Changes in anterior glenohumeral joint instability throughout a competitive season and relationships of changes in clinical assessments and tissue adaptations

1. Project Description

Baseball pitchers experience a significant load to their upper extremity while pitching. Subsequently, the throwing arm is vulnerable to acute or chronic injuries, such as muscle strains, biceps tendinopathy, labrum tear, internal impingement, and ligament sprains like the ulnar collateral ligament (UCL) of the elbow. To mitigate those injuries, it is paramount to understand throwing mechanics and the associated tissue adaptations. In the past, glenohumeral internal rotation deficit (GIRD) was one of the most common adaptations that clinicians observed at the shoulder.[1] However, recent studies revealed that the presentation of increased external rotation (ER) and decreased internal rotation (IR) is common due to a bony adaptation of their humerus caused by repetitive overhead throwing at a young age.[2,3] This humeral adaptation is referred to as humeral retroversion (HRV).

Although HRV and glenohumeral range of motion (ROM) are common adaptations in baseball pitchers, posterior capsule thickness (PCT) and anterior glenohumeral joint instability (AGI) are also unique characteristics in overhead throwing athletes.[1,4,5,6] PCT and stiffness can affect the throwing shoulder by limiting glenohumeral IR, and therefore altering the arthrokinematics of the shoulder during late cocking and follow-through.[5] This adaptation likely occurs because of repetitive eccentric stress of the posterior shoulder during the deceleration/follow-through phases of pitching.[1] On the other hand, rapid cocking of the throwing arm causes excessive glenohumeral ER, which allows potential higher ball velocity but also leads to overstretching of the anterior shoulder capsule/ligaments and places valgus stress in the medial elbow. As a result, baseball pitchers present with AIG and greater humeroulnar joint gapping, which can lead to ER gain and ultimately posterior impingement of the humeral head and UCL injury due to repetitive and excessive valgus stress.[1,7]

The adaptations of the throwing shoulder and elbow have been previously studied however, previous research have not integrated these assessments with pitching biomechanics. Understanding tissue adaptations in conjunction with throwing mechanics has a potential to mitigate upper extremity injuries and optimize clinical management of the throwing arm. Additionally, there is a gap between baseball research and features of AGI, compared with features of UCL, HRV, and PCT. Therefore, we propose the following aims:

- Aim 1: To investigate if AGI increase in collegiate baseball pitchers after a competitive season
- Aim 2: To examine relationships of changes in clinical assessments and tissue adaptations
- Aim 3: To explore relationships between tissue adaptations and pitching biomechanics

We hypothesize that AGI increase after a competitive season compared with pre-season measurement. Also, we hypothesize 1) greater changes in shoulder ER ROM are positively correlated with AGI changes, 2) greater changes of shoulder IR ROM are negatively correlated with PCT, and 3) greater changes in shoulder ER strength are negatively correlated with PCT. Finally, we hypothesize that AGI and HR are positively related with maximal shoulder ER and peak elbow valgus torque while pitching in pitching biomechanical evaluation.

2. Methodology

The research design will be a longitudinal study for clinical and tissue adaptation evaluations, and pitching biomechanics will be evaluated before the competitive season as one session. Clinical assessments include shoulder ER as well as IR ROM and strength assessments. Fifteen local collegiate baseball pitchers will be recruited by convenience sampling for this study. Inclusion criteria are 1) signing the consent form, being healthy or cleared by a physician, and 3) participating in an organized baseball team at the college level (age ≥18 years) as a pitcher. Exclusion criteria are 1) having not been cleared by a physician due to any injury, 2) being symptomatic with the throwing upper extremity at the first assessment time, or 3) having a history of shoulder dislocation with the throwing arm.

2.A. Subject demographics and patient-administered questionnaire

Participants will first answer a custom questionnaire, including age, date of birth, weight, height, hand dominance, and upper extremity injury before clinical assessments. We will use the Kerlan-Jobe Orthopedic Clinic Overhead Athlete Shoulder and Elbow score (KJOC) for the patient-administered questionnaire, which has been used as a valid and reliable tool, to assess overhead athletes' upper extremity function.[8] KJOC will be utilized before and after the competitive season.

