Change in Grip and Pinch Strength Over the Course of a Game in Professional Baseball Pitchers

Brandon J. Erickson, MD,[†*] Paul Buchheit, ATC,[‡] Joseph Rauch, DPT, ATC,[‡] Michael G. Ciccotti, MD,[§] Ryan Paul, BS,[§] and Steven B. Cohen, MD[§]

Background: Baseball pitching injuries can be related to fatigue. Changes in grip and pinch strength over the course of professional baseball games are unknown.

Hypothesis: Grip and pinch strength will decrease as the number of innings pitched increases; injured pitchers will have a lower grip strength than uninjured pitchers.

Study Design: Prospective cohort study.

Level of Evidence: Level 3.

Methods: Minor league pitchers for 1 affiliate of a single organization were included. Changes in dominant and nondominant grip, and middle and index finger pincer strength were recorded pregame and after each inning, and compared between players who sustained a shoulder/elbow injury and those who did not.

Results: Of 41 pitchers included, 6 sustained a shoulder (n = 2) or elbow (n = 4) injury during the study period. Average grip strength for all pitchers was 124.5 ± 17 lb pregame and increased slightly after the first inning (125.2 ± 17 lb), then declined slowly after the second (120.7 ± 18.5 lb), third (119.2 ± 24 lb), and fourth (113.1 ± 19.6 lb) innings. There was a slight uptick in grip strength in the fifth (118.5 ± 23.6 lb) and sixth (121.3 ± 21.8 lb) innings, but pregame levels were not reached. Evaluating uninjured and injured pitchers, the grip strength of injured pitchers was lower at all timepoints. As a percentage of uninjured pitchers grip strength, injured pitcher grip strength was 94.8% pregame, and 97.9%, 95.4%, 81.8%, 87.7%, 82.3%, and 74.5% after the first to sixth innings, respectively.

Conclusion: Dominant arm grip strength generally declined over the course of a game in professional baseball pitchers. Injured pitchers generally had weaker grip strength and a steeper decline in grip strength during games compared with uninjured pitchers.

Clinical Relevance: Incremental loss of grip strength may increase injury risk in professional baseball pitchers.

Keywords: baseball; elbow; grip strength; pinch strength; pitcher; ulnar collateral ligament (UCL)

From [†]Department of Orthopaedic Surgery, NYU Grossman School of Medicine, Rothman Orthopaedic Institute, New York, New York, [‡]Philadelphia Phillies, Philadelphia, Pennsylvania, and [§]Rothman Orthopaedic Institute, Philadelphia, Pennsylvania

*Address correspondence to Brandon J. Erickson, MD, Rothman Orthopaedic Institute, 645 Madison Ave, New York, NY 10022 (email: berickson@northwell.edu) (Twitter: @EricksonMDOrtho).

The following authors declared potential conflicts of interest: B.J.E. has received consulting fees from DePuy and Arthrex; research support from DePuy, Arthrex, Linvatec, Smith & Nephew, and Stryker; education payments from Arthrex and Smith & Nephew; and nonconsulting fees from Arthrex. S.B.C. has received research support from Arthrex and IncMajor League Baseball; consulting fees from CONMED and Linvatec; royalties from Slack, INC; and IP royalties, consulting, and speaking fees from Zimmer Biomet.

DOI: 10.1177/19417381241305401

Injury rates at all levels of baseball have been on the rise in recent years.[1,2,5,6,8,10,20,21] This has led to a significant amount of time and effort placed into research to better understand potential risk factors for injury. This research has focused on pitch count limits, the number of days of rest needed between appearances, innings limits, optimizing shoulder and elbow range of motion, and many other variables.[9,13,19-21] One area of focus that may play a role in injury, but has not garnered significant attention, is grip and pinch strength. Various types of pitches require different grips with different finger pressure and locations. As with any muscle that is used during competition, as pitchers progress through an outing, they may fatigue the flexor/pronator muscles of the forearm. Furthermore, grip and pinch strength can be a marker for the overall muscular strength and functional status of an athlete, and is currently used as an assessment tool during the National Hockey League Entry Draft Combine.[4,17,22] To date, this has not been used in baseball.

