Original Research

Glenohumeral Instability and Arm Pain in Overhead Throwing Athletes: A Correlational Study

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Background

The overhead activity of throwing a baseball is arguably the most demanding athletic endeavor placed on the glenohumeral (GH) joint. Previous studies illustrate that 75-80% of baseball players will experience some degree of upper extremity (UE) pain. GH instability is thought to play a role.

Purpose

The purpose of this study was to investigate the relationship between GH joint hypermobility and instability with measures of arm pain and performance in overhead throwing athletes.

Methods

Actively competing baseball pitchers were recruited and evaluated once with the anterior-posterior Load and Shift examination procedure, the Kerlan-Jobe Orthopedic Clinic Shoulder and Elbow Questionnaire (KJOC), and the Functional Arm Scale for Throwers (FAST). Multivariate analysis was performed to identify correlation between severe GH capsular laxity (GH instability), mild capsular laxity (GH hypermobility), no capsular laxity (GH normal), and presence of shoulder pain when pitching.

Study Design

Cross-sectional Study.

Results

Forty-five pitchers were evaluated, 62.2% of throwing shoulders were classified normal stability, 26.7% were classified hypermobile, and 11.1% were classified unstable. Average KJOC scores for pitchers with the three mobility categories were 66.1 (normal), 59.7 (hypermobile), and 45.0 (unstable). Average FAST scores among the pitchers were 19.9 (normal), 34.2 (hypermobile), and 32.2 (unstable). Pitchers with GH instability and GH hypermobility demonstrated increased arm pain compared to athletes with normal GH joints; KJOC scores of 3.2, 5.5, and 7.4 ($p = 0.0007$), respectively.

Conclusion

Pitchers with GH instability and hypermobility demonstrated significantly increased ratings of arm pain compared to pitchers with no capsular laxity.

Level of Evidence

3b

INTRODUCTION

BACKGROUND

Prevention of baseball throwing-related injuries and identification of potential risk factors for pain and injury in overhead throwing athletes is a topic of interest for physical therapists, athletic trainers, physicians, and other medical providers involved in the care and treatment of these athletes. Prevention of throwing related injuries is imperative considering current trends in injury and the incidence of surgery to the shoulder and elbow in young athletes. Up to 50% of youth pitchers between nine and 14 years old experience arm pain.[1] Analysis of 241 shoulder injuries and 150

elbow injuries in high school baseball players revealed that 93.5% and 88.0% of shoulder and elbow injuries, respectively, were throwing related injuries.[2] In addition, the risk of injury increases with increasing levels of competition.[3,4] Youth throwing-related injuries pose problems to participation and competitiveness in sport, and may also result in long-term pain and increased incidence of degenerative change to the throwing shoulder and elbow.[5]

Both translatory and angular motion changes occur in the shoulders of throwing athletes.[6,7] The dominant shoulders of pitchers have been shown to demonstrate greater amounts of anterior and posterior translation than the nondominant shoulders.[7] Additionally, angular range of motion changes occur in the dominant shoulder of pitchers with increased external rotation of 5 to 15 degrees and decreased internal rotation of 5 to 20 degrees compared to the nondominant shoulder.[7–9] These changes have been observed in athletes younger than 12 years old, and occur secondary to humeral retrotorsion, soft tissue changes, and other joint-related adaptations such as glenoid retroversion or labral tearing.[6–10]

It has been shown that glenohumeral (GH) instability contributes to shoulder pain and injury in athletes of various sports.[1,11,12] Chronic instability plays a role in degenerative conditions at the shoulder, including the development of osteochondral defects, capsuloligamentous enlargement and tearing, labral deformation, and tendinopathy.[13–15] Currently, it is not fully understood how the presence of GH instability or hypermobility in the throwing shoulders of baseball players influences ratings of pain or the role it may play in throwing arm function The purpose of this study was to investigate the relationship between GH joint hypermobility and instability with measures of arm pain and performance in overhead throwing athletes.

METHODS

IRB approval was received in the Fall of 2019. Prior to recruiting participants, a categorical inter-rater reliability test of the load and shift assessment was conducted on a cohort of thirty physical therapy students (n=30). This test was to substantiate the researchers' ability to perform and reliably assess shoulder stability with the Load and Shift test. The results of this test were compared to the results of a board-certified, fellowship-trained orthopedic physical therapist who has been a practicing clinician and educator for 37 years. The ICC value for the two researchers who later conducted the Load and Shift test on the participants in this study was found to be .81 and .85 in comparison to the aforementioned clinician, demonstrating good reliability.

