IJSPT

ORIGINAL RESEARCH

NO DIFFERENCES IN HIP RANGE OF MOTION EXISTS BETWEEN BASEBALL PLAYERS WITH AN ULNAR COLLATERAL LIGAMENT TEAR AND HEALTHY BASEBALL PLAYERS

J. Craig Garrison, PhD, PT, ATC, SCS[1]
Joseph Hannon, PT, DPT, PhD, SCS[1]
John Conway, MD[2]

ABSTRACT

Background and Purpose: Restrictions in hip rotational motion of the baseball athlete can alter throwing mechanics in a manner that is inefficient and increases risk of injury. The purpose of this study was to assess for differences in hip external rotation (ER) and internal rotation (IR) range of motion (ROM) between baseball players with an ulnar collateral ligament (UCL) tear and healthy baseball players.

Design: Case-control

Methods: Eighty-seven baseball players with a UCL tear (UCL) were compared with 87 age, experience, and position-matched healthy baseball players (CONT). UCL were enrolled at the initial visit to the outpatient sports medicine facility while CONT were measured before their baseball season. Passive hip ROM (ER and IR) of the stance and lead limbs was measured in the prone position using a bubble goniometer. Hip total range of motion (TRM) was calculated by adding ER and IR of each limb. Independent t-tests were run to compare mean group differences for hip ROM ($p < 0.05$).

Results: No differences between groups were discovered for hip ER on the stance (UCL = $33.9^\circ \pm 9.9^\circ$, CONT = $34.3^\circ \pm 10.6^\circ$, $p = 0.8$) or lead (UCL = $32.9^\circ \pm 9.9^\circ$, CONT = $34.4^\circ \pm 10.0^\circ$, $p = 0.3$) limbs. Similarly, there were no group differences in hip IR on the stance (UCL = $30.6^\circ \pm 10.5^\circ$, CONT = $29.6^\circ \pm 9.5^\circ$, $p = 0.5$) or lead (UCL = $33.5^\circ \pm 17.5^\circ$, CONT = $29.5^\circ \pm 9.0^\circ$, $p = 0.1$) limbs. The groups were also similar in hip TRM on the stance (UCL = $64.5^\circ \pm 13.7^\circ$, CONT = $64.0^\circ \pm 17.2^\circ$, $p = 0.8$) and lead (UCL = $66.4^\circ \pm 17.4^\circ$, CONT = $63.9^\circ \pm 15.6^\circ$, $p = 0.3$) limbs.

Conclusions: When measured in the prone position, hip passive ROM is not different between baseball players with a UCL tear compared to a matched healthy cohort.

Keywords: baseball, hip ROM, ulnar collateral ligament.

Level of Evidence: Level 3

[1] Texas Health Sports Medicine, Fort Worth, TX, USA
[2] Orthopedic Specialty Associates, Texas Health Sports Medicine, Fort Worth, TX, USA

Acknowledgements: The authors would like to thank the Texas Health Sports Medicine staff and research coordinators for their assistance in data collection.

No outside funding was received for this work and no conflicts of interest exist.

CORRESPONDING AUTHOR
J. Craig Garrison, PhD, PT, ATC, SCS
Texas Health Sports Medicine
800 5th Avenue, Suite 150
Fort Worth, TX 76104
T: 817-250-7515
F: 817-250-7501
E-mail: craiggarrison@texashealth.org

INTRODUCTION

The overhead throwing motion is a dynamic activity that requires interaction of sequential moving parts of the upper and lower extremity. Integration of the kinetic chain allows for energy to be created in the lower limbs and transferred through the core and spine to the throwing arm.[1] The hip joint serves as a critical link between the lower and upper extremities and helps to position the lead limb at stride foot contact during the throwing motion. Rotational motion (internal rotation = IR, external rotation = ER) at the hips during throwing is critical for energy transfer and when analyzed in combination with separation of rotation of the hips and shoulders has been shown to increase ball velocity in youth and adolescent pitchers.[2] Conversely, if hip rotational motion is restricted in either the stance (limb on same side of throwing arm) or lead (limb on opposite side of throwing arm) limb, throwing mechanics could be altered in a manner that is inefficient and increases risk of injury.[3-7]