When the flexor/pronator muscles fatigue, it may allow an increase in the amount of stress born by the ulnar collateral ligament (UCL).[15] Hoshika et al[11] performed an excellent ultrasound study on 17 male players, where they used a Telos device to impart a valgus stress on the elbow and measured the amount of medial joint opening with the arm unloaded at rest, with a valgus load (50 N) and under valgus load with the flexor digitorum superficialis (FDS) contracted in individual fingers. As expected, the authors found that the amount of medial joint space opening was higher when the elbow was loaded with a valgus stress. The interesting finding was the amount of medial joint opening was significantly less when the index and middle finger were contracting compared with when the ring finger was contracting, indicating the FDS of the middle and index finger may have a significant role in stabilizing the medial elbow.

Therefore, the purpose of this study was to measure the grip strength as well as pinch strength of the index and middle fingers of professional baseball pitchers before each game, after each inning pitched, and after they were removed from a game to determine whether grip and pinch strength decreases as number of innings pitched increase. The authors hypothesized that grip and pinch strength will decrease incrementally as the number of innings pitched increases.

METHODS

This is a retrospective study of grip strength changes over the course of each game in minor league professional baseball players. All minor league pitchers (starters and relievers) who were members of a single Major League Baseball (MLB) team and were currently pitching in the Dominican Republic league during the 2022 season were included. Data on grip and pincer strength was part of this MLB team's standard data collection so this study was deemed exempt by the institutional review board. Grip strength, as well as middle finger and index finger pincer strength, was recorded by a team athletic trainer for each player before entering a game ("pregame"), after their first inning pitched (post first inning), and after each subsequent inning pitched (second, third, etc). Grip strength was measured using the Jamar Smedley hand dynamometer (Sammons Preston).[18] Pincer strength was measured using the Baseline 12-0201 pinch gauge (Baseline). All grip strength measurements were taken with the player standing, arm at the side, the elbow flexed to 90° and the forearm in neutral rotation. For the pincer measurements, the player was standing with their forearm in full pronation with neutral wrist (in relation to extension/flexion and ulnar/radial deviation) and with the pad of assigned finger (index and middle finger) and pad of thumb flat on gauge. Per the standard of care for the club, measurements were taken once at each interval.

Grip and pincer strengths were then compared between innings and over the course of a player's outing. Data were available for 36 games. Data were collected on all pitchers regardless of the number of innings they pitched, and was recorded accordingly. Injuries were recorded by the athletic training staff over the course of the season and were defined as any injury that caused a player to miss time. For further analysis and comparison, players were then separated into those who sustained a shoulder or elbow injury and those who did not.

Statistics

Players were separated into 2 groups; those with a shoulder or elbow injury and those without. Grip strength and pincer strength data were then compared between groups. Continuous data are presented as means and standard deviations and *t* tests were used to compare grip strength between groups. Statistical significance was defined as $P < .05$.

RESULTS

Overall, 41 pitchers were included in the study, 6 of whom sustained a shoulder (n = 2) or elbow (n = 4) injury during the study period. Average grip strength for all pitchers was 124 lb ± 17 lb pregame and remained essentially the same after the first inning (125 lb ± 17 lb), but then declined slowly thereafter until the fifth and sixth inning. The uptick in the grip strength in the fifth and sixth innings did not reach pregame levels (Table 1 and Figure 1). Index and middle finger pincer strength stayed relatively consistent throughout the course of the game (Table 1, Figures 2 and 3).

When evaluating grip strength between uninjured and injured pitchers, the grip strength of the injured pitchers was lower at all timepoints but this difference did not reach statistical significance (Figure 4 and Table 2). There was no significant difference between index finger (Figures 5 and Table 3) and middle finger (Figures 6 and Table 4) pincer strength over the course of a game in pitchers who sustained an injury and those who did not.