2.B. Clinical assessments

The "Measure" app of an iPhone will be utilized for ROM assessments. A participant will be on their spine with the measuring shoulder at 90° abduction and 0° of horizontal abduction/adduction with 90° elbow flexion on a table. One clinician stabilizes the scapula while rotating the glenohumeral joint externally. Once the clinician identifies the end-feel, another clinician applies the iPhone on the proximal ulna to measure the angle. As for IR, the clinician who stabilizes the anterior shoulder rotates the joint internally until the end-feel. Once the end-feel is recognized, the measuring clinicians applies the iPhone on the proximal ulna for measurement. Regarding shoulder strength, ArmCare strength sensor (Figure 1) will be used to measure shoulder strength of ER and IR. The strength assessments will be implemented before, throughout, and after the season. Because the strength assessment tool is self-administered, participants will be guided on how to use during the first assessment. To confirm there is no compensation by any body movements, pre-season and post-season evaluations will be monitored by an investigator.

2.C. Tissue adaptation assessment

HRV, PCT, AGI, and UCL will be measured by ultrasonography.[2,4,5,9,10] We will use a Diagnostic Ultrasound (DUS) (ACUSON Redwood Ultrasound System, Siemens Healthineers USA, WA). HRV and AGI will require 2 clinicians to complete measurements. Briefly, a participant lays on a table on their spine, and the examining shoulder is abducted at 90° and the elbow flexed at 90°. One clinician applies a transducer on the anterior shoulder and identify an image of the greater tubercle, lesser tubercle, and the bicipital groove. Once the landmarks are visualized, another clinician rotates the glenohumeral joint internally until the greater and lesser tubercles appear to be in parallel, and the degrees of the internal rotation will be measured by using a measure app and applying an iPhone on the proximal ulna. The measurement will be performed twice to obtain the average bilaterally. Regarding AGI, the LigMaster™ system, which is based on the Telos GA – II/E stress device, will be utilized to apply a consistent force to the proximal humerus while assessing AGI by ultrasonography and measure the distance drawn 2 parallel lines along the posterior edge of glenoid and the humeral head. Regarding PCT, a participant sits upright on a table and rests the measuring shoulder at 0º of shoulder abduction without a tension on the posterior shoulder. A transducer will be applied just under the spine of the scapula and slide laterally until the posterior capsule is visualized. Each of HRV, PCT, and AGI measurements will be reliable by referring methods of previous studies and establishing test-retest reliability as preliminary study. Therefore, average of 2 measurements will be utilized for actual assessments in each aim. As for the UCL measurements, anterior UCL length, joint space, and UCL thickness under 2 different conditions; with and without valgus loading. The UCL will be measured from the peak of the humeral trochlea to the sublime tubercle of the ulna.

Figure. Marker placement

2.C. Biomechanical evaluation

Pitching kinematics and kinetics as well as ball velocity will be evaluated in the pitching lab at the University of Nebraska at Omaha. After clinical and tissue adaptation assessments, 41 retro-reflective markers will be placed on body landmarks (Figure) for

PitchTrak (Motion Analysis Corporation, Santana, CA), with sampling set at 400Hz. Once markers are secured by sprays and tapes, the participant will warmup as they normally require before pitching on a mound. Motion analysis system (Qualisys, AB, Goteborg, Sweden) will be used in conjunction with 20 high-speed cameras for motion capture, sampling at 320Hz. Participants will throw on a custom force plate-instrumented (Bertec, Columbus, OH) pitching mound towards a frame object, which will be placed at 17m away. Force plate sampling frequency will be set at 1,280 Hz. Three fastest fastballs will be used for kinematic and kinetic data as the average. Primary focuses are shoulder maximum shoulder ER angle, shoulder horizontal abduction at foot contact, maximum shoulder IR force and velocity, shoulder maximum distraction force, elbow flexion angle at the late cocking, and the maximum elbow valgus torque.