Clinical assessment of hip rotational motion has been studied in youth,[5-8] college,[4,9] and professional[3,10-16] baseball players with varying results. Youth baseball players demonstrate greater hip IR and total rotational motion (TRM) in younger (7-11 years) athletes when compared to the older (12-18 years) youth.[17]Additionally, healthy youth baseball pitchers (11.3 ± 1.0 years) have no significant differences in TRM between sides (stance and lead limbs).[6] Decreased hip IR (hip flexed to 90°) of the stance and lead limbs was found in youth baseball players (12.0 ± 1.9 years) who had experienced elbow pain when compared to those who had no elbow pain.[7] At the collegiate level, pitchers (20.0 ± 1.4 years) were found to have no significant hip rotational motion differences between the stance or stride limbs.[18] College baseball pitchers (19.4 ± 1.4 y/o) who were measured before the season and then again at the conclusion of the season were found to have reductions in the lead and trail (stance) limb hip ER as well as lead and trail (stance) limb TRM.[9] Although these results hint at the fact that adaptive changes at the hip may occur across the course of a collegiate baseball season, they were not associated with the overall pitching workload of these athletes. Finally, in professional baseball players, hip rotational motion (IR and ER) is similar at the beginning of the season;[3,11,13] however, deficits in rotational motion at the hip (stance or lead limbs) were found to be correlated with faulty pitching biomechanics.[15] Specifically, the loss of hip IR in the stance and lead limbs is associated with injuries to the hip, groin, abdominal, hamstring, and back injuries at the professional level.[10,12] The results of the aforementioned studies suggest that alterations in hip rotational motion may occur across the developmental stages of baseball players peaking at the professional level.

The majority of the previous studies examining hip rotational motion in baseball players have been performed in a healthy population. While these studies have tried to establish a link between deficits in or loss of hip rotational motion as a causative factor for injury to the throwing arm, currently there is little evidence exploring this relationship within the literature. Additionally, those studies that have demonstrated a relationship between hip rotational motion and injury seem to point toward a loss of hip IR as the associated factor with injury at both the youth[7] and professional level.[10,12] With the dramatic increase in the number of injuries to the ulnar collateral ligament (UCL) in baseball players across the age spectrum,[19-21] there is a heightened awareness of the need to identify risk factors that may predispose these individuals to injury. Likewise, the development of the breakdown of the UCL may surface at the professional level, but more than likely originates with the increased workload that begins to accumulate during the years of playing youth baseball.[22,23] Therefore, the purpose of this study was to assess for differences in hip external rotation (ER) and internal rotation (IR) range of motion (ROM) between adolescent baseball players with an ulnar collateral ligament (UCL) tear and age-, position- and experience-matched healthy baseball players.

METHODS

Participants

This was a retrospective case-control study; the Institutional Review Board of Texas Health Resources approved the research procedures. A total of 174 male competitive high school and collegiate baseball players volunteered to participate in this study from 2013 to 2015 during a 23-month timeframe. Eighty-seven baseball players with a UCL tear (UCL group;

17.7 ± 2.0 y/o, Ht = 183.5 ± 6.7 cm, Wt = 85.1 ± 10.2 kg) were compared with 87 age, experience, and position-matched healthy baseball players (CONT group; 18.6 ± 1.9 y/o, Ht = 185.3 ± 6.6 cm, Wt = 85.7 ± 8.5 kg).

Participants were identified during regularly scheduled visits to the participating physician and/or physical therapist. Inclusion criteria for the UCL group included the following: (1) a baseball player between the ages of 14 and 23 y/o, (2) the athlete's ability to throw was affected by the injury, (3) the athlete was unable to continue participating in baseball at the level he did before UCL tear, (4) clinical examination results were positive for a primary UCL tear diagnosed by a fellowship-trained, board certified orthopedic surgeon, (5) there was confirmation of a UCL diagnosis via MRI, and (6) the athlete was attempting to return to sport at a competitive level. Exclusion criteria were (1) a previous UCL reconstruction that failed, (2) a previous shoulder surgery for labral or rotator cuff involvement, and (3) if the patient did not plan to return to baseball after treatment. The same exclusion criteria were applied to the control participants. Participants were enrolled and consented into the study by an investigator in the outpatient sports medicine facility once they were confirmed to meet the inclusion and exclusion criteria (Figure 1).

