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ORIGINAL ARTICLE

Preseason screening of shoulder range of motion and humeral retrotorsion does not predict injury in high school baseball players

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Background: Shoulder and elbow injuries are commonplace in high school baseball. Although altered shoulder range of motion (ROM) and humeral retrotorsion angles have been associated with injuries, the efficacy of preseason screening of these characteristics remains controversial.
Methods: We conducted preseason screenings for shoulder internal and external rotation ROM and humeral retrotorsion on 832 high school baseball players and tracked their exposure and incidence on throwing-related shoulder and elbow injuries during a subsequent season. Poisson regression with robust error variance was used to determine whether preseason screening could identify injury risk in baseball players and whether the injury risk was higher for pitchers compared with players who do not pitch.
Results: Shoulder rotation ROM or humeral retrotorsion at preseason did not predict the risk of throwing-related upper extremity injury ($P = .15$-$.89$). Injury risk was 3.84 higher for baseball players who pitched compared with those who did not (95% confidence interval, 1.72-8.56; $P = .001$).
Discussion: Preseason measures of shoulder ROM and humeral retrotorsion may not be effective in identifying players who are at increased injury risk. Because shoulder ROM is a measure that fluctuates under a variety of influences, future study should investigate whether taking multiple measurements during a season can identify at-risk players. The usefulness of preseason screening may also depend on rigor of participation in sports. Future studies should investigate how preseason shoulder characteristics and participation factors (ie, pitch count and frequency, competitive level, pitching in multiple leagues) interact to predict injury risk in baseball players.
Level of evidence: Level I; Prospective Design; Prognosis Study

Keywords: screening; injury risk; evaluation; physical characteristics; baseball; humeral retrotorsion

Throwing-related upper extremity injuries comprise a large portion of all injuries occurring in baseball, making them commonplace among competitive baseball players.[4,10,13,14,16-18,27,31,38,39] Alternations in shoulder range of motion (ROM) have been long considered a contributing factor to these

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injuries,[1,2,9,21,39,40,43,46,47] and significant emphasis is thus placed on evaluating shoulder ROM characteristics by clinicians who are working with baseball players. Specifically, glenohumeral internal rotation deficit (GIRD),[5,9,21,37,39] adaptive gain in external rotation ROM,[46] and loss of total rotation ROM[9,35,39,47] and horizontal adduction ROM[39] on the dominant limb have been linked to throwing-related upper extremity injuries. Humeral retrotorsion angle, which influences shoulder rotation ROM, has also been linked to injuries in some studies.[24,26,44,45]

Although there is mounting evidence linking alterations in shoulder ROM characteristics to injury,[1,2,5,9,21,35,43] whether screening of these characteristics in preseason can help identify baseball players with increased injury risk remains unclear. The studies by Shanley et al[37,39] indicated that greater loss of total rotation ROM, deficit in horizontal adduction ROM, and GIRD at preseason are associated with increased risk of injury in high school baseball players. Contrarily, Tyler et al[42] reported that having >20° GIRD at baseline was protective of injury in a study of high school baseball players, and Wilk et al[46,47] reported GIRD was unrelated to injury risk in 2 studies of professional baseball pitchers. Greater dominant-limb humeral retrotorsion angle has been linked to lower risk of shoulder injuries[26] and few days lost from participation[32] but with greater risk of elbow injury[26] in professional baseball pitchers. In addition, decreased humeral retrotorsion angles of the nondominant limb were also been linked to an increased risk of throwing-related injuries among high school and collegiate pitchers in a small prospective study.[45]

Because of the inconsistent findings from the previous studies,[37,39,42,46,47] whether preseason shoulder ROM characteristics and humeral retrotorsion can predict in-season injury risk remains inconclusive. Investigating whether the data collected in preseason can predict injury risk during the season is clinically meaningful, because it can help us determine how to best use the clinical data. Therefore, the purpose of this study was to prospectively evaluate whether the shoulder ROM and humeral retrotorsion characteristics affect the risk of throwing-related shoulder and elbow injuries that occur during a baseball season in a large sample of high school baseball players.