At all timepoints, the grip strength of the injured players was less than that of the noninjured players and declined at a faster rate over the course of the game.

Table 1. Dominant hand grip strength, index finger pincer strength, and middle finger pincer strength for all included players over the course of a game

	Pregame	Post first inning	Post second inning	Post third inning	Post fourth inning	Post fifth inning	Post sixth inning
Grip strength	124.5	125.2	120.7	119.2	113.1	118.5	121.3
Index finger pinch	17.3	17.7	16.9	17.2	17.5	18.9	16.7
Middle finger pinch	17.7	18.3	18.5	18.3	19.3	19.6	18.9

All measurements are given in lb.

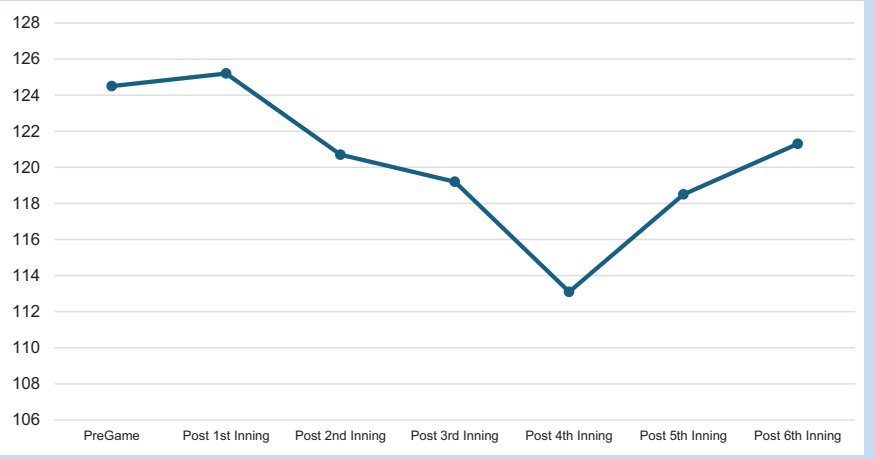

Figure 1. Change in dominant arm grip strength over the course of a game for all players included in this study.

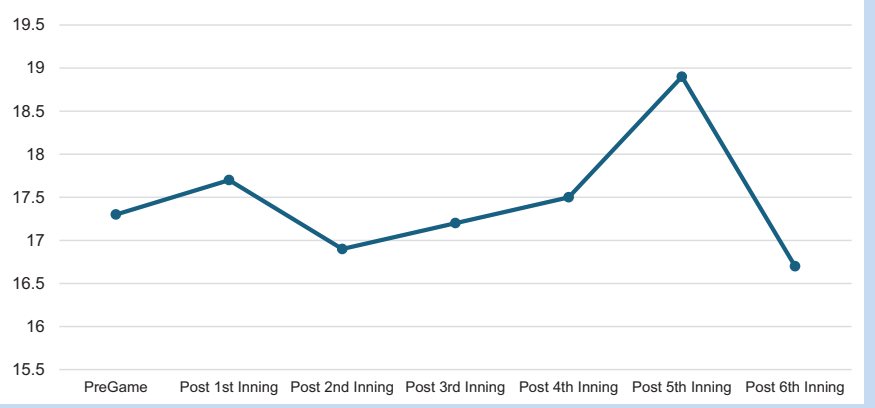

Figure 2. Change in dominant index finger pincer strength over the course of a game for all players included in this study.

