INTRODUCTION

Baseball is a popular team sport in North America, Latin America, and East Asia. Throwing and hitting are two important skills. Hitting a ball is perhaps the most difficult fundamental motor skill because it requires both temporal and spatial accuracy. Bat swing is considered an open kinetic chain motion because there are sequential segmental rotations (proximal-to-distal order) to get the highest linear speed at the tip of the bat (Welch et al., 1995). Even though there have been arguments of “hips driving arm swing” and “arms driving hip rotation” among coaches and players (Lau, 1986), kinematics and inter-segmental coordination of leading arm and trailing arm were not reported. Also the arms motion itself is considered as a closed kinetic chain motion until the hands possibly separate following impact. Anecdotally players believe the trailing arm (dominant arm) is the “power” and the leading arm (non-dominant arm) is the “guide” in the bat swing.

The main objective of this study was to investigate 3D angular kinematics of the upper body in order to see the sequence of segmental angular velocity. In addition, the kinematics and intra-limb coordination of an overloaded bat swing were analyzed to justify the roles of each arm.

METHODS

Nine college students (7 males and 2 females) who had played baseball or softball in high school and/or community college participated in this study. They were informed of the purpose of this study and signed informed consent prior to data collection. Ten high speed (200 Hz) cameras (Eagles system, Motion Analysis) were used to collect position data of markers on the body. Twenty-five markers were defined on the subject’s upper body, bat, and a tee to provide 3D position data and to build angular kinematics.

Subjects were asked to perform five bat swings with a standard bat (909 g) as fast as possible at an imaginary target on a tee (no ball contact). Following a 5-min break, they performed the same task with an overloaded bat (a standard bat + 568-g donut mass). Neither model nor feedback was given to the subjects. Collected data were smoothed by a second order zero-lag Butterworth filter (cutoff frequency of 10 Hz) and used for segmental angular velocity.

The local reference frame and direction cosine relative to the global reference frame were calculated. Then component angular velocities and resultant angular velocities with respect to the global reference frame were calculated. The resultant angular velocity profiles were used to provide the variables of intra- and inter-limb coordination.

RESULTS AND DISCUSSION

Segmental angular velocity profiles for a typical subject (Figure 1) and means of time-to-peak velocity difference and peak angular velocity differences between
adjacent segments for 9 subjects (Figure 2) showed that there was no significant temporal delay within leading arm segments and core sections, but there was significant temporal delay between lower and upper arms of the trailing arm ($p<.05$).

Only the two-way repeated measures ANOVA on time-to-peak velocity differences in the leading arm showed a significant interaction of bat weights and adjacent segments ($p<.05$) (see Figure 3). The overloaded bat induced a negative temporal delay of upper arm and trunk significantly and that was compensated by a longer positive temporal delay of lower arm and upper arm in the leading arm.

**SUMMARY/CONCLUSIONS**

Neither opinion of “hips driving arm swing” and “arms driving hip rotation” was fully supported by angular kinematics. The core section and lead arm segments rotated simultaneously as a unit in the bat swing. Significant temporal delay of upper and lower arms was found in the trailing arm. The significant peak angular velocity differences in the trailing arm supported the role of the trailing arm generating power during bat swing. Intra-limb coordination of the leading arm was significantly affected by the overloaded bat, while the trailing arm was invariant.

**REFERENCES**


Lau (1986). The art of hitting .300 (2nd Ed.).