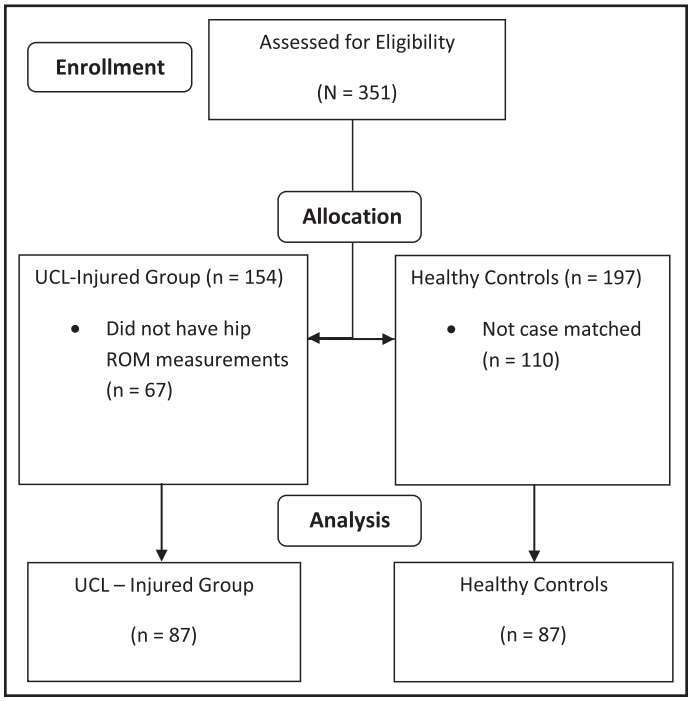

Figure 1. *Flow Diagram for Allocation of Healthy Controls vs. UCL-Injured.*

Measurements of Passive Range of Motion

Hip ROM testing was performed at the UCL participant's initial visit to the outpatient sports medicine center. All control participants were measured either before their fall or spring baseball seasons using the same methods as the UCL group. Measurements were taken by two physical therapists who had undergone training and demonstrated excellent reliability for hip ER (intraclass correlation coefficient [24] 2,k = 0.94; standard error of the mean = 2.6) and hip IR (intraclass correlation coefficient [24] 2,k = 0.98; standard error of the mean = 3.8). Passive hip ER and IR of the stance (limb on same side of throwing arm) and lead (limb on opposite side of throwing arm) limbs were measured using a standard goniometer fitted with a bubble level attachment (Figure 2). The participant was positioned in a prone position and stabilized with a belt around the

Figure 2. *Hip internal rotation range of motion measurement.*

hips while the investigator passively moved the limb until end range was noticed by an abrupt end feel or movement was elicited at the sacroiliac joint.

Main Outcomes Measures

Mean passive hip ER and IR ROM of both the stance and lead limbs was calculated and compared between groups. Hip total range of motion (TRM) was calculated by adding ER and IR of each limb and for each group.

Statistical Analysis

A priori statistical power analysis was performed using hip IR motion as the primary outcome, and it was determined that a total of 80 participants (40 in the control group and 40 in the UCL group) would be needed to detect statistically significant differences based on an 80% power calculation. Independent t-tests were computed to compare mean group differences for hip ROM.

RESULTS

Table 1 highlights the descriptive demographic characteristics of the participants. There was a slight difference for age ($p = 0.007$), but no differences for height ($p = 0.079$), weight ($p = 0.643$), or years of experience ($p = 0.061$) between groups. Eighty-three percent of the participants were right hand dominant in both groups, while 68.9% were pitchers in the UCL group and 54.0% were pitchers in the healthy group.

No differences between groups were detected for hip ER on the stance (UCL = $33.9^\circ \pm 9.9^\circ$, CONT = $34.3^\circ \pm 10.6^\circ$, $p = 0.77$) or lead (UCL = $32.9^\circ \pm 9.9^\circ$, CONT = $34.4^\circ \pm 10.0^\circ$, $p = 0.31$) limbs. Similarly, there were no group differences in hip IR on the stance (UCL = $30.6^\circ \pm 10.5^\circ$, CONT = $29.6^\circ \pm 9.5^\circ$, $p = 0.53$) or lead (UCL = $33.5^\circ \pm 17.5^\circ$, CONT = $29.5^\circ \pm 9.0^\circ$, $p = 0.06$) limbs. The groups were also similar in hip TRM on the stance (UCL = $64.5^\circ \pm 13.7^\circ$, CONT = $64.0^\circ \pm 17.2^\circ$, $p = 0.83$) and lead (UCL = $66.4^\circ \pm 17.4^\circ$, CONT = $63.9^\circ \pm 15.6^\circ$, $p = 0.33$) limbs (Table 2).