PARTICIPANTS

Baseball pitchers (n=45) trained at the Overhead Athletic Institute were recruited to participate in this study. All participants met the inclusion criteria of being male and currently competing in baseball. Participants were excluded from this study if they reported having undergone surgery within the prior 12 months, were under the age of 13 or over the age of 30 years old or were not currently competing due to injury. Participants were asked to report any history of previous arm injury.

CONSENT

Prior to participation, subjects and/or their parents/guardians (for those under 18 years old) were informed about the aim of this study and that their consent would be necessary to participate. Pitchers under 18 years old required parent/guardian permission as well as personal assent. All participants and/or their parents/guardians were provided informed written consent prior to testing. This study was approved by the Oakland University Institutional Review Board: IRB Protocol # 1902.004.

OBJECTIVE MEASURES OF ARM PAIN AND DYSFUNCTION

TESTING PROCEDURES

Following obtaining informed consent, a consistent testing procedure was performed. Each participant first was provided the KJOC questionnaire, upon its completion the FAST survey was provided. When the FAST survey was completed the Load and Shift test was conducted on the participant's throwing shoulder. The Load and Shift test was conducted with the participant seated on a treatment table, the participant was instructed to gently lift their chest as to be positioned in a more erect posture and to relax their throwing arm, allowing it to hang by their side. The researcher, standing in front of the participant, then stabilized scapula posteriorly and clavicle anteriorly with one hand and while grasping humeral head with the other hand by gradually compressing through the soft tissues (Figure 1). Mid-range anterior and posterior translatory oscillations of the humeral head were performed followed by anterior translation and posterior translation into tissue resistance. No surveys, KJOC or FAST, were analyzed by the researchers prior to the application of the Load and Shift test.

KERLAN JOBE ORTHOPEDIC CLINIC SURVEY (KJOC)

To quantify arm pain and dysfunction, participants completed the Kerlan-Jobe Orthopedic Clinic Shoulder and Elbow Questionnaire (KJOC), which is a Patient-Reported Outcomes (PRO) Scale. The KJOC scale evaluates the functional status of the upper extremity (UE) in overhead athletes. It includes 10 items divided into three categories: impact of injury on function and athletic performance (five items), UE symptoms (four items), and interpersonal relationships related to performance (one item). The responses are recorded using a visual analog scale, where a mark is placed along a 10-cm line indicating the athlete's current level of physical function. The KJOC's scores range from 0-100 with lower scores indicating greater disability. The KJOC demonstrated excellent reliability and can distinguish between athletes with or without shoulder or elbow

pain.[16,17] The KJOC has been used as an effective means of assessing arm pain and injury in collegiate and professional throwing athletes and shows good correlation with the Youth Throwers Scale in adolescents.[18–22]

THE FUNCTIONAL ARM SCALE FOR THROWERS (FAST)

To further investigate the functional status of the participants arm, a second PRO scale, the FAST, was also collected. The FAST is a 22-item PRO scale that includes five subscales: pain ((six items), throwing (10 items), ADL (five items), psychological impact (four items), and advancement (three items). There is also an additional nine-item module specifically for pitchers. Higher FAST scores indicated greater disability. The FAST demonstrated excellent test-retest reliability (ICC, 0.91-0.98), acceptable correlation with the DASH (ICC = .49-.82) and KJOC (ICC = 0.62-0.81) scores and classified 85.1% of players into the correct injury group. The FAST has been validated as an effective PRO scale in adolescent and adult throwing athletes.[23,24] For UE injury status, the FAST proved 91% sensitivity and 75% specificity. The FAST is a valid and reliable tool for assessing reported health care outcomes in throwing athletes with injury.[24]

LOAD AND SHIFT TEST

The Load and Shift (L-S) test has proven to be a valid and reliable means of assessing GH joint mobility.[25] The accuracy of the L-S test has been validated in comparison to MRI arthrograms of the shoulder by van Kampen et al.[26] The L-S test has been demonstrated to be 84% accurate in diagnosis of labral tearing and shoulder instability compared to MRI arthrogram.[26]

