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Risk Factors for Posterior Shoulder Instability in Young Athletes

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Background: While posterior glenohumeral instability is becoming increasingly common among young athletes, little is known of the risk factors for injury.

Purpose: To determine the modifiable and nonmodifiable risk factors for posterior shoulder instability in a high-risk cohort.

Study Design: Case-control study (prognosis); Level of evidence, 2.

Methods: A prospective cohort study in which 714 young athletes were followed from June 2006 through May 2010 was conducted. Baseline testing included a subjective history of instability, instability testing by a sports medicine fellowship–trained orthopaedic surgeon, range of motion, strength measurement with a handheld dynamometer, and bilateral noncontrast magnetic resonance imaging of the shoulder. A musculoskeletal radiologist measured glenoid version, height, depth, rotator interval (RI) height, RI width, RI area, and RI index. Participants were followed to document all acute posterior shoulder instability events during the 4-year follow-up period. The time to the posterior shoulder instability event during the follow-up period was the primary outcome of interest. Univariate and multivariable Cox proportional hazards regression models were used to analyze the data.

Results: Complete data on 714 participants were obtained. During the 4-year surveillance period, 46 shoulders sustained documented glenohumeral instability events, of which only 7 were posterior in direction. The baseline factors that were associated with subsequent posterior instability during follow-up were increased glenoid retroversion ($P < .0001$), increased external rotation strength in adduction ($P = .029$) and at 45° of abduction ($P = .015$), and increased internal rotation strength in adduction ($P = .038$).

Conclusion: This is the largest known prospective study to follow healthy participants in the development of posterior shoulder instability. Posterior instability represents 10% of all instability events. The most significant risk factor was increased glenoid retroversion. While increased internal/external strength was also associated with subsequent instability, it is unclear whether these strength differences are causative or reactive to the difference in glenoid anatomy. This work confirms that increased glenoid retroversion is a significant prospective risk factor for posterior instability.

Keywords: shoulder instability; posterior instability; glenoid retroversion; injury prevention

Posterior glenohumeral instability is becoming increasingly common among young athletes. The relative incidence of posterior instability has been shown to be approximately 10% of all instability events, with the majority of cases being subluxation or incomplete events.[12] Recent reports of arthroscopic stabilization suggest that this condition is being increasingly recognized in athletes.[1,2,8,14]

Despite the increased occurrence of acute posterior glenohumeral instability events in athletes, surprisingly little is known about the risk factors associated with these injuries. A common injury mechanism is a fall onto an outstretched hand.[1] Posterior instability has also been noted in football players (especially blocking linemen)[2,15,19] and weight lifters (particularly with bench presses).[13,15] Increased glenoid retroversion has been noted in patients with posterior instability,[2] but it is unclear whether bony changes are predictive or adaptive.[15] Other specific risk factors for posterior instability are poorly understood.

To develop primary prevention strategies for shoulder instability in athletes, it is critical to determine the modifiable and nonmodifiable risk factors for this injury. We attempted to prospectively study posterior shoulder instability in a high-risk cohort. We hypothesized that an

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increase in glenoid retroversion at baseline, before injury, would be a significant risk factor for posterior shoulder instability during the 4-year follow-up period.

MATERIALS AND METHODS

Design and Setting

In 2006, we initiated a prospective cohort study in a group at high risk for shoulder instability to identify the risk factors for this debilitating condition. Participants were assessed with baseline testing and followed during their 4 years of study at our institution for subsequent injuries, and this cohort has been described previously in the literature.[3,4,11] They were required to participate in either intercollegiate or intramural athletics as well as fulfill military and physical education requirements during the follow-up period, which have been described previously.[10] The high risk of shoulder instability in this population has also been previously documented.[12] We obtained institutional review board approval from our institution before initiating this study.

Participants

We offered enrollment to all of the 1301 matriculating students at our institution, ultimately enrolling 1050 participants with informed consent. We were able to obtain complete baseline data on 714 participants, which compose this study cohort. Only those who were able to complete all baseline assessments were included in the final cohort. Of these 714 participants, a total of 630 (88%) were male, while 84 (12%) were female. This is consistent with the student population at our institution, which is usually 85% male. All participants were deemed fit for entry into military service by the Department of Defense Medical Evaluation Review System (DoDMERS).

