A New Approach for Assessing Kinematics of Torso Twist in Baseball Batting: A Preliminary Report

Yoshitaka Morishita[1], Toshimasa Yanai[2], Yuichi Hirano[1]

Department of Sports Sciences, Japan Institute of Sports Sciences, Tokyo, Japan[1]
School of Sports Sciences, Waseda University, Saitama, Japan[2]

KEYWORDS: projection angle, proximal-distal pattern, pelvis, thorax, shoulder girdles

INTRODUCTION: The motions of segments involved in striking and throwing events are generally sequenced in a proximal-to-distal fashion (Putnam 1993). Welch et al. (1995) analyzed baseball batting using a rigid-body-link model with a two-segment torso, and indicated the importance that the lower torso starts rotation in the direction of pitcher before the upper torso, which, in turn, should start before the arm segments. Also, this sequential motion is considered to allow the kinetic link system to generate synergy between the musculature of the torso and upper extremity. Specifically, the upper torso is expected to have an important function to accelerate distal upper extremity and bat. However previous studies employed a two-segment torso model and the influence of the motions of the shoulder-girdles to the torso's sequential action for twisting was ignored. In the present study, torso's sequential twisting was analyzed with a three-segment torso model, and the kinematics of torso twist in baseball batting was evaluated.

METHOD: Two male collegiate baseball batters (height: 175.3 ± 2.5 cm, mass: 65.1 ± 0.2 kg, age: 19 yr) participated in this study. After performing sufficient warm-up, they engaged in a series of batting trials using a batting tee. Each subject was asked to adjust the horizontal position of the batting tee and the height of the tee was set at the level of his anterior superior iliac spines (ASISs). Each subject was instructed to hit the ball towards center field with maximal effort. The experiment was continued until three successful batting trials were recorded with an optical motion capture system (VICON-MX, Oxford Metrics Inc.) at the sampling rate of 500Hz. The positions of acromions (ACs), ASISs, sternal notch (SN), xiphoid process (XP), seventh cervical spine (C7), eighth thoracic spine (T8), ASISs, and posterior superior iliac spines (PSISs) were measured in the global coordinate system (Gs) to formulate a three-segment torso model. For the trial in which the fastest bat-head velocity was attained, the orientations of the upper, middle, and lower torso segments were determined. The orientations of the lower torso (pelvis) and the upper torso (shoulder girdles) were defined as the horizontal projections of the vector connecting ASISs and of the vector connecting ACs, respectively (Fig. 1). The orientation of the mid-torso (throax) was defined as the horizontal projection of the cross-product computed from the vector pointing from C7 to SN and the vector pointing from center of SN and C7 to the center of XP and T8. The orientation of each segement was then expressed as the angle measured from the Y-axis. The angular velocity of each segment was also calculated as the time derivative of the angle.

The accuracy in defining the three-segment torso model with the present approach was assessed by determining the root mean square errors (RMSE) of the lengths and the angles of the quadrangles representing the segments of thorax and pelvis computed over the analysis interval (200 ms).

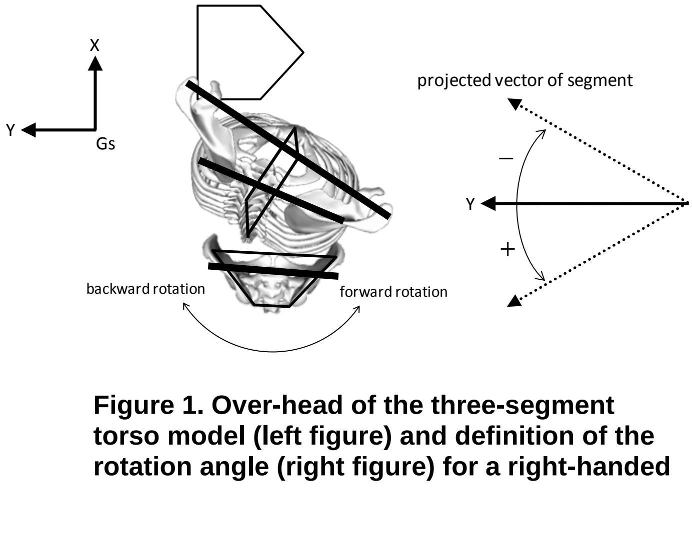
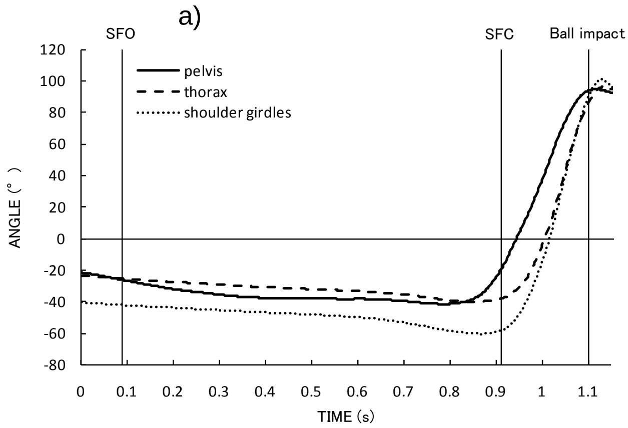


