Kinematic and temporal parameters of high school baseball pitchers in different velocity groups

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INTRODUCTION

Throwing velocity is one of the most important components of a successful baseball pitch [1, 2]. Previous work by Matsuo et al. found significant differences in kinematic and temporal parameters between high velocity and low velocity pitchers in collegiate and professional baseball [2]. However, to our knowledge no study has examined the differences in kinematic and temporal parameters between high velocity and low velocity groups in high school pitchers. Additionally, there is a lack of research focusing on the relationship between kinematics and performance in high school baseball pitchers, which may be important for advancing to collegiate or professional baseball. Therefore the aim of this study was to investigate differences in kinematic and temporal parameters between high and low velocity high school pitchers. We hypothesized that there will be significant differences in kinematic and temporal parameters between high and low velocity high school pitchers, and specifically high velocity pitchers would demonstrate greater maximal shoulder external rotation, greater forward trunk tilt at ball release and greater lead knee extension angular velocity at ball release [2].

METHODS

Thirty-two high school male baseball pitchers (height = 1.83±0.07 m, mass = 75.6±10.9) were recruited. The Ohio State University institutional review board approved this study. All participants signed assent forms and permission was obtained from their parents. Before testing, the pitchers were instructed to warm up and prepare themselves just as they would do for an actual game. Once the pitchers were ready, they were instructed to throw 15 fastball pitches from a pitcher’s mound towards a target. A passive optical three-dimensional motion capture system (Vicon Inc., Oxford UK), was used to collect marker trajectories at 300 Hz. Trajectories were filtered using a 4th order Butterworth low-pass filter with a cut-off frequency of 13.4 Hz [2]. Twelve kinematic parameters and nine temporal parameters were calculated to match the previous study done by Matsuo et al [2]. Three representative trials with the most complete trajectory data from each pitcher were selected for further analysis. The 10 pitchers with the greatest hand velocity (23.1±0.83 m/s) and lowest hand velocity (18.9±0.95 m/s) were assigned to the high and low velocity groups, respectively. Student’s t tests were used to compare differences between groups for all the parameters, with statistical significance set a priori at p<0.01.

RESULTS AND DISCUSSION

Means and standard deviations of kinematic parameters of the two groups are presented in Table 1. To compare the high school pitchers with the low velocity collegiate and professional pitchers, data from Matsuo et al. [2] was added in the Table.

The high velocity group showed significantly greater peak trunk rotation velocity and peak glenohumeral internal rotation angular velocity, and showed trends toward significantly greater peak elbow angular extension velocity and maximum knee extension angular velocity at ball release (p<0.02). No differences were observed between groups for temporal parameters.

Similar to collegiate and professional pitchers, we found that high velocity pitchers trended towards having greater knee extension velocity at ball release [2]. However, contrary to our expectations, we did not find any differences in maximal external shoulder rotation and forward trunk tilt, which have been related to greater ball velocity in professional
and collegiate pitchers [2]. In addition to those variables, we found that glenohumeral internal rotation angular velocity and peak trunk rotation angular velocity were greater in the high velocity group than in the low velocity group. Because the time between strike foot contact and ball release is very short, high angular velocities are required to throw efficiently [1] and it is likely that these significant differences drive the higher ball velocities in that group.

These results suggest that there may be different kinematics distinguishing high velocity pitchers from low velocity pitchers in high school, compared to the more experienced collegiate and professional pitchers who may already have a baseline level of motor expertise. Pitching experience, body maturation, body adaptation and coordination may also play a role in the different kinematic variables affecting performance of high school pitchers as opposed to collegiate or professional pitchers. As shown in Table 1, our groups did not match Matsuo’s low velocity group in any of the measured variables, except for lead knee extension angular velocity at ball release.

Understanding the kinematic differences between high velocity and low velocity pitchers may help determine which pitching mechanics produces maximal ball velocity in high school pitchers. The differences between the groups in our study and those in Matsuo’s study suggest that it would also be very valuable to investigate how pitching mechanics change with maturation and experience from youth to elite baseball.

**CONCLUSIONS**

High school pitchers who throw with high velocity showed greater peak trunk rotation angular velocity, and peak glenohumeral internal rotation velocity, with trends towards greater maximum knee extension angular velocity and peak elbow extension velocity when compared to those who throw with low velocity. These differences do not match the differences between high- and low-velocity groups at elite levels, suggesting that results from adult pitchers cannot be assumed to be generalizable across ages and experience levels.

**REFERENCES**


**Table 1:** Means and standard deviations of kinematic parameters between high and low velocity groups. A column with the data from Matsuo et al. [2] of the low velocity collegiate and professional pitchers is added for comparison. *Matsuo et al. reported peak ball velocity, not peak hand velocity.*

<table>
<thead>
<tr>
<th>Variable</th>
<th>High velocity group (n=10)</th>
<th>Low velocity group (n=10)</th>
<th>High v. Low</th>
<th>Matsuo 2001 Low Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak hand velocity (m/s)</td>
<td>23.1±0.8</td>
<td>18.9±0.9</td>
<td>-</td>
<td>33.2±0.9*</td>
</tr>
<tr>
<td>Peak trunk rotation angular velocity (°/s)</td>
<td>1019.5±102.4</td>
<td>841.9±96.8</td>
<td>&lt; 0.001</td>
<td>1179±104</td>
</tr>
<tr>
<td>Peak elbow extension angular velocity (°/s)</td>
<td>2009.6±116.5</td>
<td>1796.9±232.1</td>
<td>0.018</td>
<td>2353±320</td>
</tr>
<tr>
<td>Peak glenohumeral internal rotation angular velocity (°/s)</td>
<td>3920.1±547.7</td>
<td>3218.4±425.9</td>
<td>0.005</td>
<td>7350±1283</td>
</tr>
<tr>
<td>Lead knee extension angular velocity at ball release (°/s)</td>
<td>200.5±73.6</td>
<td>109.3±86.0</td>
<td>0.020</td>
<td>124±141</td>
</tr>
<tr>
<td>Trunk tilt at ball release (°)</td>
<td>43.7±8.2</td>
<td>46.9±12.3</td>
<td>0.506</td>
<td>28.6±11.1</td>
</tr>
<tr>
<td>Maximal shoulder external rotation (°)</td>
<td>142.7±8.7</td>
<td>142.2±16.5</td>
<td>0.939</td>
<td>166.3±9.0</td>
</tr>
</tbody>
</table>