Baseline Assessments

A subjective history of instability was solicited through a baseline questionnaire. A physical examination of each shoulder was performed by a single sports medicine fellowship–trained orthopaedic surgeon (B.D.O.) to include load shift in all directions, anterior apprehension, relocation testing, sulcus sign, as well as a 9-point Beighton scale to assess ligamentous laxity. We also performed measures of glenohumeral range of motion to include cross-body adduction, forward flexion, external rotation in adduction, and internal/external rotation of the arm adducted to 90°. Strength was measured with a handheld dynamometer to assess adduction, internal/external rotation in adduction, and internal/external rotation at 45° of adduction. The methods and results for the baseline physical examination, range of motion, and strength measurements in this cohort have been presented previously.[3,11,16,18]

Imaging

Bilateral noncontrast magnetic resonance imaging (MRI) scans were obtained using an abbreviated protocol at baseline upon entry into the cohort. A musculoskeletal radiologist (S.E.C.) reviewed these images and measured glenoid version, glenoid height, glenoid depth, rotator interval (RI) height, RI width, RI area, and RI index.[7] The musculoskeletal radiologist was blinded to the other baseline assessments and whether participants sustained a shoulder instability event during the follow-up period.

Surveillance

Participants were followed prospectively in our closed health care system from June 2006 through May 2010. All acute posterior shoulder instability events were documented during the 4-year surveillance period. There were no posterior dislocations in our cohort, but posterior subluxation events were determined by history, physical examination findings, imaging results, and findings at surgery (if performed). All suspected cases of shoulder instability that occurred during the follow-up period were reviewed by a single sports medicine fellowship–trained orthopaedic surgeon (B.D.O.), who was blinded to the baseline data.

Patients with a history of pain from a fall on an outstretched hand or during blocking, checking, or bench press were evaluated with a complete instability examination. This examination included load shift in all directions, anterior apprehension and relocation, as well as posterior apprehension and jerk testing. A low threshold for obtaining MRI scans was used, with acute injuries undergoing nongadolinium-enhanced MRI and chronic injuries using an MRI arthrogram. Participants whose symptoms, clinical examination findings, and examination under anesthesia and arthroscopic surgery results were consistent with anterior instability were classified as patients with anterior instability, regardless of the presence of a concomitant posterior labral tear. This is important to note as we have previously reported anterior and posterior labral tears from single anterior events as well as a high rate of combined labral lesions in our population.[5,6] Participants whose clinical picture was consistent with posterior instability were classified as patients with posterior instability. All participants with documented posterior subluxation events in this cohort had a history that included pain with push-ups, posterior apprehension on physical examination, and a confirmed posterior labral tear on either MRI and/or arthroscopic examination.

Statistical Analysis

Initially, we calculated means and standard deviations or medians and interquartile ranges (IQRs) for continuous variables and frequencies and proportions for categorical variables. For continuous variables, we used independent *t* tests to examine differences between those who experienced posterior instability events during the follow-up period compared with those who did not. If assumptions for the *t* test were not met, the nonparametric equivalent, the Kruskal-Wallis test, was used. For categorical variables, we examined associations between the variables and

TABLE 1
Participants With Posterior Instability Events[a]

Participant	Glenoid Version at Baseline, deg	Instability History	Instability Type	Time to Event, d	Mechanism (Activity)	Pathological Lesion on MRI After Injury
1	−22.6	No	Subluxation	104	Unknown	Reverse Bankart
2	−21.2	No	Subluxation	209	Obstacle course	Reverse Bankart (bony)
3	−18.8	No	Subluxation	669	Rugby	Reverse Bankart (bony)
4	−4.4	No	Subluxation	1159	Push-ups	Reverse Bankart with GLAD lesion
5	−13.5	Yes	Subluxation	187	Diving	Reverse Bankart
6	−17.6	Yes	Subluxation	444	Lacrosse	Reverse Bankart (bony), reverse Hill-Sachs
7	−9.8	No	Subluxation	147	Football	Reverse Bankart

[a]GLAD, glenolabral articular disruption; MRI, magnetic resonance imaging.

