# ANALYSIS OF ANGULAR MOMENTUM THE WHOLE BODY DURING GLIDE HITTING AND KICK HITTING IN BASEBALL

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The purpose of this study were to analyze the biomechanical characteristics of glide and kick hitting in baseball which exerted by professional baseball players in Taiwan. Five professional baseball players were selected as the subjects. The experiment used two JVC-DV 9800 high-speed digital cameras(120 Hz).The video data was treated by Kwon3D 3.0 motion analysis system. The following are the main results: The kick hitting could get better rotation benefit and optimum. In the stride phase, angular momentum of the body is increasing by body inertia. In the rotation phase, the velocity increasing of the body center of gravity makes the angular momentum increase. The largest angular momentum appears right before the ball hit. Because the body inertia in ball hitting moment was very small, the angular momentum was mainly affected by angular velocity. In the phase, the average value, largest value and hitting moment value of angular momentum with kick hitting are larger than those with glide hitting. Therefore, the kick hitting could get larger linear and angular momentum.

**KEY WORDS:** baseball, glide hitting, kick hitting, angular momentum

**INTRODUCTION:** In the period of batting, the ground reaction force effected the rotations of body and bat, transform of power which were important to identify the system of batting motion and the ground reaction force (Messier & Owen, 1986). The source of batting power was lower extremities. There was a great benefit by a firm motion of lower extremities. The lower extremities of batting distinguished the motions of support leg and stride leg. By the stride leg exerted the floor, it produced a ground reaction force which pulled the knee adducting, and rotated the upper extremities by the hip moving. The angular momentum was multiplied angular velocities by the moment of inertia. As usual, calculation of the angular momentum in human bodies were hypothesis the rigid body. By the three-dimensional cinematographic technical analysis, the angular momentum of whole body mass oppositely was represented body angular momentum(Robertson, Caldwell, Hamill, Kame, & Whittlesey, 2003). The values of angular impulse acted on articles which decided the body angular momentum. In order to be a great striker, player should be striking and reacting fast, chousing a suit batting action. Thus, the preparation of batting was important. As we knew that kick hitting would increased the moment of batting and ball velocity (Robson, 2003). Theoretically, baseball batting in kicking hitting had its motion which rotated the trunk and the biomechanical of all extremities would change. Therefore, it was worth to identify.

**METHODS:** Five professional baseball players (mean age 29 ± 1.8 yrs ; height 1.76 ± 4.1 m ; body weight 78.6 ± 4.2 kg) took part in the experiment and preferred to hit the ball using the right hand. Two JVC camera (GR-DVL9800) synchronized to sample the hitting motions at 120 Hz ( shutter speed was 1/120 s ) and placed 12 m from the subject. Three-dimensional coordinates were derived by a video analysis system (Kwon3D 3.0 motion analysis system) to gain the kinematics parameters of human. For calibrating the performance area, a calibration frame with 15 control points was videotaped before the trails. The raw data was filtered by which called Butterworth Fourth-order Zero Lag Digital Filter. The experimental result acquired the angular momentum of body, angular velocity of body and the moment of inertia under different hitting motions.The study divided the whole motion into the stance phase, the stride phase, the rotation phase and follow through phase by camera films. Each experimenter used the same stick to perform two different hitting motions (glide hitting and kick hitting). Five trials were recorded at each hitting motion for each subject.

