Contributions of Longitudinal and Normal Hand Forces to the Speed of a Bat

Bianca Urquidi, Jesus Dapena. Indiana University, Bloomington, IN

Previous research on batting has focused on the overall motions of the skill and on the interactions between the feet and the ground. In contrast, the interactions between the hands and the bat are very important, but poorly understood.

PURPOSE: To measure the cumulative contributions of the longitudinal (FL) and normal (FN) hand forces and of the bat's weight to the velocity of the bat center of mass (CM) during the swing. **METHODS:** Six trials of a former varsity collegiate softball player considered to use standard batting technique were filmed with two cameras shooting at 100 Hz. The swing was analyzed from the lift of the lead (left) leg until just prior to the impact of the bat with the ball, a period that lasted 0.51 ± 0.03 s. The films were digitized, and three-dimensional location data were obtained for the two ends of the bat using the Direct Linear Transformation method. Woltring's quintic spline was used to compute smoothed location, velocity and acceleration values for the two ends of the bat. The linear velocity and acceleration of the bat's CM were calculated from the velocities and accelerations of the bat endpoints. The net force exerted on the bat was computed from the mass of the bat and the acceleration of the CM. The weight of the bat (W) was subtracted from the net force to compute the force vector F exerted by the hands on the bat. This resultant force was projected on the longitudinal axis of the bat to calculate FL. FL was subtracted from F to compute FN. For each instant of the swing, vectors FL, FN and W were projected onto the instantaneous velocity vector of the bat CM, and divided by the mass of the bat to calculate their respective contributions to the tangential acceleration of the bat CM. These accelerations were then integrated separately using the trapezoidal rule to calculate the cumulative contributions of the three forces to the speed of the bat's CM. **RESULTS:** The bat speed at left foot takeoff was 0.43 ± 0.12 m/s, and the final bat speed just prior to impact was 18.78 ± 2.81 m/s, an increase of 18.36 ± 2.55 m/s. The contributions of the three forces to this speed increase were: longitudinal force: 18.94 ± 1.28 m/s; normal force: -3.51 ± 2.19 m/s; weight: 3.02 ± 0.23 m/s. **CONCLUSIONS:** The major contributing force to the speed of the bat is the longitudinal force exerted by the hands on the bat. The normal force only acts to reorient the bat, and actually tends to produce a small reduction in the bat speed, while the weight of the bat makes a small positive contribution to bat speed as the CM travels through its generally downward path.