ROTATION CHARACTERISTICS OF THE SHOULDER, TORSO, AND PELVIS DURING PITCHING FOR TAIWAN ELITE AND SUBELITE COLLEGIATE BASEBALL PITCHERS

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INTRODUCTION

Many kinematic variables from each phase of the baseball throw have been identified as being important to maximal throwing velocity[1] as well as to the potential for injury, especially in the elbow, shoulder, and hip joints. Although torso motion can produce high force relative to distal extremeties, very few of the trunk kinematic variables were described, only trunk tilt and later trunk tilt angle, trunk flexion [2,3].

However, trunk rotation and twist rotation in terms of the stretch X-factor, which in golf is the difference between shoulder and pelvis rotation during the swing, have not been studied for the baseball throw. It is believed that extra stretch during the early down swing allows the upper-body muscles to contract more forcefully and hence to provide more power. Therefore, this study investigates kinematics of the upper torso and pelvis, including the horizontal rotation of upper torso and pelvis, twist of the trunk (i.e., the X-factor, the difference of the included angle between shoulder and pelvis), and flexion of the trunk during windup, stride, arm cocking, arm acceleration, arm deceleration and follow-through [4]. Integrated study of the torso, shoulder, and pelvis motions may not only contribute to pitching strategy, but also could be helpful to reduce the harm to the shoulder. Through studying Taiwan Elite pitchers and subelite pitchers who usually has less muscle mass and weight, and different pitching pattern compared to west pitchers.

METHODS

3D motion data of the entire body during fastballs thrown by ten collegiate pitchers were collected at 250 Hz by seven high speed cameras attached to a VICON 3D motion analysis system (Oxford Metrics, UK) . Pitchers were chosen from the top four collegiate teams in Taiwan, and represented both elite and sub-elite groups.. Reflective markers were attached at multiple points on the entire body of subjects.. Using calculated 3D positional data of the entire body, kinematic characteristics of the pitch, including horizontal rotation of upper torso and pelvis, twist of trunk (X-factor), and trunk flexion of trunk were obtained. X-factor, the difference of the included angle between shoulder and pelvis from maximum backward twist to ball release, was illustrated in Figure 1.

(a) at max. backward twist (b) at release

Figure 1: Definition of X-factor: (a) and (b) are top-view of the subject, X-factor is equal to $\theta_r - \theta_b$, where θ_r is negative.

RESULTS AND DISCUSSION

Representative data from the two groups are presented in Table 1. Elite pitchers exhibited proper sequential movement of the entire body, with a greater angular velocity of twist and flexion motions, and larger X-factors. They also pitched faster, and the net torques at the shoulder before ball release, as calculated by inverse dynamics, were higher.

Such proper mechanics also delay the onset of fatigue, leading to more consistent performance [5]. In the long term, overuse injuries, which may result from cumulative microtrauma, may be reduced through utilizing aforementioned techniques.

CONCLUSIONS

The experimental data may give more detail look to the integrated shoulder, torso, and pelvis motion. Greater range and speed of trunk flexion and twist rotation demonstrate better ball speed performance. The results confirmed the point of view that the motion of trunk, in proper order, is also an important factor to the speed of pitched ball [6] and help to achieve the optimal pitching and contribute to injury prevention of shoulder in baseball players.

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Table 1 The rotation variables of shoulder, torso, and pelvis in pitching motion from elite and subelite picthcers

	Speed of ball	Trunk flexion angle	Max. flexion angular speed	X-factor stretch (twist angle)	Max. twist angular speed	Max. net torque at shoulder
Sub-elite	35.25 m/s	32.73 °	309.63 °/s	66.12 °	733.14 °/s	52.6 N-m
Elite	36.93 m/s	42.89 °	454.03 °/s	88.31 °	943.70 °/s	57.6 N-m