**RESULTS AND DISCUSSION:** Angular momentum of the body during the glide and kick hitting in baseball. The angular momentum of a mass was the product of its moment of inertia and its angular velocity. If body was rotating, the moment of inertia was increasing and its angular velocity must be decreasing. An alternative way of determining total body angular momentum makes use of the external forces and moments of force acting on the body and the angular impulses they produce. Angular momentum of the body of glide and kick hitting during the stance phase were 5.2 ± 0.7 kg-m$^2$/s and 4.6 ± 0.5 kg-m$^2$/s (Table1 and Figure1). Angular velocity of body of glide and kick hitting during stride phase were 6.2±1.1 deg/s and 6.1 ± 1.1 deg/s (Table 2 and Figure 2).By withdrawing the forefoot, the arms were raising back before hitting to increasing moment of inertia the body and angular momentum of the body was increasing. The moment of inertia the body of glide and kick hitting were 2.1 ± 0.3 kg-m$^2$ and 2.4 ± 0.4 kg-m$^2$ (Table 3 and Figure 3).Therefore, angular momentum of the body increasing during this phase was derived from moment of inertia of body center of gravity. Angular momentum of the body of glide and kick hitting were 12.7 ± 2.0 kg-m$^2$/s and 14.6 ± 2.4 kg-m$^2$/s. The center of body gravity moving forward to perform hitting motion during the rotation phase. The moment of inertia the body of glide and kick hitting were 2.1 ± 0.3 kg-m$^2$ and 0.9 ± 0.1 kg-m$^2$.The angular velocity increasing of the body of glide and kick hitting were 36.8 ± 3.7 deg/s and 45.8 ± 3.6 deg/s, which were derived from the rotation of body. Although, the moment of inertia of body decreasing and angular velocity of body increasing to make angular momentum of the body increasing. Angular momentum of the body of glide hitting was 39.7 ± 4.0 kg-m$^2$/s greater than kick hitting was 35.5 ± 3.3 kg-m$^2$/s. The maximum value of angular momentum of the body appeared before the ball was hit. The maximum value of angular momentum of the body of glide and kick hitting were 80.8 ± 3.2 kg-m$^2$/s and 70.4 ± 2.3 kg-m$^2$/s. Angular momentum of the body of glide and kick hitting were 18.7 ± 1.6 kg-m$^2$/s and 27.2 ± 1.3 kg-m$^2$/s, angular velocity of glide and kick hitting were 43.6 ± 3.3 deg/s and 34.7 ± 1.6 deg/s when the ball was hit. Specifically, the kick hitting before the hit affected the momentum of hit, and increased the effect when the ball was hit (Robson, 2003).

**Table 1 Angular momentum variation of the body during the different hitting process. *N=5***

| | Glide hitting | Kick hitting |
|---|---|---|
| stance phase (kg-m$^2$/s) | 5.2 ± 0.7 | 4.6 ± 0.5 |
| stride phase (kg-m$^2$/s) | 12.7 ± 2.0 | 14.6 ± 2.3 |
| rotation phase (kg-m2/s) | 35.5 ± 3.3 | 39.7 ± 4.0 |
| maximum (kg-m$^2$/s) | 70.4 ± 2.3 | 80.8 ± 3.2 |
| hitting ball (kg-m$^2$/s) | 18.7 ± 1.6 | 27.2 ± 1.3 |

**Table 2 Angular velocity variation of the body during the different hitting process. N=5**

| | Glide hitting | Kick hitting |
|---|---|---|
| stance phase (deg/s) | 4.3 ± 0.7 | 3.5 ± 0.5 |
| stride phase (deg/s) | 6.2 ± 1.1 | 6.1 ± 1.1 |
| rotation phase (deg/s) | 36.7 ± 3.7 | 45.8 ± 3.6 |
| maximum (deg/s) | 40.8 ± 3.8 | 47.5 ± 4.2 |
| hitting ball (deg/s) | 34.7 ± 1.6 | 43.6 ± 3.3 |

**Table 3 The moment of inertia variation of the body during the different hitting process. N=5**

| | Glide hitting | Kick hitting |
|---|---|---|
| stance phase ($kg\text{-}m^2$) | 1.2 ± 0.2 | 1.3 ± 0.2 |
| stride phase ($kg\text{-}m^2$) | 2.1 ± 0.3 | 2.4 ± 0.4 |
| rotation phase (kg-m2) | 1.0 ± 0.1 | 0.9 ± 0.1 |
| maximum (kg-m2) | 5.2 ± 0.3 | 5.6 ± 0.2 |
| hitting ball ($kg\text{-}m^2$) | 0.5 ± 0.1 | 0.6 ± 0.1 |

