CONTRIBUTIONS OF GRIP FORCES AND TORQUES TO BAT HEAD SPEED IN BASEBALL HITTING

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INTRODUCTION

The motions of any striking implement are determined by the force and torque exerted on it by the hands and by the force of gravity [1, 2]. Vaughan [1] reported the force and torque applied by the hands relative to the swing plane in a golf swing. Willmott and Dapena [2] developed a model that assessed the contributions of the hand forces and torques to the speed of a swinging implement, and applied it to the field hockey hit. However, the contributions to the speed of the distal bat endpoint ("bat head") in a baseball hitting motion by the force ("grip force") and torque ("grip torque") applied at the grip by the hands have never been studied.

The purpose of this study was to clarify the contributions of grip forces and torques to the speed of the bat head during a baseball hitting motion.

METHODS

After obtaining informed consent, eight skilled right-handed male varsity batters (age 19±1 yrs; height 1.71±0.06 m; body mass 71±12 kg) participated in this study. Subjects were asked to hit a ball projected by a circular-wheel-type pitching machine set at 120 km/h. The motions of maximum effort hits executed by each subject were recorded using two high-speed genlocked video cameras (HSV-500C^3, NAC) set at 250 Hz.

Three-dimensional coordinate data of 21 body landmarks, the two bat endpoints (tip and tail) and the ball centre were obtained using the DLT technique. Then they were smoothed using quintic spline functions with optimal cutoff frequencies for each landmark and coordinate (4-20 Hz).

The individual contributions of the grip forces and torques to the speed of the bat head were calculated using a previously reported model [2]. The swing plane from the instant of the stride foot landing (SFL) to the bat-ball impact (a period called the bat swing phase) was defined from the linear velocity of the bat head and the bat's longitudinal axis. The calculation was executed over the bat swing phase.

The subjects were divided into two groups based on the speed of the bat head at impact: a higher group (HG) and a lower group (LG). We performed a non-paired t-test to compare the variables between the two groups. The significance level was set at $p<0.05$.

RESULTS AND DISCUSSION

Table 1 shows the bat head speed and the individual contributions to it. The measured bat head speed at impact (36.5±2.9 m/s) corresponded well with the sum of the calculated contributions by the model (36.6±2.8 m/s). The main positive contributions during the swing phase came from the force parallel to the bat's longitudinal axis (54±4%) and from the torque normal to that axis (49±13%). All other positive contributions were very small (≤4%). These results were similar to those for the field hockey hit [2], except that the contribution due to the normal torque was smaller than in the hockey hit. This result shows that in baseball hitting the parallel force is crucial for the increase of bat head speed.

Although statistically significant differences were found between the velocities of the bat head in the HG (38.6±2.8 m/s) and the LG (34.6±0.5 m/s), no significant differences were found between the two groups in regard to the individual contributions (Table 1). However, the differences between the contributions of the normal torque in the two groups (HG: 52±14%; LG: 47±13%) approached statistical significance. This suggests that in baseball hitting the snap of the hand grip might be one of the key techniques for improving the lower group's bat head speed.

CONCLUSIONS

The head speed of the bat at impact was mainly produced by the parallel component of grip force and by the normal component of grip torque. Other contributions were very small. These results were similar to those found for the field hockey hit. Speed differences seemed to be due mainly to greater effort rather than to differences in motion patterns.

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REFERENCES

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2. Willmott A and Dapena J. *Proceedings of ISB XXth Congress and ASB 29th Annual Meeting*, Cleveland, OH, Abstract 661, 2005.

Table 1: Comparison of the variables between the higher group (HG) and the lower group (LG) (*: p<.05; ns: not significant).

	Total (n=8)	HG (n=4)	LG (n=4)	t-test
Speed of the bat head at impact calculated by the model ($m.s^{-1}$)	36.6 ± 2.8	38.6 ± 2.8	34.6 ± 0.5	*
Parallel component of the grip force [F_L] (%)	54 ± 4	54 ± 4	55 ± 6	ns
Normal component of the grip torque [T_N] (%)	49 ± 13	52 ± 14	47 ± 13	ns
Speed of the bat c.m. at the instant of SFL [V_{Gi}] (%)	4 ± 1	4 ± 1	5 ± 1	ns
Weight of the bat [W] (%)	4 ± 1	3 ± 1	4 ± 1	ns
Angular momentum of the bat at the instant of SFL [H_i] (%)	1 ± 1	1 ± 1	1 ± 0	ns
Normal component of the grip force [F_{N-L}] plus its torque about the bat c.m. [F_{N-R}] (%)	–12 ± 9	–14 ± 9	–11 ± 9	ns