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Journal of Sport and Health Science 4 (2015) 299–306

www.jshs.org.cn

Original article

Physical contributors to glenohumeral internal rotation deficit in high school baseball players

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Received 30 December 2013; revised 15 March 2014; accepted 24 April 2014
Available online 23 September 2014

Abstract

Background: Glenohumeral internal rotation deficit (GIRD) is a risk factor for shoulder and elbow injury in baseball players. Although this evidence forms a basis for recommending stretching, clinical measures of internal rotation range of motion (ROM) do not differentiate if GIRD is due to muscular, capsuloligamentous, or osseous factors. Understanding the contributions of these structures to GIRD is important for the development of targeted interventions. We hypothesize that the osseous component will have the greatest relative contribution to GIRD, followed by muscle stiffness and posterior capsule thickness.

Methods: Internal rotation ROM, muscle stiffness (teres minor, infraspinatus, and posterior deltoid), posterior capsule thickness, and humeral retrotorsion were evaluated on 156 baseball players. A side-to-side difference was calculated for each variable. Variables were entered into a multivariable linear regression to determine the significant predictors of GIRD.

Results: The regression model was statistically significant ($R^2 = 0.134$, $F(1, 156) = 24.0$, $p < 0.01$) with only humeral retrotorsion difference remaining as a significant predictor ($\beta = -0.243$, $t_{156} = -4.9$, $p < 0.01$). A greater humeral retrotorsion side-to-side difference was associated with more GIRD.

Conclusion: Humeral retrotorsion accounted for 13.3% of the variance in GIRD. The stiffness of the superficial shoulder muscles and capsular thickness, as measured in this study, were not predictors of GIRD. Factors not assessed in this study, such as deeper muscle stiffness, capsule/ligament laxity, and neuromuscular regulation of muscle stiffness may also contribute to GIRD. Since it is the largest contributor to GIRD, causes of changes in humeral retrotorsion need to be identified. The osseous component only accounted for 13.3% of the variance in GIRD, indicating a large contribution from soft tissues factors that were not addressed in this study. These factors need to be identified to develop evidence-based evaluations and intervention programs to decrease the risk of injury in baseball players.

Keywords: Baseball; GIRD; Humeral retrotorsion; Muscle stiffness; Posterior capsule thickness

1. Introduction

Physical examination of the dominant (throwing) shoulder of baseball players consistently demonstrates glenohumeral internal and external rotation range of motion (ROM) adaptations when compared to the non-dominant (non-throwing) limb.[1–8] A typical baseball player presents with greater humeral external rotation (external rotation gain) and less internal rotation on the dominant limb (glenohumeral internal rotation deficit (GIRD))[2,3,6,9–11] compared to their non-dominant limb. GIRD is calculated as the difference in the maximum humeral internal rotation angle between the

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Peer review under responsibility of Shanghai University of Sport.

2095-2546/$ - see front matter
http://dx.doi.org/10.1016/j.jshs.2014.04.008

dominant (throwing) and nondominant (non-throwing) limbs.[12] A deficit of 10°−17° of internal rotation is common in the dominant arm of throwing athletes who have not suffered a shoulder injury.[2,6,13] Baseball players also present with significantly increased external rotation ROM when comparing the dominant shoulder to the non-dominant shoulder.[1,2,14] The external rotation gain tends to range between 8° and 12° and is offset with a corresponding decrease in internal rotation.[1] During the cocking phase of pitching and throwing, the high level of loading on the shoulder passive restraints may cause gradual stretching of the capsular collagen leading to an increase in external rotation ROM.[15−17] Increased external rotation ROM coupled with high joint forces can exceed the physiological limits of the shoulder joint, compromising joint stability.[15]

In baseball players it has been demonstrated that total range of motion (TROM) of the dominant (throwing) arm is equal to TROM of the nondominant (non-throwing) arm.[2,3,6] Some have hypothesized that TROM is more relevant for evaluating injury risk and that as long as internal rotation ROM loss is equal to external rotation ROM gain, there is not an increased risk for injury.[14] Side-to-side differences in TROM have previously been described as risk factors for the development of throwing related injuries in baseball players.[17]