DISCUSSION

Adolescent baseball players with a UCL tear do not demonstrate differences in hip rotational motion in either the stance or lead limbs when compared to a matched, healthy cohort. The hip joint has been shown to be the primary source of movement for trunk twisting or rotation,[25] which is necessary to achieve optimal positioning for the trunk and pelvis during the throwing motion.[26] Inadequate mobility in the hips of a baseball player may limit the transfer of energy to the upper extremity and consequently predispose the athlete to alterations in the throwing motion and subsequent risk of injury.[3-7] The similarities between both hip IR and ER motions between limbs and across groups in the present study suggest that the available ROM needed for this population of baseball players may not help to differentiate those with and without injury to the UCL when measured in a prone position.

The findings of the current study are similar to previous hip rotational motion data in healthy youth baseball players when measured in the prone position.[8,17,27] When 44 healthy adolescent baseball players were measured for hip ROM, the lead (IR = $32.0 \pm 8.9^\circ$, ER = $30.3 \pm 6.1^\circ$, TRM = $62.1 \pm 7.5^\circ$) and stance (IR = $30.6 \pm 6.2^\circ$, ER = $30.0 \pm 7.4^\circ$, TRM = $60.4 \pm 6.8^\circ$) limbs were comparable to values in the present study.[17] Additionally, between limb hip rotational ROM symmetry was very similar in the adolescent healthy group when compared to the current findings in the UCL group.[17] In the same way, hip ROM has previously been studied in relation to glenohumeral ROM and overall pitch volume in youth baseball pitchers, showing hip ROM values that are similar to the ones

Table 1. *Participant Demographics.*

	UCL (n=87)	Control (n=87)	p-value
Age (yrs)	17.7±2.0	18.6±1.9	p = 0.01
Years of Experience	13.0±3.1	13.7±2.0	p = 0.06
Height (cm)	183.4±6.8	185.3±6.5	p = 0.08
Weight (kg)	85.1±10.2	85.8±8.5	p = 0.64

Table 2. *Participant Hip ROM Means and Standard Deviations between Groups.*

	UCL (n=87)	Control (n=87)	p-value
Hip ER ROM (Stance)	33.9±9.9°	34.3±10.6°	p = 0.77
Hip ER ROM (Lead)	32.9±9.9°	34.4±10.0	p = 0.31
Hip IR ROM (Stance)	30.6±10.5°	29.6±9.5°	p = 0.53
Hip IR ROM (Lead)	33.5±17.5°	29.5±9.0°	p = 0.06
Hip TRM (Stance)	64.5±13.7°	64.0±17.2°	p = 0.83
Hip TRM (Lead)	66.4±17.4°	63.9±15.6°	p = 0.33

* ER = external rotation; IR = internal rotation; ROM = range of motion; UCL = ulnar collateral ligament; Stance = limb on same side of throwing arm; Lead = limb on opposite side of throwing arm

** Significance set at $p<0.05$

presented in the current study on both the lead and stance limbs.[27] Although some significant relationships across the variables were found, further study is required to determine the clinical relevance. While the age of these baseball players in these earlier studies[17,27] was slightly younger (15.4 ± 2.1 and 13.9 ± 2.9 y/o) than those individuals in the existing investigation, equivalent measurement techniques (prone) were used. Differences in hip IR ROM have been demonstrated between preadolescent (9.9 ± 15 y) and adolescent (15.1 ± 1.3 y) baseball players with the younger athletes exhibiting significantly greater ROM on both the dominant (preadolescent = 40.81°, adolescent = 33.09°) and nondominant (preadolescent = 38.37°, adolescent = 34.35°) limbs.[8] While the adolescent hip IR ROM values of Beckett et al.[8] study were similar to the values in the present study, hip ER ROM was greater across both groups and on both limbs (preadolescent_dominant = 37.65°, adolescent_dominant = 38.54°; preadolescent_nondominant = 38.70°, adolescent_nondominant = 38.85°). The results of these earlier studies[8,17,27] in combination with the current findings imply that when measured in the prone position, youth baseball players have similar hip ROM on both the stance and leads limbs and hip ROM may not necessarily be associated with upper extremity injury.