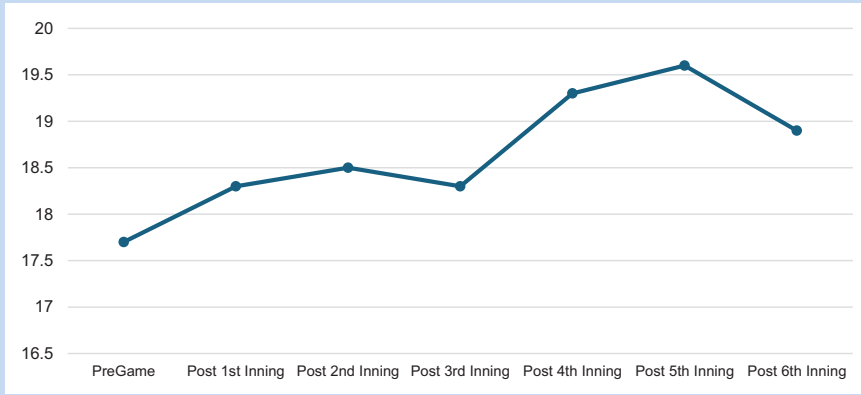

Figure 3. Change in dominant middle finger pincer strength over the course of a game for all players included in this study.

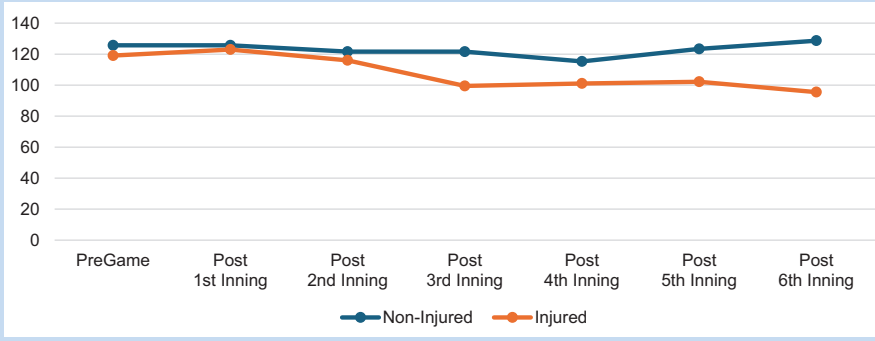

Figure 4. Dominant hand grip strength for injured versus noninjured pitchers over the course of a game.

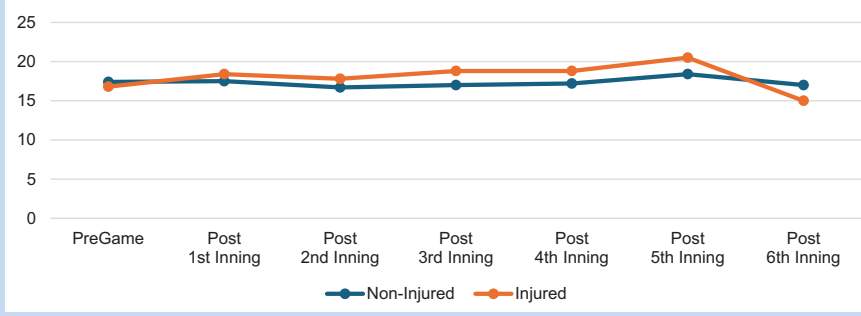

Figure 5. Dominant hand index finger pincer strength for injured versus noninjured pitchers over the course of a game.

DISCUSSION

Injuries of the shoulder and elbow in professional baseball continue to be a major source of concern as players lose the ability to compete for an extended period of time. Many different strategies have been implemented in an effort to decrease injury risk. Flexor pronator weakness/fatigue may lead to increased stress on the medial elbow, which could increase a player's risk for injury. The study hypothesis was partly confirmed as the grip strength for players decreased over the course of the game compared with pregame levels. Furthermore, players who sustained a shoulder or elbow injury

