CHANGES IN THE TRANSFER OF ANGULAR MOMEMTUM THROUGH FATIGUE AFTER 120 BASEBALL PITCHES

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INTRODUCTION: The purpose of this study was to clarify the changes in the angular momentum of the system in three stages (early stage, middle stage and final stage) of fatigue during 120 baseball pitches, and to compare the transmission of angular momentum to the arm-plus-ball system in the three stages of fatigue.

METHODS: One hundred twenty fastball pitches by three Japanese male varsity pitchers were videotaped using three-dimensional (3D) DLT procedures. The 3D coordinate data of the body landmarks were obtained for three pitches of each subject, selected from the early, middle and final fatigue stages during 120 baseball pitches. The coordinates were expressed in an orthogonal reference frame: The X axis pointed toward the right (normal to the direction of the throw), the Y axis forward, and the Z axis upward. The location of the center of mass and the angular momentum values of 16 body segments and of the ball were calculated using a method based on Dapena (1997). The 3D angular momentum of the body-minus-arm, arm-plus-ball and combined system were calculated for three instants: (1) the plant of stride foot (PSF), (2) the mid-point of double support phase, and (3) the ball release (BRL).

Table 1. Angular momentum ($kg{\cdot}m^2/s$). (Mean±SD)

	Early stage			Middle stage			Final stage		
Times:	1	2	3	1	2	3	1	2	3
	PSF		BRL	PSF		BRL	PSF		BRL
H_X									
body-minus-arm	-16±5	-10±3	-3±1	-12±9	-10±6	-5±3	-13±8	-6±7	-5±5
arm-plus-ball	-3±1	-12±3	-23±1	-3±1	-11±4	-24±2	-4±1	-12±4	-23±2
system	-20±5	-22±6	-26±2	-15±10	-21±10	-29±6	-17±9	-18±11	-28±6
H_Y									
body-minus-arm	-13±1	-17±5	-6±1	-8±3	-15±2	-6±2	-11±3	-11±2	-7±2
arm-plus-ball	4±3	8±1	-2±1	3±3	7±1	-2±2	4±3	7±1	-2±1
system	-10±2	-10±6	-7±2	-4±1	-8±3	-8±4	-6±0	-5±1	-9±3
H_Z									
body-minus-arm	14±2	14±2	7±2	16±3	14±2	6±3	15±3	13±1	5±1
arm-plus-ball	2±2	6±1	11±2	2±3	6±2	11±3	3±2	6±1	11±2
system	16±2	21±1	18±4	18±1	19±2	16±6	18±1	19±1	16±3

RESULTS AND DISCUSSION: Average angular momentum values for the three pitches of each fatigue stage are shown in Table 1. To facilitate the following discussion, the terms "clockwise" (CW) and "counterclockwise" (CCW) will replace the signs of the X, Y and Z angular momentum components; the directions will correspond to views from the right, from behind and from overhead for the HX, HY and HZ angular momentum components, respectively. The angular momentum changes in all three stages of fatigue were similar to those of our previous study (Miyanishi et al., 2003). In the following discussion, we will concentrate on the differences in the transmission of angular momentum in the three fatigue stages, except the HZ angular momentum, because the transmission of this angular momentum was quite similar in the three fatigue stages, as shown in Table 1. During the 1st half of DS there was a loss of CW HX of the body-minus-arm in all three fatigue stages, but particularly for the final fatigue stage, with a change from a CW HX of 13 kg·m2/s at PSF to a CW HX of 6 kg·m2/s at the mid-point of DS. There was a constant gain of CW HX of the arm-plus-ball in all three fatigue stages during both the 1st half and the 2nd half of DS. During the 1st half of DS there was a gain of CCW HY of the body-minus-arm in both the early and middle fatigue stages. However, in the final fatigue stage, the angular momentum did not change during this period (CCW HY of 11 kg·m2/s at PSF and CCW HY of 11 kg·m2/s at mid-point of DS). These results indicate that the throwing arm segments for the final fatigue stage should be needed to produce much more angular momentum than that for the earlier fatigue stages in order to compensate for the loss of angular momentum produced by other body segments (mainly legs and trunk).

REFERENCE:

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