the only significant risk factor for undergoing surgery was pitching more than 100 innings in a single season. Throwing curveballs as well as playing catcher in addition to pitcher showed a non-statistically significant increase in the number of players who underwent surgery. Olsen et al¹⁸ surveyed adolescent pitchers who underwent shoulder or elbow surgery and compared them with a control group who never had shoulder or elbow surgery. Pitchers who underwent surgery pitched more months per year, games per year, innings per game, pitches per game, pitches per year, and warm-up pitches before games. However, despite commenting on several risk factors, neither study evaluated the climate in which the pitchers were raised.

In the only dedicated study to report on risk factors for UCL reconstruction, Petty et al¹⁹ examined 27 high school

players at an average of 35 months after their UCL reconstruction. They found 6 risk factors for undergoing UCL reconstruction, which included year-round throwing, overuse both in showcase events and in season, throwing faster than 80 miles per hour, inadequate warm-ups, and throwing breaking pitches before age 14 years. Some of these risk factors have been challenged, as Fleisig et al⁹ did not see a significant risk in throwing curveballs and Olsen et al¹⁸ reported pitchers who threw more warm-up pitches were more likely to undergo shoulder or elbow surgery than did those who threw fewer.¹⁹ Furthermore, the study by Petty et al¹⁹ included only 27 high school pitchers, whereas the current study focused on professional players and evaluated every MLB pitcher who underwent UCL reconstruction.

As our study did not look specifically at pitch counts or innings pitched during the years these MLB pitchers were playing, we cannot definitively conclude that pitchers from warmer climates threw more pitches or pitched more innings in a single year than those in cold climates. However, we can definitively conclude that pitchers from warm climates are more likely to undergo UCL reconstruction and at fewer seasons into their MLB careers than are pitchers from cold weather climates. These data, in turn, raise the question of whether a pitcher has a finite number of innings he can throw before he is predisposed to an elbow injury, and it may indirectly support conserving these innings in adolescent and high school pitchers. The data from the current study show that pitchers from warm weather areas underwent UCL reconstruction approximately 1 year earlier than pitchers from cold weather areas (27.57 ± 0.61 vs 28.44 ± 0.83 years old) ($P = .089$). It also showed that pitchers from warm weather areas pitched significantly fewer years in MLB prior to requiring UCL reconstruction, as warm weather pitchers averaged 3.98 ± 0.61 seasons in MLB prior to surgery while cold weather pitchers averaged 5.03 ± 0.85 seasons prior to surgery ($P = .047$). Henceforth, these data tend to support the idea that pitchers have a finite number of throws and/or innings in their native elbow and that conserving workload at younger ages can lead to longer MLB careers and delay the need for reconstructive surgery. Our findings suggest that pitchers from cold weather areas are less prone to UCL injury on entry into MLB, perhaps because wear and tear on the elbow is less in the younger years.

Limitations

This study has several limitations. We used publicly available data, and although doing so has been shown in many recent studies to report reliable outcomes,^{2,3,6-8,10,16,17} it must be recognized. There is the possibility that a pitcher changed residences during their high school years and thus was misclassified, although this information was generally available. In addition, we could not find reliable information on what age the pitchers began pitching. We attempted to use a logical latitude (the 33rd latitude) to split the world into warm and cold weather areas, but it is possible that players outside of this latitude played baseball year-round and players inside this latitude did not. No concomitant injuries or attempted nonoperative treatments were taken

into consideration. Further studies critically evaluating the number of pitches, innings, and games pitchers from warm weather areas throw are necessary to determine whether the current Little League pitch counts for adolescents should be updated or whether pitchers should have a mandatory off-season in which they cannot pitch competitively.

CONCLUSION

Major League Baseball pitchers who played high school baseball in warm weather climates have undergone medial UCL reconstruction more frequently and earlier in their MLB careers than pitchers who played in cold weather areas.

NOTES

- i. Warm weather areas (n = 23): California, Texas, Florida, Georgia, Louisiana, Arizona, Hawaii, New Mexico, Mississippi, South Carolina, Alabama, Mexico, Nicaragua, Panama, Brazil, Colombia, Venezuela, Dominican Republic, Cuba, Puerto Rico, Curacao, Jamaica, Australia.
- ii. Cold weather areas (n = 50): Ohio, New York, Illinois, Connecticut, Kansas, Maryland, Massachusetts, Colorado, Kentucky, Michigan, Nebraska, North Carolina, Pennsylvania, Washington, Wisconsin, Indiana, Iowa, Nevada, Arkansas, Minnesota, Montana, New Hampshire, Oklahoma, Rhode Island, Tennessee, Washington DC, West Virginia, Alaska, Delaware, Idaho, Missouri, Maine, New Jersey, North Dakota, Oregon, South Dakota, Utah, Vermont, Wyoming, Virginia, Italy, Canada, Japan, England, Germany, the Netherlands, South Korea, Taiwan, West Germany, Ireland.

