A MECHANICAL CAUSE OF BODY ROTATION ABOUNT THE VERTICAL AXIS IN BASEBALL BATTING

T. Yanai
Chukyo University, Toyota, Japan
E-mail: tyanai@life.chukyo-u.ac.jp

INTRODUCTION

In baseball batting, the batter swings the bat in a circular path toward the ball to strike it. This circular path of the bat swing is generated "first by the turning of the torso and finally by action at the wrists (Adrian & Cooper, 1995)." Visual observations of batting performances suggest that the entire body, rather than the torso alone, rotates about a near-vertical axis passing through the body's center of mass. Such a rotation of the entire body could only be generated by the external forces acting eccentric to the center of mass and by the free moments acting on the body. In the present study, the moment of the ground reaction forces around the center of mass of the body and the free moment were computed separately for each leg and the contribution of each leg in generating body rotation was examined.

METHODS

After having provided written informed consent, twenty members of collegiate varsity baseball team performed the so-called "toss batting" in the Motion Analysis Laboratory. For the toss batting, the ball was tossed toward the ball-impact zone of the batter by another player kneeling on the ground at approximately 3 m away from the subject. The subject placing each leg on a force platform (9287B, Kistler Instrumentw AG, Switzerland) struck the ball toward the net located in the same field beside the tosser. After unlimited practices, each subject performed five trials of toss batting for data collection. Each trial was initiated by having the subject stand still on the force platforms in a relaxed body position. When the subject was found still and the force data became constant for more than two seconds, the subject was instructed to set ready for the toss-batting, and then he executed. For each trial, the force data was recorded with a WAD software (DKH co.Ltd., Japan). The trials were also recorded by a high speed camcorder (Fastcam-PCI, Photoron USA Inc, USA) so as to identify the instant of impact.

The mechanical cause of the body's rotation about the vertical axis passing through the CM was divided into four components; the moment of the ground reaction force acting on the front leg around the CM (Mf), the moment of the ground reaction force acting on the back leg around the CM (Mb), the free moment acting on the front leg (Ff), and the free moment acting on the front leg (Fb). The instantaneous positions of the center of mass (CM) of the performer was computed by double-integrating over time the acceleration of the CM which, in turn, was determined from the ground reaction force and the subject's body mass. The initial position of the CM for the integration was determined for the period during which the subject was standing still. The moment of the ground reaction force acting on each leg around the CM was determined by computing the cross product of the vector pointing from the CM to the center of pressure location and the ground reaction force acting on the leg. Finally contribution of each of the four components to the body's rotation was determined by time-integrating

each factor over time to determine the angular momentum generated thoroughly by that component toward the ball impact.

RESULTS AND DISCUSSION

The angular momentum of the performer's body was near zero at the instant of the front-leg touch-down (Figure 1), and it increased sharply toward the instant of impact (24 ± 4.3 kgm^2/s). The contribution of the Mf was found largest (mean=22 kgm^2/s), followed by Mb (mean=10 kgm^2/s). Ff and Fb (means = -6 kgm^2/s and -1 kgm^2/s, respectively) contributed negatively.

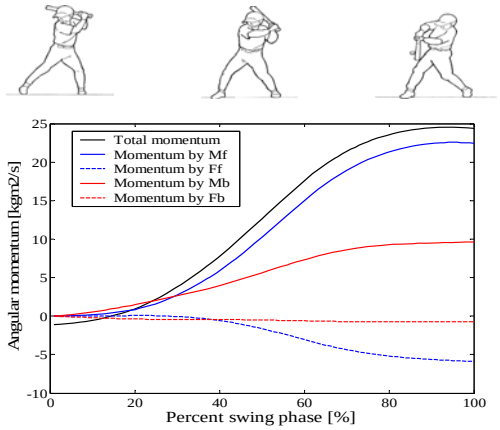

Figure 1: The mean values across the subjects for the total angular momentum of the body and their components. Swing phase initiated from the instant of front-leg touch-down and finished at the instant of ball impact.

The results clearly indicate that the rotation of the body during baseball batting is generated primarily by the moment of the ground reaction forces acting on the legs around the CM. In particular, the maximum ground reaction force generated by the front leg pushing the ground toward the homebase (mean=292 N) had a large moment arm (mean=0.52 m), having produced the largest turning effect to the body (Figure 2). The ground reaction forces acting toward or away from the pitcher had short moment arms (means=0.16 & 0.0 m for front & back leg, respectively), having produced limited moments around the CM (Figure 2). These results support the theoretical postulations described in the previous study (Messier and Owen, 1986).

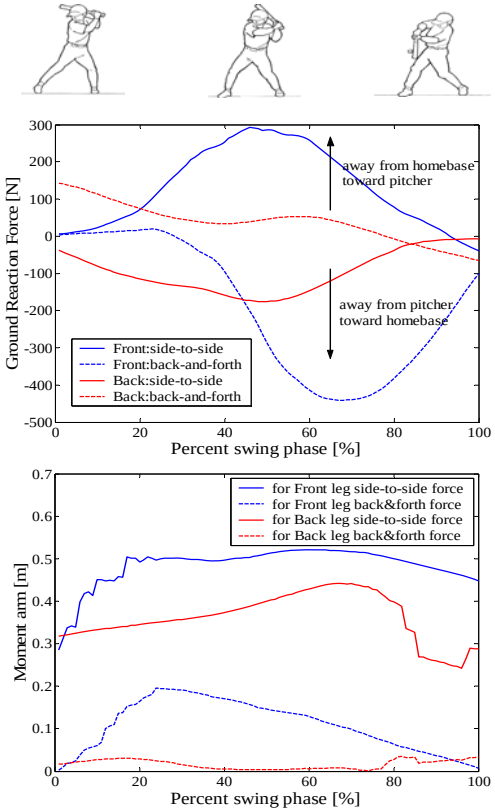

Figure 2: The mean values across the subjects for the ground reaction forces acting on the legs (above) and their moment arms (below).

The total angular momentum generated by the ground reaction forces and free moments acting on the front leg (17 ± 4.0 kgm^2/s) was found significantly greater (p=0.00) than that on the back leg (9 ± 2.2kgm^2/s). This result indicates that the front leg acts as the primary source of body rotation for bat swing.

REFERENCE

Adrian MJ and Cooper JM. *Biomechanics of Human Movement*, Brown & Benchmark, Madison, WI. 1995.

Messier SP and Owen M. (1986). *Res Quart* **57**,329-333.