When a loss in internal rotation ROM occurs on the dominant limb without an associated increase in external rotation ROM, pathological GIRD presents. It has also recently been suggested that pathological GIRD is more relevant to injury risk in overhead athletes than simply evaluating GIRD.[18] GIRD has previously been identified as a risk factor for shoulder and elbow injury, such as internal impingement,[4] superior labral lesions,[19] and ulnar collateral ligament injury.[20] For example, baseball players with 25° or more of GIRD are at an increased risk of shoulder and elbow injury[17] and pitchers with 20° or more of GIRD are twice as likely to sustain a throwing-related shoulder injury that limits their ability to pitch compared to those who did not have GIRD.[16]

While the exact causes of GIRD are unknown, it is commonly attributed to subtle microtrauma to the static and dynamic restraints of the glenohumeral joint from repetitive overhead throwing, contracture of the posteroinferior joint capsule, and osseous adaptation of the humerus.[2,5,6,13,21,22] Hypertrophic changes from the high distraction forces placed on the shoulder during repetitive throwing/pitching have been theorized to be the cause of thickening of the posterior glenohumeral capsule (in the dominant limb of collegiate baseball players) and has been correlated with lesser humeral rotation ROM.[13] Stiffness of the posterior shoulder musculature may also play a significant role in restricting internal rotation ROM. Hung et al.[22] demonstrated that stiffness of the teres minor, infraspinatus, and posterior deltoid correlated with a deficit in internal rotation in patients diagnosed with stiff shoulder. Similar to the posterior glenohumeral capsule, the hypothesis is that stiffness develops in the posterior shoulder musculature in order to counteract the distraction forces that occur during the throwing motion.

In addition to the soft tissue contributors discussed above, the amount of humeral rotation ROM is also a function of the amount of humeral retrotorsion present in the upper extremity.[2,5,6,21] Humeral retrotorsion represents the amount that the distal humerus is twisted relative to the proximal humerus. The contribution of humeral retrotorsion to humeral rotation ROM may be especially large in overhead athletes, given the torsional moments that are placed on the humerus during the act of throwing.[23] The dominant limbs of throwing athletes repeatedly show more humeral retrotorsion, shifting the glenohumeral rotation arc toward the external rotation direction, thus decreasing internal rotation.[2,5,6,24,25] This decreased internal rotation results in the deceiving appearance of having posterior shoulder hypomobility, prompting clinicians to prescribe a stretching program,[26,27] when in fact the soft tissue tightness may not be presented.

As part of the injury evaluation process, as well as during pre-participation screenings, humeral rotation ROM is measured to identify GIRD in overhead athletes.[14,28,29] When GIRD is identified, treatment that targets posterior shoulder structures is often prescribed, as the deficit in internal rotation ROM is theorized to result from tightness of the soft tissue in the posterior shoulder.[15,26−28,30] These treatments include stretching exercises to address muscle flexibility,[26,30] joint mobilization to address capsular tightness,[31] and other forms of manual therapy[32] to address neuromuscular abnormality. Yet ROM data that are obtained clinically and interpreted as measures of soft tissue tightness likely reflect contributions from capsuloligamentous, musculotendinous, and osseous components that affect the clinical interpretation. Those components include the amount of posterior glenohumeral capsule thickness, stiffness in the posterior shoulder musculature, and the amount of humeral retrotorsion present.[2,5,6,13,21,22]

Therefore, the purpose of this study was to determine the extent to which muscular, capsuloligamentous, and osseous factors contribute to ROM characteristics commonly seen in baseball players. By understanding which factors have the greatest relative contributions to clinical measures of range motion, clinicians can develop more effective interventions to reduce the incidence of injuries.

2. Materials and methods

2.1. Participants

Participants were male high school baseball players (junior varsity and varsity level) who participated on one of 12 high school baseball teams from across the state of North Carolina during the 2012 spring baseball season. One hundred and fifty-six high school baseball players were included in the current analysis (age = 15.9 ± 1.4 years; height = 178.4 ± 6.5 cm; mass = 74.1 ± 12.2 kg). Of the 156 players included in the analysis, 88% (140 players) experienced GIRD, with less internal rotation ROM on the dominant side compared to the non-dominant side (a more negative number indicates greater GIRD). Prior to participation, a parent/guardian of all