REFERENCES

1. Amin NH, Old AB, Tabb LP, Garg R, Toossi N, Cerynik DL. Performance outcomes after repair of complete achilles tendon ruptures in national basketball association players. *Am J Sports Med.* 2013;41:1864-1868.
2. Baseball Almanac. Major League Baseball players by birthplace. <http://www.baseball-almanac.com/players/birthplace.php>. Accessed June 1, 2014.
3. Cerynik DL, Lewullis GE, Joves BC, Palmer MP, Tom JA. Outcomes of microfracture in professional basketball players. *Knee Surg Sports Traumatol Arthrosc.* 2009;17:1135-1139.
4. Dines JS, Jones KJ, Kahlenberg C, Rosenbaum A, Osbahr DC, Altchek DW. Elbow ulnar collateral ligament reconstruction in javelin throwers at a minimum 2-year follow-up. *Am J Sports Med.* 2012;40:148-151.
5. Dodson CC, Slenker N, Cohen SB, Ciccotti MG, DeLuca P. Ulnar collateral ligament injuries of the elbow in professional football quarterbacks. *J Shoulder Elbow Surg.* 2010;19:1276-1280.
6. Erickson BJ, Gupta AK, Harris JD, et al. Rate of return to pitching and performance after Tommy John surgery in Major League Baseball pitchers. *Am J Sports Med.* 2014;42:536-543.
7. Erickson BJ, Harris JD, Fillingham YA, et al. Performance and return to sport after anterior cruciate ligament reconstruction in X Games skiers and snowboarder. *Orthop J Sports Med.* 2013;1(6). doi: 2325967113511196.
8. Erickson BJ, Harris JD, Cvetanovich GL, et al. Performance and return to sport after anterior cruciate ligament reconstruction in male Major League Soccer players. *Orthop J Sports Med.* 2013;1(2). doi: 2325967113497189.
9. Fleisig GS, Andrews JR, Cutter GR, et al. Risk of serious injury for young baseball pitchers: a 10-year prospective study. *Am J Sports Med.* 2011;39:253-257.

10. Harris JD, Erickson BJ, Bach BR Jr, et al. Return to sport and performance after anterior cruciate ligament reconstruction in National Basketball Association players. *Sports Health*. 2013;5:562-568.
11. Jobe FW, Stark H, Lombardo SJ. Reconstruction of the ulnar collateral ligament in athletes. *J Bone Joint Surg Am*. 1986;68:1158-1163.
12. Jones KJ, Conte S, Patterson N, ElAttrache NS, Dines JS. Functional outcomes following revision ulnar collateral ligament reconstruction in Major League Baseball pitchers. *J Shoulder Elbow Surg*. 2013;22:642-646.
13. Kenter K, Behr CT, Warren RF, O'Brien SJ, Barnes R. Acute elbow injuries in the National Football League. *J Shoulder Elbow Surg*. 2000;9:1-5.
14. Makhni EC, Lee RW, Morrow ZS, Gualtieri AP, Gorroochurn P, Ahmad CS. Performance, return to competition, and reinjury after Tommy John surgery in Major League Baseball pitchers: a review of 147 cases. *Am J Sports Med*. 2014;42:1323-1332.
15. Morrey BF, An KN. Articular and ligamentous contributions to the stability of the elbow joint. *Am J Sports Med*. 1983;11:315-319.
16. Namdari S, Baldwin K, Anakwenze O, Park MJ, Huffman GR, Sennett BJ. Results and performance after microfracture in National Basketball Association athletes. *Am J Sports Med*. 2009;37:943-948.
17. Namdari S, Scott K, Milby A, Baldwin K, Lee GC. Athletic performance after ACL reconstruction in the Women's National Basketball Association. *Phys Sportsmed*. 2011;39:36-41.
18. Olsen SJ 2nd, Fleisig GS, Dun S, Loftice J, Andrews JR. Risk factors for shoulder and elbow injuries in adolescent baseball pitchers. *Am J Sports Med*. 2006;34:905-912.
19. Petty DH, Andrews JR, Fleisig GS, Cain EL. Ulnar collateral ligament reconstruction in high school baseball players: clinical results and injury risk factors. *Am J Sports Med*. 2004;32:1158-1164.
20. The Data and Story Library. US temperatures. <http://mste.illinois.edu/malcz/DATA/WEATHER/Temperatures.html>. Accessed June 1, 2014.
21. Timmerman LA, Andrews JR. Histology and arthroscopic anatomy of the ulnar collateral ligament of the elbow. *Am J Sports Med*. 1994;22:667-673.
22. Tullos HS, Erwin WD, Woods GW, Wukasch DC, Cooley DA, King JW. Unusual lesions of the pitching arm. *Clin Orthop Relat Res*. 1972;88:169-182.