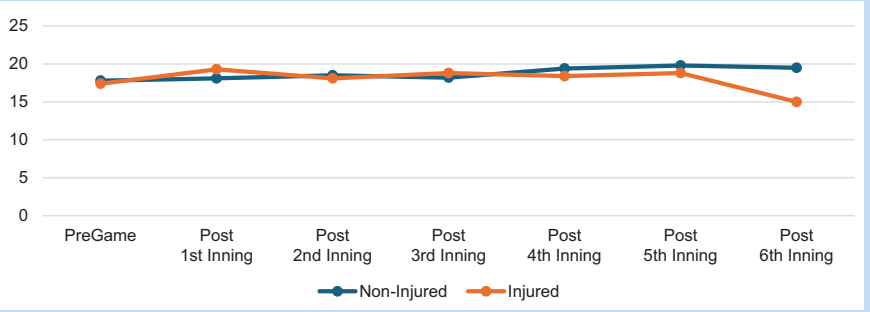

Figure 6. Dominant hand middle finger pincer strength for injured versus noninjured pitchers over the course of a game.

Table 2. Dominant hand grip strength comparison between injured and noninjured pitchers

	Pregame	Post first inning	Post second inning	Post third inning	Post fourth inning	Post fifth inning	Post sixth inning
Noninjured	125.7	125.7	121.6	121.6	115.3	123.4	128.7
Injured	119.1	123	116	99.5	101.1	102.2	95.5
Difference	6.6	2.7	5.6	22.1	14.2	21.2	33.2
P value	.45	.76	.51	.18	.37	.28	N/A
Percentage noninjured	94.80	97.90	95.40	81.80	87.70	82.30	74.20

All measurements are given in lb. N/A, not available.

Table 3. Dominant hand index finger pincer strength comparison between injured and noninjured pitchers

	Pregame	Post first inning	Post second inning	Post third inning	Post fourth inning	Post fifth inning	Post sixth inning
Noninjured	17.4	17.5	16.7	17	17.2	18.4	17
Injured	16.8	18.4	17.8	18.8	18.8	20.5	15
Difference	0.6	–0.9	–1.1	–1.8	–1.6	–2.1	2
P value	.78	.33	.85	.62	.50	.52	N/A
Percentage noninjured	96.60	105.10	106.60	110.60	109.30	111.40	88.20

Pincer strength is provided in lb. The percentage noninjured row is the index pincer strength of the injured players divided by the grip strength of the noninjured players. N/A, not available.

had weaker grip strength compared with players who did not sustain a shoulder or elbow injury, although this difference was not statistically significant.

Several studies have evaluated the anatomy of the medial elbow, which is particularly relevant in throwers. Morrey[14] and Morrey and An et al[15,16] found that the UCL was the primary stabilizer to valgus stress at the elbow, but that the flexor pronator mass was one of the secondary stabilizers of the elbow.[7] Ikezu et al[12] evaluated 56 cadaver elbows and assessed the anterior and posterior bundles of the UCL as well as the common flexor tendon and how this related to the UCL. The authors found that, in almost 50% elbows, the common flexor

Table 4. Dominant hand middle finger pincer strength comparison between injured and noninjured pitchers

	Pregame	Post first inning	Post second inning	Post third inning	Post fourth inning	Post fifth inning	Post sixth inning
Noninjured	17.8	18.1	18.5	18.2	19.4	19.8	19.5
Injured	17.4	19.3	18.1	18.8	18.4	18.8	15
Difference	0.4	–1.2	0.4	–0.6	1	1	4.5
P value	.50	.27	.37	.78	.73	.78	N/A
Percentage noninjured	97.80	106.60	97.80	103.30	94.90	95.00	76.90

Pincer strength is provided in lb. The percentage noninjured row is the grip strength of the injured players divided by the grip strength of the noninjured players. N/A, not available.

