BIOMECHANICS OF PITCHING WITH INJURY IMPLICATIONS

Naiquan Zheng, Glenn S. Fleisig, Steve B. Barrentine, James R. Andrews

American Sports Medicine Institute, 1313 13th Street South, Birmingham, AL 35205
Email: nigelz@asmi.org URL: http://www.asmi.org

INTRODUCTION

Shoulder and elbow are the two most commonly injured joints of baseball pitchers. Their injury mechanisms are still not known. Applications of biomechanics may provide some insights. An understanding and application of proper throwing mechanics may also improve performance and reduce the risk of injury. Motions, forces and torques at the shoulder and elbow during pitching are presented and discussed with related injuries.

METHODS

Twenty-nine healthy professional and college baseball pitchers were tested in an indoor laboratory as previously described (Fleisig et al, 1995). Fourteen reflective markers were placed on bony landmarks. Three-dimensional coordinates were determined with an automatic digitizing system (Motion Analysis Corporation, Santa Rosa, CA). Marker position data were filtered with a 13.4 Hz low-pass fourth-order Butterworth filter. Data were normalized in time, based upon the time of lead foot contact (0%) and ball release (100%) before averaging. Using inverse dynamics, shoulder kinetic parameters were calculated as the force and torque applied by the trunk to the upper arm (Fleisig et al., 1995). Similarly, elbow kinetics was calculated as the force and torque applied by the upper arm to the forearm.

RESULTS

The ball speed was 38.1±0.7 m/s with the range of 37.1 to 40.2 m/s. The interval from foot contact to ball release for the group averaged 0.139±0.002 seconds. The axial rotation of the spine decreased during stride phase, reaching its minimum at foot contact (-51.4±9.6°). It reached neutral position (-0.9±0.2°) at ball release. The lateral bending of the spine at foot contact was 1.6±5.5°. The spine bent laterally 28.2±6.2° at ball release. The shoulder was abducted 94±9° and horizontally abducted 7±7° at ball release. The shoulder externally rotated about 50° at foot contact and reached 177±7° shortly before ball release (Fig. 1). The elbow angle was about 82° at foot contact and extended to 158±6° at ball release.

Fig. 1 Shoulder external rotation during pitching (the radius stands for time in millisecond, normalized from foot contact (140 ms) and ball release (279 ms)).

Based upon the force and torque at the shoulder and elbow, there were two critical instants. The first occurred near the maximum external rotation of the arm. At
this instant a maximum varus torque of 64±12 Nm was generated at the elbow. In addition, a 16 Nm flexion torque, 300 N medial force, a 160 N anterior force and a 270 N proximal force were produced at the elbow. The second critical instant for the shoulder occurred immediately after ball release. At this instant, a maximum proximal force of 1070±120 N was generated. In addition, an anterior force of 80 N, an inferior force of 100 N, a 26 Nm adduction torque and a 44 Nm horizontal adduction torque were produced at the shoulder.

DISCUSSION

The UCL and articulation between the radial head and humeral capitellum withstood valgus torque applied by the forearm to the elbow. Fleisig et al (1995) reported that the load on the ulnar collateral ligament (UCL) during pitching is near its maximum capacity. The corresponding elbow injuries include UCL tear, muscle tears, avulsion fractures, lateral elbow compressive injury. The varus torque and rapid extension of the elbow explains the mechanism of olecranon impingement. The shoulder externally rotated about 180 degrees and internally rotated at 7000 deg/sec before ball release. As the abducted arm externally rotated at the shoulder, the humeral head translates anteriorly. At maximum external rotation, the posterior rotator cuff may become impinged between the glenoid labrum and the humeral head. This “over-rotation” injury can cause degeneration of both the superior labrum and the rotator cuff. Muscles and other soft tissues at the shoulder generate over 1000 N to stop the rapidly moving arm during arm deceleration. Such large proximal force plus internal rotation and horizontal adduction at the shoulder might be the cause of rotator cuff tear, impingement, and the labrum degeneration.

At ball release, the spine had little axial rotation and the shoulder had little horizontal adduction. Excessive spine axial rotation will result in the pitching arm being behind the ball release zone, which would require a pitcher to have significant shoulder horizontal adduction to compensate for the excessive spine rotation. Such shoulder horizontal adduction at ball release may shift the humeral head to the rim of the glenoid fossa, causing the humeral head to be reseated off-center and placing the labrum in jeopardy for injury. At ball release, the spine laterally bent about 28° to raise the pitching arm. In order to keep the desired position of the forearm at ball release a pitcher may compensate for any loss of lateral bending by extra shoulder abduction. Such compensation may cause high stress and impingement of the shoulder.

SUMMARY

Baseball pitching is one of most demanding activities of the shoulder and elbow. The shoulder had about 180 degrees external rotation with internal rotation velocity of 7000 deg/sec. Two critical instants, one during arm cocking and the other after ball release, had high forces and torques at the shoulder and elbow. They were found related to the shoulder and elbow injuries. More research is needed to identify factors related to these injuries. A biomechanical model of the shoulder with detailed structures may find direct relation of the force and torque at the shoulder to these injuries. Studies correlating kinematics and incidence of injury would also be helpful.

Reference: