SHOULDER JOINT VELOCITY DURING FASTBALL PITCHING IN BASEBALL

Xavier Gasparutto[1], Erik van der Graaff[2] , Frans van der Helm[1] and Dirkjan Veeger[1,2]

Sports Engineering Institute, Delft University of Technology, Delft, The Netherland[1]
MOVE Institute, Vrije Universiteit Amsterdam, Amsterdam, The Netherland[2]

The purpose of this study was to assess the rotation and translation velocity of the shoulder complex during fastball pitching in baseball. 8 pitchers from the Dutch AAA team performed each 3 fastball pitches. Their motion was recorded by an opto-electronic device. Kinematic computation was performed using the quaternion algebra. The results showed that the endo-rotation, depression and backward rotation velocity of the humerus at ball release are initiated by a translation of the scapular girdle in the forward and upward direction before ball release.

KEY WORDS: baseball, pitching, upper limb, shoulder, velocity

INTRODUCTION: Pitching in baseball is one of the most studied motion in sports biomechanics (Elliott et al. 1986, Fleisig et al. 1999, Matsuo et al. 2001, Werner et al. 2008, Naito et al. 2014). However when analysing the motion of the shoulder complex during pitching, most of the studies only look at the motion of the humerus relative to the thorax. This study aims at describing the motion of the shoulder complex in a more detailed way by computing the rotational velocity and the translation velocity at the shoulder. The translation motion is due to the scapular girdle mobility and is seldom taken into account.

METHODS: 8 pitchers from the Dutch AAA team (age: 16.1 ± 0.7years, size: 1.82 ± 0.8m, weight: 76.9 ± 8.1 kg) participated in this study. The Faculty of Human Movement Sciences' local ethical committee approved this research project. Informed consent was signed by the participant and/or their legal tutor. After a proper warm up, the pitchers were equipped with skin markers, including 6 markers on the throwing upper limb and 4 markers on the thorax. Then, they were asked to perform 5 fastball pitches from a portable pitching mound. 3 pitches per players were used in this study. The motion of the markers was recorded by a 10-camera (T40S, 100Hz) VICON motion capturing system.
The proposal from the ISB (Wu et al. 2005) was used for the definition of the local coordinate systems (LCS) and joint coordinate systems (JCS) of the upper limb and thorax. Regression equations adapted in the ISB conventions were used to estimate the gleno-humeral (GH) joint position (Dumas et al. 2007) and the scapular motion (Pascoal, 2001). Segment and joint angular velocity were computed using the quaternions algebra (Dumas et al. 2004). The angular velocity of the humerus with respect to the scapula was projected on the shoulder JCS using a non-orthonormal projection (Desroches et al. 2010). The linear velocity of the shoulder joint was computed as the derivative of the position of the GH joint center in the thorax coordinate system and expressed in the thoracic LCS. The time for ball release was estimated as the time of maximal linear velocity of the marker fixed on the interphalangea distalis III.

RESULTS: Concerning the shoulder rotation velocity (figure 1), before ball release the results showed: a maximal elevation velocity of -1360 ± 435 deg.s^{-1} and a maximal exo-rotation velocity of -2400 ± 810 deg.s^{-1}. This motion is immediately followed at ball release by: a maximal backward rotation velocity of -2000 ± 800 deg.s^{-1}, a maximal depression velocity of 1300 ± 670 deg.s^{-1} and a maximal peak of endo-rotation of 3100 ± 1000 deg.s^{-1}. The results on the shoulder linear velocity (figure 2) showed before ball release: a maximal velocity peak of -0.4 ± 0.2 m.s^{-1} in the backward direction followed by a maximal peak of 0.9

± 0.2 m.s^{-1} in the forward direction, a maximal peak of 0.5 ± 0.1 m.s^{-1} in the downward direction followed by a maximal peak of 0.55 ± 0.2 m.s^{-1} in the upward direction and a maximal peak of -0.7 ± 0.2 m.s^{-1} in the medial direction. At ball release the linear velocity has a peak of 0.5 ± 0.2 m.s^{-1} in the forward direction and a peak of 0.2 ± 0.1 m.s^{-1} in the lateral direction, the upward/downward velocity is close to 0 m.s^{-1}.

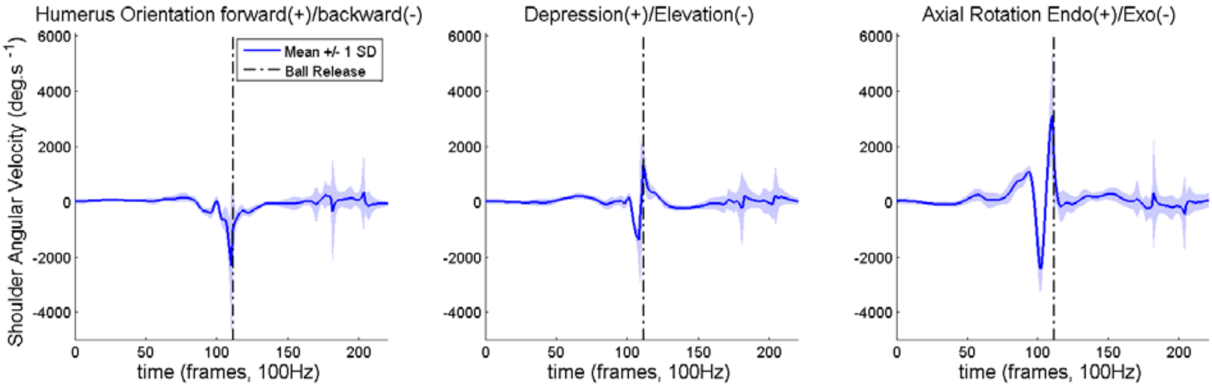

Figure 1: Shoulder angular velocity in the shoulder JCS

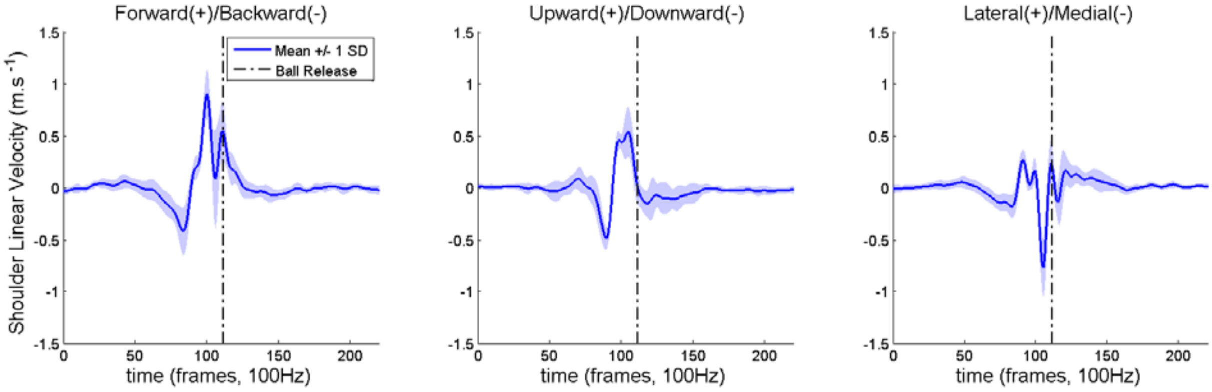

Figure 2: Shoulder linear velocity in the thorax LCS

DISCUSSION: Those results show that during pitching the shoulder complex motion starts with a translation motion in the backward and downward direction during the preparation of the throw followed by a forward and upward motion initiating the shoulder endo-rotation and depression and backward rotation. The sequential motions of the shoulder complex suggest the existence of a kinematic chain in the upper limb including the shoulder motion as one of its link. Further studies are needed to test this hypothesis and to assess the contribution of the shoulder linear velocity to the ball velocity.

The angular velocity were lower than the angular velocities reported in the literature. In a review on baseball pitching, Oyama (2014) reported maximal internal rotation of the shoulder between 6000 and 7000 deg.s^{-1} and Naito et al. (2014) reported maximal internal rotation of the shoulder of 4500 deg.s^{-1}. Those difference could be explained by the fact that we studied the relative motion of the humerus with respect to the scapula whereas those studies looked at the relative motion of the humerus relative to the thorax, thus taking into account the motion of the scapular girdle.

The lateral/medial translation in the shoulder joint can be explained by the fact that the translation motion can be seen as the rotation of the scapular girdle. However we chose in this study to compute it as a linear motion to underline this movement of the scapular girdle.

The main limitation of this study is the use of regression for the scapular motion. The measurement of scapular motion during pitching will be done in further studies.

CONCLUSION: This study assessed the rotation and translation velocity of the shoulder complex during pitching. The results showed that the endo-rotation, depression and backward rotation velocity of the humerus is initiated by a translation of the scapular girdle in the forward and upward direction before the ball release suggesting the existence of a kinematic chain in the upper limb. However this study didn't estimate the contribution of the scapular girdle linear velocity to the ball velocity. This will require further investigation.

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