tendon was intimately related to, and confluent with, a portion of the UCL and could not be separated, whereas in the other 50% the structures appeared distinctly separate. This indicates the flexor pronator mass likely plays a significant role in medial elbow stability. However, it is unclear whether fatigue of the flexor pronator can lead to increased stress across the UCL and potentially an increased risk for injury. Ciccotti et al[3] performed a cadaveric study to evaluate the contribution of various medial elbow structures, including all portions of the UCL and flexor pronator mass, to medial elbow stability. The authors sectioned structures in different orders and evaluated medial joint gapping. The anterior bundle of the UCL was found to contribute the most medial stability. Interestingly, the posterior bundle of the UCL, transverse bundle of the UCL and the flexor pronator mass all contributed a similar amount of stability. This finding is particularly relevant because this was conducted on cadavers where the flexor pronator was not contracting. It is likely that the contribution of the flexor pronator would increase significantly when the muscle mass is contracting. Only 2 shoulder injuries were seen in this cohort of patients in the current study. It is unclear whether the grip/pincer strength played a role in this as an overall marker for fatigue in the upper extremity. Further work is needed on this subject.

The current study found that grip strength in pitchers generally decreased over the course of a game while middle and index finger pincer strength remained relatively constant. When compared with pitchers who did not sustain a shoulder or elbow injury, pitchers who did sustain an injury saw a steeper decline in dominant hand grip strength throughout the game although this difference was not statistically significant. This finding indicates that the flexor pronator muscles of these injured players may have fatigued faster, and, once fatigued, may not have had the ability to protect the UCL as much as the flexor muscles of the uninjured group. Yanai et al[23] evaluated the amount of maximum voluntary isometric varus strength (MVIVS) that the flexor pronator needed to generate to protect the UCL. They found that the elbow musculature had to produce 21% to 49% MVIVS to avoid acute failure of intact UCL. Hence, if these muscles fatigued to where they could not produce this amount of force, the UCL would be at risk for injury. It is not completely clear why pincer strength did not decrease along with grip strength. Interestingly, the pregame and post first inning grip strength of the injured players was very similar to that of the uninjured pitchers, but, as the game went on, the difference between the 2 groups widened significantly, and by the 6th inning showed a 25% difference between the groups. This difference was not statistically significant but is likely clinically relevant. Further work is needed on a larger scale to see whether there is a way to improve flexor pronator strength and minimize fatigue. The ultimate purpose of future studies will be to see whether there is a critical percent decline in that individual pitcher's grip strength that should alert the team to pull the pitcher from the game to mitigate injury risk.

Limitations

This study was performed over a single season in a minor league affiliate of a single professional baseball organization. As such, the results may not be generalizable to other teams and athletes of various levels of play. Also, the specific of the shoulder and elbow injuries were not available. Isolation of the flexor digitorum superficialis can also be challenging when performing these measurements. This study evaluated innings and not pitch counts, so it is unclear how the number of pitches thrown in each inning impacted the results. Furthermore, there were only a small number of injuries to the shoulder and elbow over the course of the season, so the study was underpowered to determine statistical significance between injured and uninjured pitchers. This research will continue to further investigate this potential relationship.

CONCLUSION

Dominant arm grip strength generally declined over the course of a game in professional baseball pitchers. Injured pitchers generally had weaker grip strength and saw a steeper decline in grip strength during games compared with uninjured pitchers.

ACKNOWLEDGMENT

The authors would like to acknowledge the training staff for the Philadelphia Phillies who recorded and entered all of this data over the last several years. It is because of their hard work, diligence, and attention to detail that this study was possible.