To assess the degree of shoulder instability present in the participants of this study, the L-S test was performed on all participants, as shown in Figure 1. The researcher graded the participant as normal, hypermobile, or unstable. During the L-S assessment, the GH joint was classified normal if it displayed minimal anterior and posterior translation with an immediate firm capsular end feel. The GH joint was classified as hypermobile if it displayed a great amount of anterior or posterior translation and the capsular end feel was less firm, with no immediate stop in translatory motion. Finally, the GH joint was classified unstable if the head of the humerus could be easily subluxed over the edge of the glenoid labrum, in either an anterior or posterior direction, during the L-S assessment.[27]

STATISTICAL ANALYSIS

Mean and variance values were calculated for age, total score of the KJOC and FAST (the cumulative result of all survey questions for both the KJOC and FAST), and arm pain. One-way Analysis of Variance (One-way ANOVA) was performed to identify any correlation between GH classification of unstable, hypermobile, or normal and self-reported measures of shoulder and elbow performance and discomfort. Question 2 on the KJOC, "How much arm pain do you experience in your throwing shoulder or elbow?" was used to assess arm pain from the KJOC questionnaire. Question 2 on the FAST, "How painful is your arm during 'game-speed' throwing?" was used to assess arm pain from the FAST survey.

Figure 1. Load and Shift test being performed.

Independent t-tests with unequal variances were used to test for differences in total KJOC and total FAST scores between baseball pitchers with unstable and normal shoulders and between athletes with and without a history of injury, which was recorded by the participant as part of the KJOC questionnaire. Statistical analyses were performed using Microsoft Excel Statistics Data Analysis ToolPak (Microsoft, Albuquerque, NM), alpha level of $p \leqslant 0.05$.

RESULTS

Forty-five baseball pitchers, ages 13-25 years old, mean age of 15.98 ± 2.82 were included in this cross-sectional study. Distribution of participants by age ranged from 13-25 years old. Arm dominance was recorded, with n=36 for right-handed throwers and n=9 for left-handed throwers. These descriptive statistics are presented in Table 1.

SHOULDER STABILITY, ARM PAIN, AND ARM FUNCTION

Eleven percent (n=5) of throwing shoulders were found to be unstable, 26.7% (n=12) were found to be hypermobile, and 62.2% (n=28) were found to be normal. Total KJOC score means were found to be 66.1 ± 18.4, 59.7 ± 18.0, and 45.0 ± 20.1 for normal, hypermobile, and unstable shoulders, respectively. Total FAST score means were found to be 19.9 ± 14.6, 34.2 ± 18.1, and 32.1 ± 11.2 for normal, hypermobile, and unstable shoulders, respectively. Pitchers with normal shoulders exhibited significantly higher levels of function than pitchers with unstable and hypermobile shoulders when measured with the FAST, as demonstrated in Table 2. Pitchers with normal shoulders exhibited significantly higher levels of function than pitchers with unstable shoulders when measured with the FAST and KJOC, as demonstrated in Table 3. Pitchers with normal shoulders exhibited significantly less arm pain than pitchers with un-

Table 1. Descriptive Demographics - Baseball Pitchers (total n=45, all were male, 36 were right hand dominant while 9 were left hand dominant)

Age	N
13	9
14	7
15	4
16	11
17	5
18	4
19	1
20	1
21	1
22	1
24	1
25	1
Total	45

stable and hypermobile shoulders in both the FAST and KJOC, as demonstrated in Table 4.

PREVIOUS HISTORY OF INJURY

A previous history of injury was noted in 80% (n=36) of the participants in the study. When comparing total KJOC scores of pitchers with a history of arm injury to pitchers with no history of arm injury, healthy pitchers scored 71.9, while pitchers with a history of injury scored 59.6 (p=0.029). These scores indicate reduced subjective ratings of function in pitchers with a history of arm injury. When FAST scores of pitchers with a history of injury were compared to pitchers with no history of injury, there was no statistically significant difference (p=0.095); healthy pitchers scored 16.6 while athletes with a history of injury scored 27.2.