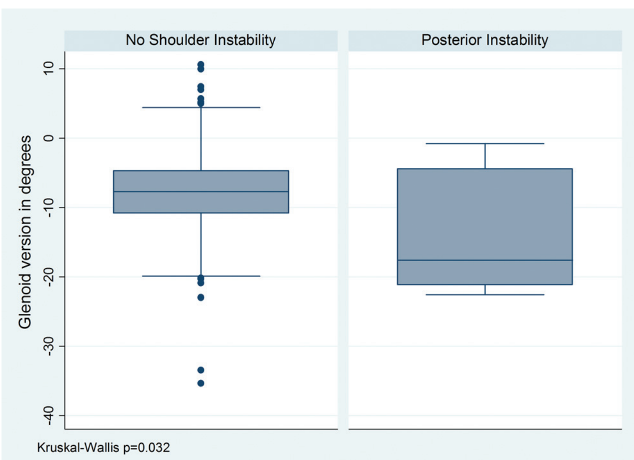

Figure 1. Box plot comparing glenoid version at baseline between participants who experienced posterior instability during follow-up and those who did not.

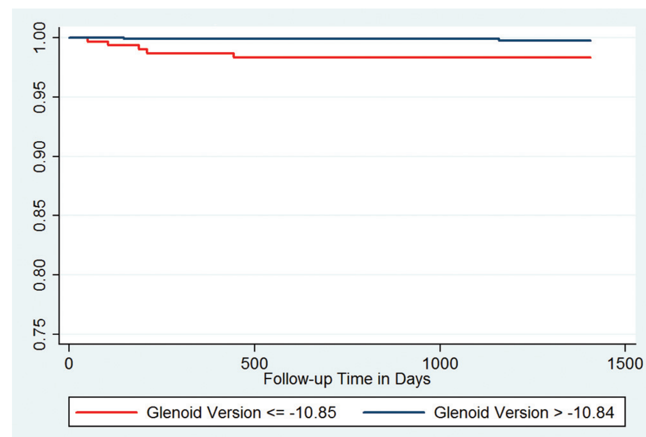

Figure 2. Kaplan-Meier survival estimates for posterior instability during follow-up comparing the upper quartile (glenoidQT2=0 $\geq$ −10.85) and the lower 3 quartiles (glenoidQT2=1 $<$ −10.85) for glenoid retroversion at baseline.

shoulder instability during the follow-up period using a χ^2 or Fisher exact test. Because the time to the posterior shoulder instability event during the follow-up period was the primary outcome of interest, univariate and multivariable Cox proportional hazards regression models were used to analyze the data. Multivariable models controlled for the influence of history of instability, sex, weight, glenoid width, and all strength measures. All analyses were performed using Stata SE version 10.1 (StataCorp, College Station, Texas).

RESULTS

Among the 714 participants who composed the cohort, 630 were male and 84 were female. Of the male participants, the mean age was 18.8 ± 1.0 years, the mean height was 178.5 ± 7.5 cm, and the mean weight was 76.1 ± 12.9 kg. Of the female participants, the mean age was 18.7 ± 0.9 years, the mean height was 165.4 ± 7.0 cm, and the mean weight was 63.2 ± 9.1 kg. During our 4-year surveillance period, 46 shoulders sustained documented acute glenohumeral instability events, of which only 7 were posterior in direction. Participants with acute anterior instability events during the follow-up period were excluded from further analyses. All posterior events occurred in male participants. Activities during injury included intercollegiate football, intercollegiate lacrosse, intercollegiate diving, intercollegiate rugby, intramural wrestling, and a military obstacle course (Table 1). Our numbers were too small to be appropriate for an analysis by sport and athletic exposure. All participants had normal physical examination findings at baseline before injury. Two participants reported a history of shoulder instability at baseline.