2.D. Data Analysis

A paired t-test will be performed to investigate differences in anterior shoulder instability between pre- and post-season measurements. To ensure the validity of the paired t-test, the normality of the differences between the pre- and post-season measurements will be assessed using the Shapiro-Wilk test. A correlation analysis will be used to analyze relationships of changes in clinical assessments and tissue adaptations as well as between tissue adaptations and pitching biomechanics. Correlational coefficients will be interpreted as >0.9=very high, 0.7-0.9=high, 0.5 0.7=moderate, and <0.3=low. A regression analysis will be performed to estimate the tissue adaptations based on the clinical assessment and pitching biomechanics.

3. Project Timeline

	2024-2025/2025-2026				
	Nov.-Jan.	Feb.-May	Jun.-Sep.	Oct.-Dec.	Jan.-May
IRB Submission					
Subject Recruitment					
Data Collection					
Data Organization					
Data Analysis					
Manuscript Preparation					

4. Roles of Student and Faculty Mentor

My faculty mentor, Dr. Samuel Wilkins, will supervise the project. I will be responsible for recruiting participants, data collection, data organization, data analysis, and writing the results for presentation under the supervision. Dr. Wilkins will be responsible for providing guidance during data collection and analysis, and advice for the manuscription.

5. Previous Internal Funding

I was awarded for my Master's project with internal funding (GRACA) in 2020 and Doctoral project in 2023. The previous projects found a moderate positive correlation between elbow valgus torque at the late cocking phase and the UCL length measured at 90° elbow flexion with valgus loading. The past projects have focused on the throwing elbow. With the current proposed study, we will explore the throwing shoulder by examining how anterior glenohumeral instability would change along with the posterior capsule thickness throughout the season and whether there is an association between the changes and pitchers' clinical and biomechanical characteristics. Also, it is meaningful for the field to explore a novice approach for the instability assessment in overhead athletes.

Budget Justification

Item	Price/Unit	Unit	Total Price
Evaluation Fee	$150/evaluation	15	$2,250
Student Stipend	$2,750	1	$2,750
Total			**$5,000**

I am requesting $5,000 to effectively complete the project. The Participant Evaluation Fee is used to cover the costs associated with completing the pitching evaluation for clinical assessments, tissue adaptation measurements, and pitching biomechanical evaluations. The student stipend will let me dedicate a sufficient amount of time to complete the data organization, analysis, and manuscription.

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Office of Research and Creative Activity
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Dear GRACA Review Committee:

I am writing to express my enthusiastic support for Tomohiro Ide's research project titled "Changes in Anterior Glenohumeral Joint Instability Throughout a Competitive Season and Relationships of Changes in Clinical Assessments and Tissue Adaptations." I have had the opportunity to observe Tomohiro's dedication, intellectual curiosity, and research skills. Tomohiro is a certified athletic trainer with extensive experience working with college and professional baseball pitchers. His previous research experience involving ultrasound evaluation and pitching biomechanics analysis has prepared him well for this project. I am confident in his ability to conduct this research independently and contribute meaningfully to the field.

Tomohiro's proposed project aligns with current research trends in sports medicine and biomechanics, particularly in the field of baseball pitching. The project aims to investigate the relationship between anterior glenohumeral joint instability (AGJI) and other clinical assessments and tissue adaptations in collegiate baseball pitchers. This research has significant implications for injury prevention and rehabilitation strategies in this population. The project objectives are well-defined and address a critical gap in the existing literature. The proposed methodology, including the longitudinal study design and clinical assessments, is appropriate and rigorous. Tomohiro's experience with ultrasound evaluation and pitching biomechanics analysis further strengthens the project's potential to contribute to the field. The proposed budget of $5,000 is adequate for this project. The participant fees will help recruit participants, and the student stipend is appropriate for the amount of work Tomo will put in for the data collection and analysis portions of the project.

I am committed to providing Tomohiro with the mentorship and support necessary to successfully complete this project. As his mentor, I have helped him conceptualize the project and will assist him with the data collection and analysis portion. I will also provide guidance on research design, data interpretation, and manuscript preparation.

In conclusion, I wholeheartedly endorse Tomohiro Ide's research project and believe that it has the potential to make a significant contribution to the understanding of upper extremity injuries in baseball pitchers. I am committed to providing him with the necessary support to ensure its success.

Sincerely,

SWilkins

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