DISCUSSION

The aim of this study was to determine if there is a correlation between measures of GH hypermobility and subjective reports of arm pain and impairment during pitching. Current literature suggests that baseball pitchers have greater GH translation and greater angular motion in their throwing shoulder compared to the non-throwing shoulder.[7] Hypermobility and instability have correlated with increased reports of pain and impairment in other sports.[1,12] The presence of joint instability and angular hypermobility has also been correlated to the development numerous orthopedic conditions including capsular strains, labral tears, internal impingement, tendinopathy, and other degenerative conditions such as osteochondral defects.[14,28,29]

Examination for excessive capsular laxity and labral instability is possible with the application of the L-S test.[25–27] Given this, the authors' believe there is a need for greater player and parental awareness of this examination procedure and the potential adverse effects of GH hypermobility on the throwing shoulder. Perhaps athletic trainers and physical therapists trained in the application of the L-S procedure could offer optional pre-season screening exams at facilities where private pitching lessons occur and at local high schools and colleges. If capsular laxity or instability is found, therapeutic advice regarding joint hypermobility, pitch count limits, the benefits of stabilization exercise, or perhaps referral to an orthopedist could be provided to that athlete.

The shoulder undergoes massive loading during the acceleration phase of the throw and immediately after ball release. Fleisig and colleagues found that in adult pitchers' shoulders undergo 380N of anterior force during acceleration and 400N of posterior force and 1080N of compressive force immediately after ball release.[30] GH instability or excessive joint translation in the presence of these large loads has the potential to damage stabilizing structures of the shoulder such as the labrum and the capsule. Excessive angular motion during the late cocking phase of the throw has been shown to increase the likelihood of capsular strains, SLAP lesions, and internal impingement.[28,31] At present, the literature does not address changes in glenohumeral translatory motion and the role this may play in shoulder pain and performance during overhead throwing. This current study examined the potential importance of this type of passive joint motion in evaluation overhead throwing athletes. The results demonstrated an association between increased passive joint translation (GH hypermobility and instability) and increased pain perception and throwing performance impairment.

LIMITATIONS

This study evaluated overhead throwing athletes (baseball pitchers) with a mean age of 15.98 years of age, as such, the current findings may not apply to more physically mature collegiate and professional baseball pitchers. The authors believe that this study should be replicated on a larger number of older baseball pitchers such as those competing

Table 2. Analysis of Variance of Total KJOC and FAST Scores and Glenohumeral Mobility, reported as mean ± SD,

Parameter	Normal	Hypermobile	Unstable	p-value
FAST Total	19.9 ± 14.6	34.2 ± 18.1	32.1 ± 11.2	0.025
KJOC Total	66.1 ±18.4	59.7 ± 18.0	45.0 ± 20.1	0.075

Outcomes are reported in units used by the questionnaire (0-100 for KJOC where higher score indicates better function and less pain and 0-100 for FAST where higher number indicates more pain and less function).

at the professional and collegiate levels. Additionally, the number of subjects (n=45), may impact the generalizability of the findings.

CONCLUSION

The results of this study indicate that baseball pitchers who exhibit greater amounts of passive anterior and posterior translation of the GH joint as demonstrated by the L-S assessment report higher levels of arm pain and discomfort. Pitchers who demonstrate increased passive humeral head translation at the GH joint also report lower levels of function and performance. Pitchers who showed the greatest amount of instability at the GH joint, as evidenced by manual subluxation of the humeral head during the load and shift assessment, demonstrated the worst overall scores for function and pain. Additional research is needed to determine the association between increased passive humeral head translation, shoulder pain, and throwing performance in other age groups.

CONFLICTS OF INTEREST

The authors of this paper declare that they have no conflicts of interest.

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Table 3. Comparison of Normal and Unstable Shoulder Total FAST and KJOC Scores, reported as mean ± SD

Parameter	Normal	Unstable	t	p-value
FAST Total	19.9 ± 14.6	32.1 ± 11.2	-2.14	0.035
KJOC Total	66.1 ± 18.4	45 ± 20.1	2.19	0.04

Outcomes reported in units used by the questionnaire (0-100 for KJOC where higher score indicates better function and less pain and 0-100 for FAST where higher number indicates more pain and less function) utilizing paired t testing.

Table 4. Analysis of Variance of Arm Pain Scores in KJOC and FAST and Glenohumeral Mobility, reported as mean ± SD

Parameter	Normal	Hypermobile	Unstable	p-value
Arm Pain FAST	2 ± 1.2	3 ± .8	3 ± 1	0.019
Arm Pain KJOC	7.4 ± 2.2	5.5 ± 2.3	3.2 ± 2.1	0.0007

Outcomes reported in units used by the questionnaire (0-10 for KJOC where lower score indicates more pain, and 0-5 for FAST where higher number indicates more pain).

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