In contrast, previous work has found a relationship between deficits in hip ROM and elbow pain in adolescent baseball players.[7] One hundred twenty-two adolescent baseball players were measured for hip ROM in a supine position with the hip flexed to 90°. Those who reported elbow pain at time of assessment or during the previous month while throwing demonstrated a decrease in hip IR in both the lead and stance limbs when compared to the no elbow pain group. The differences in findings between the Saito et al.[7] study and the current study could be attributed to the measurement technique of IR at 90° of hip flexion and the overall younger mean age of the individuals (12.0 y/o versus 17.8 y/o). When these same participants[7] were measured in prone, there were no differences in hip ROM between the pain and no pain groups, similar to the current findings of this paper. When measured in a seated position, youth baseball pitchers (11.3 ± 1.0 y/o) demonstrated greater hip ER on the lead limb with greater hip IR ROM on the stance limb.[6] Similarly, stance limb hip IR ROM (seated) increases as throwing arm scapular posterior tilting decreases at maximal humeral ER in youth baseball pitchers following a simulated game pitching protocol.[28] The results from these studies suggest that position of the hip during measurements may play a role in identifying those who may be at risk for throwing arm elbow pain and positioning of the hip in a flexion may alter the available hip ROM, thus producing different values. Additionally, the lack of hip mobility in the seated position could be attributed

to osseous (femoroacetabular impingement) and/or soft tissue changes.[7,29] Previous analyses have established a relationship between high-level sports participation (hockey, basketball, and soccer) in males and osseous changes at the femoral head-neck junction;[30] however, these bony changes have not been identified in the baseball athlete and further investigation is warranted.

The current study presents with certain limitations that need to be considered. Hip ROM measurements were only captured with the participant in the prone position. As documented earlier, the position in which hip IR and ER ROM is measured may influence both values and the ability to identify potential relationships within the kinetic chain that may be associated with upper extremity injury.[1,6,7,10] Throwing volume at time of hip ROM measurements were not controlled for during data collection which could affect the available mobility of the hip. While enrollment into the study occurred at time of injury for the UCL group, and prior to either the fall or spring baseball season for the healthy group, throwing volume was not captured. Finally, the current study population consisted of high school and college age baseball players, thus the findings of this study may not be extrapolated to the professional or little league baseball player.

CONCLUSION

The results of the current study indicate that passive hip rotational ROM does not differ between adolescent baseball players with an elbow UCL tear and a group of healthy controls when measured in the prone position. Although hip rotational ROM is thought to be related to throwing mechanics and possibly with upper extremity injuries in baseball players, the results from the current study suggest that hip ROM is similar between UCL injured and uninjured baseball athletes in this sample. The manner in which the available hip ROM is utilized may play a role in differentiating between groups.

REFERENCES

1. Chu S, Jayabalan P, Kibler W, et al. The kinetic chain revisited: New concepts on throwing mechanics and injury. *PM&R.* 2016;8(3):S69-S77.
2. Sgroi T, Chalmers P, Riff A, et al. Predictors of throwing velocity in youth and adolescent pitchers. *J Shoulder Elbow Surg.* 2015;24(9):1339-1345.
3. Laudner K, Moore S, Sipes R, et al. Functional hip characteristics of baseball pitchers and position players. *Am J Sports Med.* 2010;38(2):383-387.
4. Laudner K, Wong R, Onuki T, et al. The relationship between clinically measured hip rotational motion and shoulder biomechanics during the pitching motion. *J Sci Med Sport.* 2015;18(5):581-584.
5. Holt T, Oliver G. Hip and upper extremity kinematics in youth baseball pitchers. *J Sports Sci.* 2016;34(9):856-861.
6. Oliver G, Weimar W. Hip and shoulder range of motion in youth baseball pitchers. *J Strength Cond Res.* 2016;30(10):2823-2827.
7. Saito M, Kenmoku T, Kameyama K, et al. Relationship between tightness of the hip joint and elbow pain in adolescent baseball players. *Orthop J Sports Med.* 2014;2(5):2325967114532424.
8. Beckett M, Hannon M, Ropiak C, et al. Clinical assessment of scapula and hip joint function in preadolescent and adolescent baseball players. *Am J Sports Med.* 2014;42(10):2502-2509.
9. Zeppieri Jr G, Lentz T, Moser M, et al. Changes in hip range of motion and strength in collegiate baseball pitchers over the course of a competitive season: a pilot study. *Int J Sports Phys Ther.* 2015;10(4):505-513.
10. Li X, Ma R, Zhou H, et al. Evaluation of hip internal and external rotation range of motion as an injury risk factor for hip, abdominal and groin injuries in professional baseball players. *Orthop Rev.* 2015;7(4):111-115.
11. Sauers E, Huxel Bliven K, Johnson M, et al. Hip and glenohumeral rotational range of motion in healthy professional baseball pitchers and position players. *Am J Sports Med.* 2014;42(2):430-436.
12. Camp CL, Spiker AM, Zajac JM, et al. Decreased hip internal rotation increases the risk of back and abdominal muscle injuries in professional baseball players: Analysis of 258 player-seasons. *J Am Acad Orthop Surg.* 2018;26(9):e198-e206.
13. Camp CL, Zajac JM, Pearson D, et al. The impact of workload on the evolution of hip internal and external rotation in professional baseball players over the course of the season. *Orthop J Sports Med.* 2018;6(2):DOI: 10.1177/2325967117752105.
14. McCulloch P, Patel J, Ramkumar P, et al. Asymmetric hip rotation in professional baseball pitchers. *Orthop J Sports Med.* 2014;2(2):DOI: 10.1177/2325967114521575.
15. Robb A, Fleisig G, Wilk K, et al. Passive ranges of motion of the hips and their relationship with pitching biomechanics and ball velocity in