Materials and methods

Procedures

The current study included 832 junior varsity or varsity level male baseball players (age, 16.4 ± 1.1 years; height, 179.9 ± 6.5 cm; mass, 77.5 ± 12.3 kg) who participated at one of 28 high schools from across the state of North Carolina over 3 spring baseball seasons. Parental consent was obtained from all participants following the university Institutional Review Board guideline, and assent was also obtained from the minor participants on the day of testing.

All testing was conducted at an athletic training room, dugout, or classroom at participating high schools. The preseason data collections were completed at the beginning of the spring baseball season, before the start of any competitions. At the beginning of the testing session, each participant provided information on amount of participation, current and past playing positions, and brief throwing-related upper extremity injury history by completing a survey. After completing a survey, each player was asked to lie supine on a portable treatment table for an assessment of shoulder ROM (internal rotation, external rotation, and horizontal adduction) using a digital inclinometer (The Saunders Group, Inc., Chaska, MN, USA) and humeral retrotorsion using a digital inclinometer and diagnostic ultrasonography. The methods used to assess shoulder ROM were consistent with those that have been used by clinicians and researchers. All measurements were taken 3 times bilaterally, and the average of the 3 trials was used for statistical analysis.

The shoulder internal and external rotation ROM was assessed with the participant's arm placed in 90° of shoulder abduction and elbow flexion (Fig. 1, *A*). A small towel roll was placed under the humerus to maintain its position in the frontal plane. The examiner applied a posteriorly directed force at the acromion to stabilize the scapula while passively rotating the limb into internal and external rotation to end range. The second examiner recorded the rotation angles. A total rotation ROM was calculated by adding the internal and external rotation ROM. Reliability and precision of the shoulder rotation ROM assessment had been established (intrasession and intersession intraclass correlation coefficient$_{2,k}$, 0.911-0.988; standard error of the mean, 1.2°-2.6°).[21,23,25,28]

To measure the horizontal adduction ROM, the examiner placed 1 hand under the scapula, while the participant lifted his shoulder off the table (Fig. 1, *B*). The examiner pressed the palm against the lateral border of the scapula to stabilize the scapula in a maximally retracted position before using the other hand to move the participant's arm into horizontal adduction. At the end range, the second examiner recorded the angle formed between the humerus and the horizontal plane. The investigators have previously established the reliability (intraclass correlation coefficient$_{2,k}$, 0.91), precision (standard error of the mean, 1.1°), and construct validity of this assessment method.[25]

Humeral retrotorsion was assessed using the technique previously validated against a measurement using a computed tomography scan (Fig. 1, *C*).[22,23,45,48] While the participant's shoulder was placed in 90° of shoulder abduction and elbow flexion, an examiner positioned a 4-cm linear array ultrasound transducer (LOGIQe; General Electric, Milwaukee, WI, USA) on the participant's anterior shoulder. The ultrasound transducer was aligned vertically (verified with a bubble level) and positioned perpendicular to the long axis of the humerus. The second examiner rotated the humerus so that the bicipital groove appeared in the center of the ultrasound image, with the line connecting the apexes of greater and lesser tubercles parallel to the horizontal plane, using a grid placed over the ultrasound unit display as a guide. Once the humerus was positioned properly, a digital inclinometer, which was pressed firmly against the ulna, was used to record the forearm inclination angle relative to horizontal plane.

Side-to-side differences in internal rotation (GIRD), horizontal adduction (horizontal adduction motion deficit), and total rotation motion (total rotation motion deficit) were calculated by subtracting the dominant limb values from the nondominant limb values. Side-to-side difference in external rotation (external rotation gain) and humeral retrotorsion (humeral retrotorsion difference) were calculated by subtracting the nondominant limb values from the dominant limb values.