ORCID ID

Brandon J. Erickson https://orcid.org/0000-0003-3238-7839

REFERENCES

1. Camp CL, Dines JS, van der List JP, et al. Summative report on time out of play for Major and Minor League Baseball: an analysis of 49,955 injuries from 2011 through 2016. *Am J Sports Med*. 2018;46(7):1727-1732.
2. Chalmers PN, Erickson BJ, Ball B, Romeo AA, Verma NN. Fastball pitch velocity helps predict ulnar collateral ligament reconstruction in Major League Baseball pitchers. *Am J Sports Med*. 2016;44(8):2130-2135.
3. Ciccotti MC, Hammoud S, Dodson CC, Cohen SB, Nazarian LN, Ciccotti MG. Stress ultrasound evaluation of medial elbow instability in a cadaveric model. *Am J Sports Med*. 2014;42(10):2463-2469.
4. De Smet L, Vercammen A. Grip strength in children. *J Pediatr Orthop B*. 2001;10(4):352-354.
5. Erickson BJ, Chalmers PN, Axe MJ, Romeo AA. Exceeding pitch count recommendations in Little League Baseball increases the chance of requiring Tommy John surgery as a professional baseball pitcher. *Orthop J Sports Med*. 2017;5(3):2325967117695085.
6. Erickson BJ, Cvetanovich GL, Bach BR Jr, Bush-Joseph CA, Verma NN, Romeo AA. Should we limit innings pitched after ulnar collateral ligament reconstruction in Major League Baseball pitchers? *Am J Sports Med*. 2016;44(9):2210-2213.
7. Erickson BJ, Romeo AA. The ulnar collateral ligament injury: evaluation and treatment. *J Bone Joint Surg Am*. 2017;99(1):76-86.
8. Erickson BJ, Sgori T, Chalmers PN, et al. The impact of fatigue on baseball pitching mechanics in adolescent male pitchers. *Arthroscopy*. 2016;32(5):762-771.
9. Fleisig GS, Andrews JR. Prevention of elbow injuries in youth baseball pitchers. *Sports Health*. 2012;4(5):419-424.
10. 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(2):253-257.
11. Hoshika S, Nimura A, Takahashi N, Sugaya H, Akita K. Valgus stability is enhanced by flexor digitorum superficialis muscle contraction of the index and middle fingers. *J Orthop Surg Res*. 2020;15(1):121.
12. Ikezu M, Edama M, Matsuzawa K, et al. Morphological features of the ulnar collateral ligament of the elbow and common tendon of flexor-pronator muscles. *Orthop J Sports Med*. 2020;8(9):2325967120952415.
13. Marsh JA, Wagshol MI, Boddy KJ, et al. Effects of a six-week weighted-implement throwing program on baseball pitching velocity, kinematics, arm stress, and arm range of motion. *PeerJ*. 2018;6:e6003.
14. Morrey BF. Applied anatomy and biomechanics of the elbow joint. *Instr Course Lect*. 1986;35:59-68.
15. Morrey BF, An KN. Articular and ligamentous contributions to the stability of the elbow joint. *Am J Sports Med*. 1983;11(5):315-319.
16. Morrey BF, An KN. Functional anatomy of the ligaments of the elbow. *Clin Orthop Relat Res*. 1985(201):84-90.
17. Nightingale SC, Miller S, Turner A. The usefulness and reliability of fitness testing protocols for ice hockey players: a literature review. *J Strength Cond Res*. 2013;27(6):1742-1748.
18. Toong T, Wilson KE, Urban K, et al. Grip strength in youth ice hockey players: normative values and predictors of performance. *J Strength Cond Res*. 2018;32(12):3494-3502.
19. Wilk KE, Arrigo CA, Andrews JR. Current concepts: the stabilizing structures of the glenohumeral joint. *J Orthop Sports Phys Ther*. 1997;25(6):364-379.
20. Wilk KE, Macrina LC, Fleisig GS, et al. Deficits in glenohumeral passive range of motion increase risk of elbow injury in professional baseball pitchers: a prospective study. *Am J Sports Med*. 2014;42(9):2075-2081.
21. Wilk KE, Macrina LC, Fleisig GS, et al. Deficits in glenohumeral passive range of motion increase risk of shoulder injury in professional baseball pitchers: a prospective study. *Am J Sports Med*. 2015;43(10):2379-2385.
22. Wind AE, Takken T, Helders PJ, Engelbert RH. Is grip strength a predictor for total muscle strength in healthy children, adolescents, and young adults? *Eur J Pediatr*. 2010;169(3):281-287.
23. Yanai T, Onuma K, Crotin RL, Monda D. A novel method intersecting three-dimensional motion capture and medial elbow strength dynamometry to assess elbow injury risk in baseball pitchers. *Sci Rep*. 2023;13(1):12253.