Horizontal Shoulder Abduction Is Associated With The Timing Of Arm Rotation In Baseball Pitching

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Disclosures:

Introduction: We have reported that the amount of horizontal abduction was correlated with shoulder joint load at maximum shoulder external rotation (MER) phase during throwing motion, and thus an increase in horizontal abduction of the shoulder can cause injuries in the anterior structures and internal impingement. Therefore, excessive horizontal abduction can be a factor closely related to undesirable pitching kinematics. However, causative factor for the increase in horizontal abduction has not been clarified. The purpose of this study was to clarify the factor of the increase in horizontal abduction angle by measuring the timing of arm rotation. We hypothesized that the increased horizontal abduction angle is associated with the timing of external rotation during cocking phase.

Methods: (Subjects) Motion analysis was performed for 322 pitchers with various skill levels. Subjects who could not throw a fast ball due to shoulder or elbow pain were excluded from the study population. Age of the subjects ranged from 8 to 38 years. All study participants read and signed a consent form prior to participation in this study.

(Motion analysis system) Throwing motion was recorded using an infrared motion capture system (ProReflexTM MCU-500+, Qualisys Inc., Gothenburg, Sweden) at Nobuhara Hospital. Seven charge-coupled device cameras were placed around a regulation-size pitching mound to provide an unobstructed 360° view. Thirty-six reflective plastic spheres were attached to the subjects’ skin on anatomical locations by an experienced physical therapist. Three-dimensional positions of the markers during the motion were recorded at a rate of 500 Hz by the cameras. Ball speed was measured using a speed gun (SpeedMax2, Mizuno Corp, Tokyo, Japan). After a standard warm-up sequence, each pitcher was asked to throw a fast ball from the pitching mound toward a home plate located 18.44 m from the pitching rubber. The pitcher performed three trials and the fastest pitch was adopted for analysis. Two high-speed cameras (HSV-500C3; NAC Image Technology Inc., Tokyo, Japan) synchronized at 500 Hz recorded the pitching motion to determine the point of ball release.

(Data analysis) Local coordinate systems were established on the following segments: hand, forearm, upper arm and trunk. These coordinate systems were defined mathematically based on the location of the anatomical landmarks. A four-rigid-body model was applied to the upper-body for kinematic analyses. The Euler angle sequence was used to describe horizontal abduction/adduction, abduction/adduction, and internal/external rotation angles of the upper arm relative to the trunk. Abduction of 90° was defined as a reference measurement plane for horizontal abduction/adduction. External/internal rotation of 0° was used as a reference with external rotation as positive and internal rotation as negative values. Horizontal abduction/adduction of 0° was used as a reference with horizontal adduction as positive and horizontal abduction as negative values. First, the time period from the stride-foot contact to the timing of internal/external rotation of 0° (TR0) was calculated for 243 subjects excluding those who did not show internal rotation position in cocking phase. In assessment of relationships among the parameters, regression analysis was employed for correlation between maximum horizontal abduction angle and TR0 as well as between maximum horizontal abduction and horizontal abduction angles at MER. For kinetic analysis, the inverse dynamics was applied to estimate the joint forces and moments at the wrist, elbow and shoulder. For each subject, the mass and the moment of inertia of each body segment were estimated based on the height and weight.

Results: The relationship analysis between TR0 and maximum horizontal abduction angle showed significant correlation (r=-0.46, p<0.01) (Figure1). Additionally, the increase in maximum horizontal abduction angle was significantly associated with the increased horizontal abduction angle at MER (r=0.39, p<0.01) (Figure2). Therefore, “Late External Rotation” caused increased maximum horizontal abduction and induced an increase in horizontal abduction at MER.
Figure 1: Relationship between the time period from the stride-foot contact to the timing of internal/external rotation of 0° (TR0) and maximum horizontal abduction angle showing significant correlation ($r=-0.46, p<0.01$). “Late External Rotation” causes an increased maximum horizontal abduction angle.
Figure 2: Relationship between maximum horizontal abduction angle and horizontal abduction angle at MER. Increase in maximum horizontal abduction was significantly associated with increased horizontal abduction at MER (r=0.39, p<0.01).

**Discussion:** Large anterior shear force caused by excessive horizontal abduction angle can induce increased tension in the anterior joint structures leading to shoulder injury and instability. Characteristic bony changes such as bone loss or erosion of the greater tubercle and posterior to the glenoid cavity may be indicative of impingement occurring at these sites with excessive horizontal abduction. Therefore, it is speculated that increased horizontal abduction during pitching may not only induce damage in the anterior structures but also cause internal impingement in the shoulder. Combination of these characteristic kinematic and kinetic features may represent as an inappropriate pitching motion. Moreover, the present study showed “Late External Rotation” was another factor leading to shoulder injuries associated with increased maximum horizontal abduction. (Conclusion) A significant correlation was demonstrated between the timing of arm rotation and maximum horizontal abduction angle of the shoulder during throwing motion as well as maximum horizontal abduction angle and horizontal abduction angle at MER. Based on these results, evaluation and correction of the throwing motion focusing on the timing of arm rotation in cocking phase may be a key to reduction of harmful stresses leading to shoulder injuries in pitchers. The biomechanical findings of this study offer the base of scientific feedback for optimization of throwing motion by preventing excessive horizontal abduction at the shoulder.
Significance: The biomechanical findings of this study offer the base of scientific feedback for optimization of throwing motion by preventing excessive horizontal abduction at the shoulder.

Acknowledgments:

References:

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