GROUND REACTION FORCES AND IMPULSE DURING LANDING IS NOT CORRELATED WITH BALL SPEED IN HIGH SCHOOL BASEBALL PITCHERS

Masoumeh Soujoudi¹, Sakiko Oyama¹·², Joseph B. Myers ²

¹University of Texas at San Antonio, San Antonio, TX, USA
²University of North Carolina at Chapel Hill, Chapel Hill, NC, USA
Email: Sakiko.oyama@utsa.edu

INTRODUCTION

Baseball pitching is a whole-body movement that requires transfer of linear and angular momentum from the lower body to upper extremity, and then to the ball. Therefore, the kinematics and kinetics of lower extremity is considered important in production and transference of momentum to the ball. In fact, kinematic variables of the stride leg such as lower peak knee flexion angular velocity and greater knee extension velocity at ball release have been linked to increased ball speed. [1] It has also been described that the posterior and vertical ground reaction forces act to decelerate the lower body as the stride foot strikes the mound, which leads to transfer of momentum to the upper body to produce ball speed. [2]

Despite the perceived importance of lower extremity biomechanics on pitching performance, studies that investigated the ground reaction forces and impulse generated by the ground reaction forces in baseball pitching are limited [2, 3]. Therefore, the purpose of this study was to investigate whether the peak posterior and vertical ground reaction forces and impulses produced by the posterior and vertical ground reaction forces are correlated with ball speed in high school baseball pitchers. We hypothesize that ball speed is associated with ground reaction forces and impulses during landing.

MATERIAL AND METHODS

The data collection took place in a research laboratory. The pitches were performed from an indoor pitching mound into a backstop that was placed at a distance of 16.4m from the pitching rubber. The mound was instrumented with 2 force plates; one under the pitching “rubber” which was constructed from steel interfaced with the force plate and the other on the slope of the mound (Figure 1). The position of the force plate on the slope was adjusted based on the pitcher’s stride length. This force plate was used to capture the ground reaction forces during landing (900Hz). A seven-camera motions capture system was used to capture the kinematics (300Hz). A radar gun was used to capture ball speed.

A total of 55 high school baseball pitchers participated in this study (age: 15.5±1.2 years, height: 17.3±7.3m, mass: 73.3±10.6kg). The pitchers were fitted with reflective markers over tight-fitting clothing. After an adequate warm up, the pitchers pitched (fast-pitch) from wind-up until three strike pitches were captured. The filtered ground reaction forces were used to calculate the peak posterior and vertical ground reaction forces, and linear impulse produced by the posterior and vertical ground reaction forces before ball release. The impulse was calculated as the area under the force-time curve. The kinematic data were used to estimate the instant of ball release. The peak forces and impulses were normalized to subject’s body weight. Three-trial averages were used for statistical analyses.

Pearson product-moment correlation coefficients were used for data analysis. A priori-alpha was set to 0.05.
RESULTS AND DISCUSSION

The mean and standard deviation of the variables are presented in Table 1. An exemplary ground reaction force during landing is presented in Figure 2. The characteristics of the ground reaction force during landing were similar to what was reported in the study by MacWilliams et al [2].

Table 1: Mean and standard deviation (SD) of the variables examined in this study

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak posterior ground reaction force</td>
<td>-0.67</td>
<td>0.14</td>
</tr>
<tr>
<td>Peak vertical ground reaction force</td>
<td>1.47</td>
<td>0.28</td>
</tr>
<tr>
<td>Posterior impulse (%BW)</td>
<td>-27.80</td>
<td>6.16</td>
</tr>
<tr>
<td>Vertical impulse (%BW)</td>
<td>64.68</td>
<td>10.88</td>
</tr>
</tbody>
</table>

BW: Body weight

Figure 2: Exemplary ground reaction force during landing

Ball speed was not significantly correlated with any of the ground reaction force or impulse variables (Table 2).

Table 2. Correlation between ball speed and force variables examined in this study

<table>
<thead>
<tr>
<th></th>
<th>Posterior GRF</th>
<th>Vertical GRF</th>
<th>Posterior Impulse</th>
<th>Vertical Impulse</th>
</tr>
</thead>
<tbody>
<tr>
<td>r</td>
<td>-.177</td>
<td>-.004</td>
<td>-.163</td>
<td>-.034</td>
</tr>
<tr>
<td>p</td>
<td>.200</td>
<td>.975</td>
<td>.240</td>
<td>.809</td>
</tr>
</tbody>
</table>

Our hypothesis that ball speed is associated with ground reaction forces and impulses during landing was rejected. This observation indicates that factors other than ground reaction force during landing have a larger influence on between-pitcher variance in ball speed.

MacWilliams et al [2] reported significant correlations between ball speed and peak posterior and vertical ground reaction forces within a single pitcher. This observation suggests that although the ground reaction forces during landing is not related to inter-pitcher variance in ball speed, it may be related to within-pitcher variance in ball speed. Therefore, we cannot dismiss the importance of the ground reaction forces during landing on pitching performance.

The relationship between ball speed and posterior and vertical impulses were examined in this study because the change in momentum is caused by the impulse, and not by the peak force. However, the relationships between ball speed and posterior/vertical impulses were non-significant, just like the relationships between ball speed and peak posterior/vertical forces.

Only the ground reaction forces and impulses during landing were analyzed in this study. Since the ground reaction forces acting on the stance leg produce pitcher’s forward momentum, the relationships between ball speed and ground reaction forces and impulses during the stance phase (push off force) should be investigated in future studies. Additionally, examining the effects of lower extremity joint energetics on ball speed would help strength and conditioning specialists design effective exercise programs for baseball pitchers.

CONCLUSIONS

We observed that the posterior and vertical ground reaction forces or impulses produced by the posterior and vertical ground reaction forces during landing are not correlated with ball speed. Although ground reaction force during landing may be related to within-pitcher variance in ball speed, it does not seem to be related to inter-pitcher variance in ball speed.

REFERENCES