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KINETIC COMPARISON OF UPPER EXTREMITY BETWEEN FASTBALL AND CURVEBALL IN BASEBALL PITCHING MODELING: A CASE STUDY

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INTRODUCTION

To prevent injury, breaking ball can't be thrown in youth baseball game. But previous studies showed that breaking balls, just like curveball, may not be more potentially harmful than the fastball for youth and adult pitchers [1, 2, 4]. The aforementioned references reported on inverse dynamic analysis by rigid body segments without soft tissues (muscles, tendons, and ligaments), and it is well-known that the computed joint reaction forces in the absence of muscle forces may be severely underestimated. The purpose of the current research was to calculate the joint torques and joint reaction forces of upper extremity with muscles in the AnyBody Modeling System in baseball pitching in order to investigate the risk of upper extremity injuries on fastball and curveball pitching.

METHODS

One elite Taiwanese male college baseball pitcher (age: 20 years old, body height: 177 cm, body weight: 75 kg, maximum ball velocity: 42.2 m/s) who played in the first class college league volunteered to participate in the research. A radar gun (Stalker Sport speed gun, Applied Concepts Inc., Plano, TX, USA) was used to measure the ball velocity, a motion analysis system (Eagle System, Motion Analysis Corporation, Santa Rosa, CA, USA) was used to measure the position data of reflective markers, and two force plates (AMTI BP600900 & BP400600, Advanced Management Technology Inc., VA, USA) were used to measure the ground reaction force. 40 reflective markers were placed bilaterally at bony landmarks of the participant. After warming up with his own routine, the participant was asked to throw three fastball and three curveball randomly from an indoor mound to a strike-zone-size target located about 9 m away. The data of the fastest strike pitches were used for the analysis. Marker position data were filtered with a low-pass Butterworth filter and output as a C3D file by the Cortex 1.1.4 software. The cut-off frequency of each marker was decided by residual analysis [5] and ranged between 5 Hz and 25 Hz. The 3D musculoskeletal model of the full body, named GaitFullBody, was downloaded and modified from an open-source repository of the AnyBody Modeling System (AnyBody Technology A/S, Aalborg, Denmark). There were 62 segments and 131 muscles in this model, and the 7 segments that we focused on were clavicula, scapula, humerus, ulna, radius, wrist-joint-segment, and hand. After importing the C3D file of the marker position and the ground reaction force data, the body height, weight, body segment parameters and the length of segment, marker position and starting position were set to fit the trial. An object (with official baseball size and weight) was attached to the hand segment to simulate the inertia effect of the baseball. Then the model was set to move with the markers and a motion and parameter optimization was executed to optimize the kinematic parameters and the model scaling to the experimental data. Subsequently an inverse dynamic analysis was executed to calculate the forces in the mechanical system with muscles included in the model.

RESULTS AND DISCUSSION

The elbow varus torque of curveball pitching during arm cocking phase was greater than fastball (as Fig. 1). The valgus forces that generated during the late cocking phase can cause micro tears of the ulnar collateral ligament, with subsequent weakening and laxity of the ligament [3], and UCL reconstruction is commonly performed in major league pitchers.

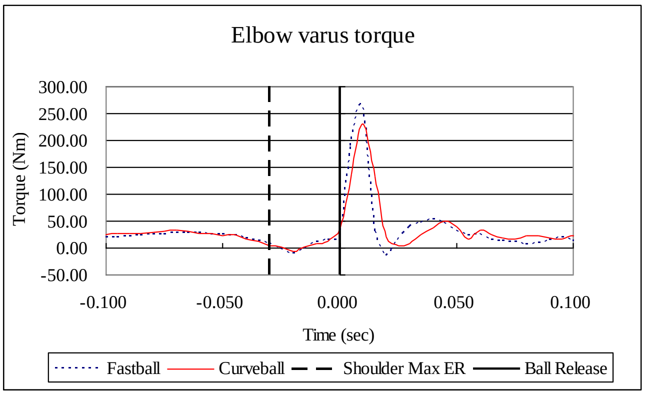

Fig. 1 Comparison of elbow varus torque from arm cocking phase to arm deceleration phase between fastball and curveball pitching

CONCLUSIONS

Curveball may produce larger elbow varus torque than fastball during arm cocking phase. At least, curveball may be harmful as fastball.

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Reference	Fleisig et al. (2006)		Nakamura et al. (2010)		Current research	
Subjects	21 American collegiate pitchers		14 Japanese adult pitchers		1 elite Taiwanese pitcher (NPB)	
Pitches	FB	CB	FB	CB	FB	CB
Ball velocity (m/s)	35±1	29±1	33.1±1.73	27.4±2.08	35.3	26.9
Arm cocking phase						
Shoulder IR torque (Nm)	84±13	81±14	59.7±9.42	56.5±8.67	130.25	122.65
Elbow varus torque (Nm)	82±13	79±14	60.2±10.15	59.0±10.22	26.89	32.76
Shoulder anterior force (N)			332.3±48.72	314.9±45.06	518.31	493.98
Shoulder proximal force (N)			454.1±104.03	418.3±111.06	203.17	185.29
Elbow anterior force (N)			226.8±47.03	225.2±48.15	-461.85	-416.21
Arm acceleration phase						
Wrist flexion torque (Nm)	6±4	7±4			12.48	3.72
Forearm pronation torque (Nm)	5±4	5±3			5.37	3.72
Elbow flexion torque (Nm)	40±9	41±16	49.9±7.74	43.8±9.99	47.67	37.56
Shoulder proximal force (N)	1057±157	998±155			1238.95	1077.82
Elbow proximal force (N)	988±110	934±103			-1622.94	-1609.16