A Kinematic Analysis of the Upper Body during Progressive Baseball Swings

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INTRODUCTION:

Baseball is a popular, yet challenging sport played by approximately 15.9 million people in the United States each year. Repetitive hitting and throwing is associated with an increased potential for injury, especially about the upper extremity. Interval programs are a mainstay in rehabilitation following injury to progressively reintroduce the specific demands of sport to affected tissues. Such progressions often include multiple swing types, such as dry swings, tee hitting, soft toss, and hitting off a pitching machine, performed at increasing effort levels. Despite numerous studies on return to pitching programs, no studies to date have analyzed the phases of a progressive return to hitting program with respect to the physiologic demands seen in the upper extremities. When rehabilitating an injury to the shoulder, elbow or wrist, and whether it is on the lead arm (bottom hand) or back arm (top hand), may require that the hitting progression be tailored based on these results. The purpose of this investigation was to compare upper extremity kinematics during a progressive return to hitting program with five distinct swing types each performed at three levels.

METHODS:

Sixteen position players of a Division I collegiate baseball team were included in the study. Each performed 15 swings [5 swings each at the following effort levels corresponding to % max effort: LOW (25-50%), MED (50-75%), and HIGH (75-100%)] of the following swing types: dry swings with reduced weight (wiffle bat) (DSw), dry swings with regulation bat (DSr), live hitting from a tee (Tee), soft toss (ST), and pitching machine (PM). Kinematic data was recorded using a camera motion capture system. Kinematics were analyzed for the shoulder, elbow, and wrist. Each swing was analyzed from elbow drop until change in bat direction. To facilitate comparison among all swing types, ball contact was simulated (sBC) as the point at which the bat is perpendicular to the line from home plate to the pitcher's plate. Differences across swing types and effort levels were determined by one way Analysis of variance (ANOVA) followed by a Bonferroni post-hoc test for pairwise comparisons. (Significance was set at $p<0.05$ for all analyses).

RESULTS:

Wrist Kinematics (Figure 1): During LOW and MED swings, in the lead arm, significantly less ($p<.05$) ulnar deviation was observed at sBC with both DSw and DSr compared to Tee and ST, and between DSw and PM. **Elbow Kinematics (Figure 2):** In the back arm, significantly more pronation was observed at sBC during DSw than all other swing types at HIGH effort ($p<.05$). After ball contact in the lead arm, the minimum pronation (maximum supination) was significantly higher with DSw than all other swing types at all effort levels ($p<0.01$). **Shoulder Kinematics (Figure 3):** In the back arm at sBC, there is significantly less shoulder abduction during DSw (LOW,MED) and DSr (LOW) than Tee, ST, and PM swings. In the lead arm at sBC, there is significantly more shoulder abduction during DSr and Tee swings than ST and PM swings at all effort levels. In the back arm at sBC, there is significantly more horizontal adduction during DSw swings than Tee (LOW, MED), ST (all efforts), and PM (LOW, MED), during DSr swings than ST and PM at LOW effort, and during Tee swings that PM at LOW effort. In the lead arm at sBC, less horizontal adduction was observed in DSr swings than DSw, ST, and PM at all efforts. More horizontal adduction was observed during PM swings than DSw, DSr, and Tee swings at all efforts and during ST swings than DSw at MED effort and Tee at all efforts.

DISCUSSION AND CONCLUSION:

The results from this investigation indicate that the current hitting progression may require adaptations, specifically to account for different injury types and locations. With regard to upper body kinematics, dry swings with either a reduced weight bat or regulation do not replicate a natural swing motion regardless of perceived intensity. These findings indicate that once an athlete may be able to swing with a regulation bat without physical limitations, progression to swing types involving ball contact should be made as soon as possible. Further, the elevated ROM made during dry swings should be further studied for potential risks, especially considering the fact that dry swings are commonly prescribed in the early phases of returning to hitting. These findings will aid physicians, physical therapists, athletic trainers, and coaches in decision making for progressive return to batting following upper extremity injuries. Future investigations should determine the value of utilizing such measures as baseline assessments for comparison following injury to set appropriate rehabilitation milestones with hitting mechanics as an important variable for consideration.

Figure 1: Wrist Kinematics

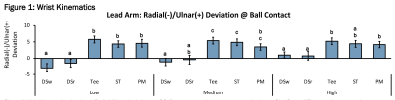

Figure 1: Wrist kinematics. Lead arm Radial/Ulnar deviation at sBC. Data presented as means ± standard error. Significant differences between swing types within each effort level are indicated with different letters.

Figure 2: Elbow Kinematics

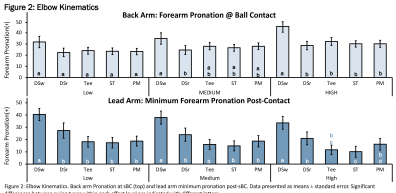

Figure 2: Elbow Kinematics. Back arm Pronation at sBC (top) and lead arm minimum pronation post-sBC. Data presented as means ± standard error. Significant differences between swing types within each effort level are indicated with different letters.

Figure 3: Shoulder Kinematics

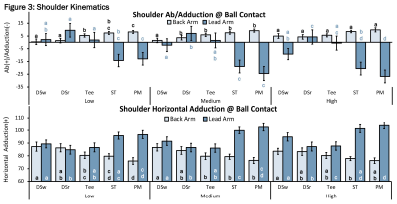

Figure 3: Shoulder kinematics. Ab/adduction (top) and horizontal ab/adduction (bottom). Data presented as means ± standard error. Significant differences between swing types within each arm and effort level are indicated with different letters. Comparisons between arms are not reported.