The most significant risk factor in our univariate analysis was an increase in glenoid retroversion. The median version in noninjured participants was −7.7° (IQR, 7.7°) compared with −17.6° (IQR, 16.8°) in injured participants, and the difference between the groups at baseline was statistically significant (P = .032) (Figure 1). While controlling for a history of instability and using the noninjured participants as the reference group, the hazard ratio (HR) was 1.17 (95% confidence interval [CI], 1.03-1.34; P = .017), meaning that for every 1° of increased retroversion, there was a 17% increased risk of subsequent posterior shoulder instability. After controlling for a history of shoulder instability, participants in the upper quartile for glenoid retroversion were nearly 6 times more likely (HR, 5.83; 95% CI, 1.11-30.65; P = .037) to experience an acute posterior shoulder instability event during the follow-up period when compared with participants in the lower 3 quartiles for glenoid retroversion (Figure 2). There were no significant differences for glenoid height, width, and depth or RI measures.

We did note significant differences in strength measures among the injured and noninjured participants. Injured participants were stronger in external rotation in adduction (HR, 1.06; 95% CI, 1.01-1.12; P = .019) and at 45° of abduction (HR, 1.07; 95% CI, 1.01-1.13; P = .022). We also noted an increase in internal rotation strength in adduction (HR, 1.05; 95% CI, 1.00-1.11; P = .074). The ratio of internal to external rotation strength at 45° was also significant (HR, 0.97; 95% CI, 0.96-0.99; P = .007).

DISCUSSION

This is the largest known prospective study to follow healthy participants in the development of posterior shoulder instability. We noted that increased glenoid retroversion was a significant prospective risk factor: with every 1° of increased retroversion, there was a 17% increased risk of subsequent posterior shoulder instability. Others have reported increased glenoid retroversion in patients with posterior instability in retrospective studies or case-control studies. Bradley et al[2] reported on a cohort of 100 young athletes undergoing arthroscopic posterior repair, and the 48 patients with MRI scans reviewed had an increase in chondrolabral retroversion (measure including soft tissues) compared with controls. von Eisenhart-Rothe et al[17] reported on 14 patients with atraumatic instability and laxity compared with 28 controls and found a significant increase in glenoid retroversion. Because of the design, previous studies could not determine whether the observed differences in retroversion were the cause of posterior instability or a result of the instability event. While we are not the first to report the finding that increased glenoid retroversion is associated with posterior instability, we were able to confirm that increased retroversion before injury is a prospective risk factor for subsequent posterior instability.

One of our primary objectives was to prospectively identify modifiable risk factors, such as rotator cuff strength, for posterior instability, as they may provide an avenue for the development of injury prevention interventions. Our analysis of strength suggested that an increase in external and internal rotation strength at baseline was associated with posterior instability during the follow-up period, which is contrary to our initial hypothesis. We had anticipated that a decrease in rotator cuff strength would be associated with posterior instability during follow-up. It is likely that greater rotator cuff strength at baseline may be an adaptation to the secondary stabilizers to compensate for the increased retroversion observed in the current study rather than the cause of posterior instability. As a result, it is important to interpret our findings related to the association between rotator cuff strength at baseline and the subsequent risk of posterior instability with caution.

The limitations of this study are the small number of posterior events documented during our period of study. Posterior instability does not typically present similarly to anterior instability, and a diagnosis can be more challenging. However, given the length of our period of study and the intensity of the mandatory athletic requirements in our cohort, we are confident that patients with posterior instability whose symptoms limited their activities were captured in our cohort. Despite our small numbers, we were able to clearly demonstrate that glenoid version is a significant risk factor for this injury, implying an extreme effect size for this variable. Another limitation was our use of a single observer for our MRI measurements, made necessary by the large number of measurements obtained. However, excellent interobserver and intraobserver reliability has been shown previously.[9] The strengths of our study are the prospective methods and premorbid imaging, as well as the high-risk young athletic population.

Future work in this area may involve determining the amount of glenoid retroversion in patients with posterior instability that is acceptable for a soft tissue repair and the critical level that would suggest the need for a glenoid osteotomy with concomitant repair. We are not currently employing any prevention protocols based upon our data, nor do we recommend screening of high-risk athletes with imaging or strength assessments at this time.

In conclusion, posterior instability represents 10% of all instability events. The most significant risk factor was increased glenoid retroversion. While increased internal/external rotation strength was also associated with subsequent instability, it is unclear whether these strength differences are causative or reactive to the difference in glenoid anatomy. This work confirms that increased glenoid retroversion is a significant prospective risk factor for posterior instability.

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