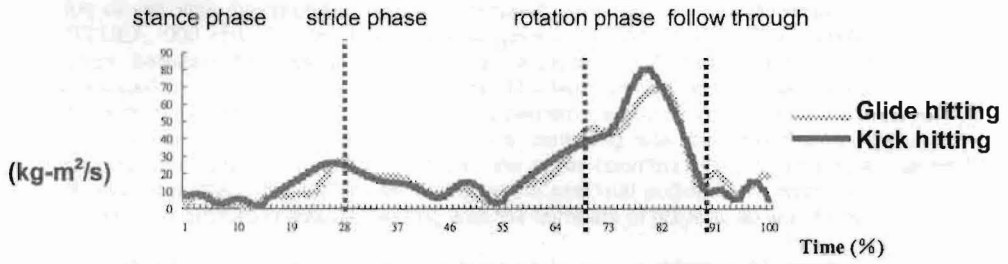


**Figure 1 Average angular momentum of body of glide and kick hitting.**

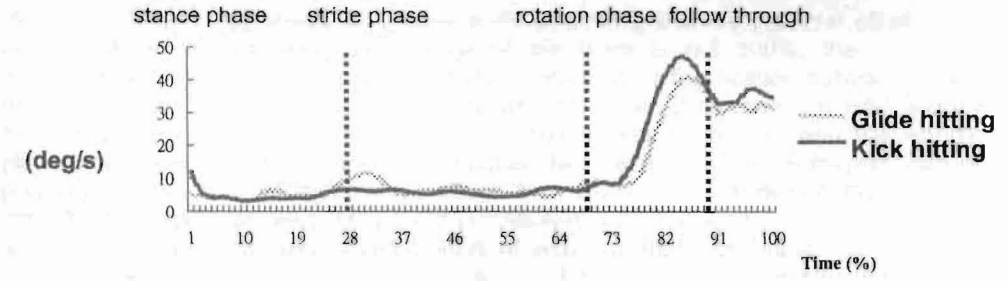


**Figure 2 Average angular velocity of body of glide and kick hitting.**

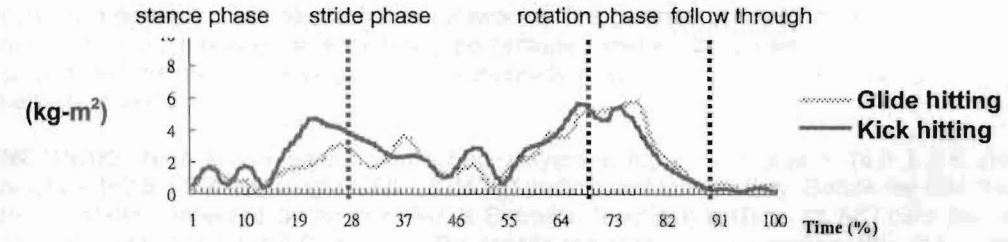


**Figure 3 Average the moment of inertia of body of glide and kick hitting.**

**CONCLUSION**: This main purpose of research bestows two kinds of and attacks movements with swing in order to probe into domestic excellent topnotch athletics of duty, after analysing and discussing via the parameter of this research experimental result income, put in order and obtain the following conclusion synthetically: The kick hitting could get better rotation benefit and optimum. In the stride phase, angular momentum of the body is increasing by body inertia. In the rotation phase, the velocity increasing of the body center of gravity makes the angular momentum increase. The largest angular momentum appears right before the ball hit. Because the body inertia in ball hitting moment was very small, the angular momentum was mainly affected by angular velocity. In the phase, the average value, largest

value and hitting moment value of angular momentum with kick hitting are larger than those with glide hitting. Therefore, the kick hitting could get larger linear and angular momentum.

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