professional baseball pitchers. *Am J Sports Med.* 2010;38(12):2487-2493.

16. Scher S, Anderson K, Weber N, et al. Associations among hip and shoulder range of motion and shoulder injury in professional baseball players. *J Athl Train.* 2010;45(2):191-197.
17. Picha KJ, Harding JL, Bliven KCH. Glenohumeral and hip range-of-motion and strength measures in youth baseball athletes. *J Athl Train.* 2016;51(6):466-473.
18. Cheatham SW, Shimamura KK, Kolber MJ. Differences in hip range of motion among collegiate pitchers when compared to youth and professional baseball pitcher data. *J Can Chiropr Assoc.* 2016;60(3):233-240.
19. Camp CL, Conte S, D'Angelo J, et al. Epidemiology of ulnar collateral ligament reconstruction in Major and Minor League Baseball pitchers: comprehensive report of 1429 cases. *J Shoulder Elbow Surg.* 2018;27(5):871-878.
20. Conte SA, Fleisig GS, Dines JS, et al. Prevalence of ulnar collateral ligament surgery in professional baseball players. *Am J Sports Med.* 2015;43(7):1764-1769.
21. Rothermich MA, Conte SA, Aune KT, et al. Incidence of elbow ulnar collateral ligament surgery in collegiate baseball players. *Orthop J Sports Med.* 2018;6(4):doi: 10.1177/2325967118764657.
22. Bruce JR, Hess R, Joyner P, et al. How much valgus instability can be expected with ulnar collateral ligament (UCL) injuries? A review of 273 baseball players with UCL injuries. *J Shoulder Elbow Surg.* 2014;23(10):1521-1526.
23. Ellenbecker TS, Mattalino AJ, Elam EA, et al. Medial elbow joint laxity in professional baseball pitchers. *Am J Sports Med.* 1998;26(3):420-424.
24. Della Villa S, Boldrini L, Ricci M, et al. Clinical outcomes and return-to-sports participation of 50 soccer players after anterior cruciate ligament reconstruction through a sport-specific rehabilitation protocol. *Sports Health.* 2012;4(1):17-24.
25. Lee RY, Wong TK. Relationship between the movements of the lumbar spine and hip. *Hum Mov Sci.* 2002;21(4):481-494.
26. Stodden DF, Fleisig GS, McLean SP, et al. Relationship of pelvis and upper torso kinematics to pitched baseball velocity. *J App Biomech.* 2001;17(2):164-172.
27. Harding JL, Picha KJ, Bliven KCH. Pitch volume and glenohumeral and hip motion and strength in youth baseball pitchers. *J Athl Train.* 2018;53(1):60-65.
28. Oliver GD, Weimar W. Hip range of motion and scapula position in youth baseball pitching pre and post simulated game. *J Sports Sci.* 2015;33(14):1447-1453.
29. Siebenrock KA, Behning A, Mamisch TC, et al. Growth plate alteration precedes cam-type deformity in elite basketball players. *Clin Orthop Relat Res.* 2013;471(4):1084-1091.
30. Nepple JJ, Vigdorchik JM, Clohisy JC. What is the association between sports participation and the development of proximal femoral cam deformity? A systematic review and meta-analysis. *Am J Sports Med.* 2015;43(11):2833-2840.