Figure 1. Over-head of the three-segment torso model (left figure) and definition of the rotation angle (right figure) for a right-handed

RESULTS: The accuracy of the three-segment torso model was reasonable for the present study (RMSE of 0.3 cm and 0.5° for pelvis segement and 0.4 cm and 1.5° for thorax segment, respectively). At step foot off (SFO), the orientations of the pelvis and thorax were angled to face slightly backward by a similar amount (-25 ± 1° and -21 ± 1°, respectively) and that of the shoulder girdles was angled even more in the same direction (-35 ± 7°). Shortly before the instant of step foot contact (SFC), the pelvis initiated rotation, and the thorax and shoulder girdles followed it simultaneously at SFC (Fig. 2a). The ranges of motion were approximately 120° for the pelvis and thorax and 144 ± 7° for the shoulder girdles. The pelvis recorded the peak angular velocity at 1.012 s after SFC (Fig. 2b), and 0.028 s later the thorax and shoulder girdles attained the peaks (1165 ± 49°/s and 1007 ± 78°/s, respectively).



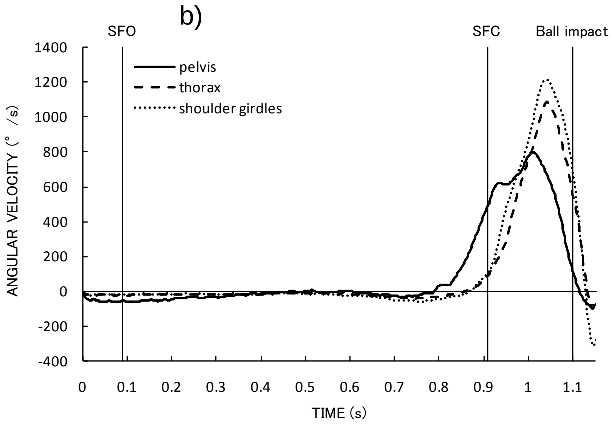
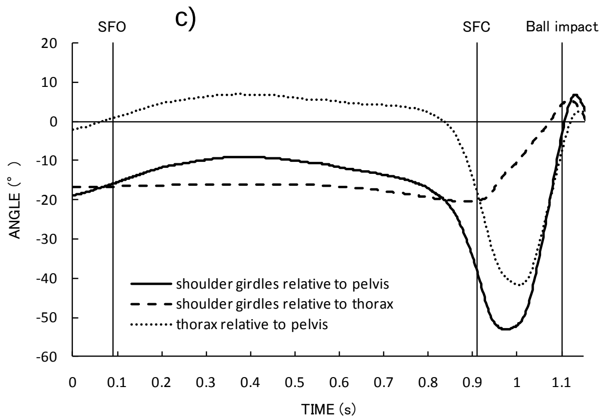


Figure 2. A typical pattern of change in angular displacement (a) and velocity (b) of pelvis, thorax and shoulder girdles, and the relative angles (c) of each segment.



DISCUSSION: The difference in the angles between the pelvis and thorax indicates the twisting of the thorax relative to the pelvis (Fig. 2c). The accumulated twist up to 0.1 s prior to the ball impact was returned completely by the ball impact. This accumulation-return of twist might produce a stretch-shortening effect. The delayed timings at which these segments attained the maximum angular velocity indicate that the pelvis and thorax move with the proximal-distal pattern. In contrast, no difference in timing was found between the thorax and shoulder girdles suggests that the proximal-distal pattern, and also the stretch-shortening effect, does not exist between these segments.

CONCLUSION: With the new kinematic model, the pelvis and thorax were found to move in a proximal-distal sequence, and their twist-accumulation was followed by immediate return observed within 0.2 s suggests an involvement of stretch-shortening cycle. The thorax and shoulder girdles did not demonstrate such patterns during baseball batting.

REFERENCES:

Putnam, C.A. (1993). Sequential Motions of Body Segments in Striking and Throwing Skills. *Journal of Biomechanics*, 26(Suppl. 1), 125-135.

Welch, C.M., Banks, S.A., Cook, F.F. and Draovitch, P. (1995). Hitting a Baseball: A Biomechanical Description. *Journal of Orthopaedic & Sports Physical Therapy*, 22(5), 193-201.