KINETIC COMPARISONS BETWEEN AMERICAN AND KOREAN PROFESSIONAL BASEBALL PITCHERS

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INTRODUCTION

With numerous professional baseball leagues throughout North America, South America, Asia, and Australia, pitching mechanics are likely to be taught differently according to cultural influences. Since several kinematic differences have previously been reported between American and Korean professional pitchers (Escamilla et al. 1999), it is hypothesized that kinetic differences may also exist. Fleisig et al. (Fleisig et al., 1995) have proposed several injury mechanisms that may be associated with baseball pitching kinetics. Therefore, the purpose of this study was to quantify and compare shoulder and elbow kinetic data between American and Korean professional pitchers, and provide possible injury implications for these two groups.

MATERIALS AND METHODS

Eighteen healthy professional baseball pitchers served as subjects. The American group (n=11) were born and raised in the United States and pitched for minor and major league teams. The Korean group (n=7) were born and raised in Korea, and pitched for the Korean Dolphins. The American group had a mean mass, height, and age of 83.4±5.2 kg, 1.81±0.10 m, and 22.6±3.5 y, respectively, while the Korean group had a mean mass, height, and age of 76.9±8.7 kg, 1.77±0.11 m, and 25.1±4.1 y, respectively. Reflective markers were attached bilaterally at the lateral malleoli, lateral femoral epicondyles, greater femoral trochanters, lateral superior tip of the acromions, lateral humeral epicondyles, and wrists. Shoulder and elbow joint center locations of the throwing arm were calculated in each time frame. Data were collected for 8-10 fastball pitches thrown with 100% effort from an indoor pitching mound towards a strike zone located at regulation distance. A Motion Analysis four-camera automatic digitizing system was used to collect 200 Hz video data. Eleven kinetic parameters were measured during the arm cocking (lead foot contact to maximum shoulder external rotation), arm acceleration (maximum shoulder external rotation to ball release), and arm deceleration (ball release to maximum shoulder internal rotation) phases of the pitch. Shoulder and elbow kinetics were calculated utilizing inverse dynamics. Kinetic data were averaged for the three fastball trials with the highest ball velocity and that were thrown for strikes. Unpaired t-tests were used to assess significant kinetic differences ($p<0.05$).

RESULTS AND DISCUSSION

Kinetic comparisons are shown in Table 1. Kinetic differences are probably due more to kinematic differences than anthropometric differences, since there were no significant differences in body weight and body height, but several kinematic differences were observed between the two groups (Escamilla et al., 1999). Kinetic differences may also help explain the 10% greater ball velocity by the American group (38±1 m/s vs. 35±1 m/s).

The 29% greater maximum shoulder internal rotation torque observed in the American group suggests that the shoulder internal rotators may be more active in this group. These muscles contract eccentrically during

the arm-cocking phase in order to control the rate of shoulder external rotation (DiGiovine et al., 1992). Elbow varus torque reached its maximum value during the arm-cocking phase, with the American group generating 33% more torque. This greater varus torque may in part be due to maximum shoulder external rotation being 15° greater in the American group compared to the Korean group (Escamilla et al., 1999). Since varus torque is needed to resist elbow valgus stress, this stress may be greater in the American group. This can lead to an increased injury risk in the UCL. Radiocapitellar compression injuries are also at a higher risk, such as avascular necrosis, osteochondritis dissecans, and osteochondral chip fractures (Fleisig et al, 1995). Maximum elbow flexor torque occurred during the arm acceleration phase to help decelerate the rapid rate of elbow extension. This torque was 33% greater in the American pitchers. The elbow flexors, which help generate this torque, have shown moderate activity during the arm acceleration phase (DiGiovine et al., 1992). Hence, the elbow flexors may be more active in the American group compared to Korean group. The final significant differences were maximum elbow and shoulder proximal forces, which occurred during the arm deceleration phase. These forces, which were approximately 25-30% greater in the American group, are needed in order to help resist shoulder and elbow distraction. These were the largest forces generated during the pitch, being in excess of body weight. The greater shoulder and elbow forces and torques generated by the American group may predispose this group to a higher risk of injury to elbow and shoulder structures, such as rotator cuff tensile failure (Fleisig et al.,1995).

Since all kinetic parameters were quantified through inverse dynamics, the actual forces generated across the articulating surfaces of the shoulder and elbow still remain unknown. In order to accurately calculate these forces, shoulder and elbow muscle and ligamentous forces would need to be determined. Due to complexity of the elbow and shoulder joints, mathematical modeling and computer optimizations are needed to help estimate these articulating forces. There are currently no known modeling or optimization programs that have been employed to calculate these articulating forces during baseball pitching. This should be the focus of future baseball pitching studies.

REFERENCES

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Table 1. Mean (M±SD) max shoulder (Sh) and elbow (Elb) forces (N) and torques (N·m) between American and Korean pitchers.

	American (n = 11)	Korean (n = 7)
Arm-Cocking Phase		
Sh anterior force	360±70	350±75
Sh horiz adduction torque	98±15	86±21
Sh internal rotation torque*	**63±10**	**49±10**
Elb medial force	295±55	260±55
Elb varus torque**	**61±10**	**46±7**
Arm Acceleration Phase		
Elb flexor torque**	**56±12**	**42±6**
Arm Deceleration Phase		
Sh proximal force**	**1090±160**	**830±165**
Elb proximal force**	**900±125**	**725±135**
Sh adduction torque	87±31	81±15
Sh posterior force	340±120	315±85
Sh horiz abduction torque	77±35	68±17

*$p < 0.05$; **$p < 0.01$