Comparison of Shoulder Rotation Torques and Velocity in the Overhead Baseball Pitch and the Windmill Softball Fastpitch

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INTRODUCTION: Numerous biomechanical studies have identified stresses placed on baseball pitchers’ throwing arm which have led to improved training regimes and the implementation of pitch count regulations. Survey data from 2009, revealed that there is no significant difference in overall injury rate between high school baseball and softball players (Stanley, 2011). The shoulder was noted as the most prevalent body site injured in both sports and primarily among pitchers. Despite the distinctive patterns of overhead and windmill pitch deliveries, both groups report shoulder injuries. Yet, the relationship of pitch mechanics and shoulder stress during fastpitch softball pitchers remains under investigated. Due to growth of participation in female fastpitch softball and the identification of similar injury types, biomechanical research comparable to their male counterparts is warranted. Interpretation of the similarities and differences of the biomechanical stresses between pitchers of the two sports could lead to more directed training and injury prevention programs. The purpose of this study is to compare biomechanical variables previously associated with shoulder injury risk (shoulder rotation torque, velocity, compression/distraction force and the extremes of shoulder rotation motion) between fastpitch softball and overhead baseball pitchers.

METHODS: 26 collegiate and high school pitchers underwent 3D biomechanical pitch analyses using 20 Vicon high-speed motion capture cameras (240Hz and 360Hz). 15 female fast-pitch softball pitchers (mean age: 16.13 ± 1.89 years) and 11 male baseball pitchers (mean age: 17.18 ± 1.40 years) provided written informed consent to participate in this institutional review board approved study. All pitchers threw the standard mound-to-plate path distance for their respective sport (SB: 13.11 m, BB:18.29 m). Softball pitchers averaged 56 ± 22 pitches and baseball pitchers averaged 32 ± 7 pitches. A Stalker Pro II radar gun collected pitch speeds. The average of the three fastest, most accurate pitches were used to calculate subjects’ peak shoulder: rotation angles and torques, internal and external rotation velocity, and compression/distraction force. A standard goniometric protocol assessed passive shoulder rotation motion prior to throwing. The average number of pitches each subject threw per game was also recorded. Independent T-Test and ANOVA statistical analyses were performed.

RESULTS: The average pitch speed for softball players was lower (23.40 m/s, SD = 1.79) than for baseball (32.12 m/s, SD = 3.37), p = 0.001. There was no difference in the reported number of pitches per game in softball (x̄ = 95.53, SD = 19.53) and baseball pitchers (x̄ = 88.60, SD = 13.98), p = 0.34. No statistical difference was found in total arc of passive shoulder rotation between softball (157.60° SD= 8.98) and baseball pitchers (156.10°, SD= 11.38), p = 0.72. Comparatively, peak shoulder distraction forces were greater among the baseball pitchers, p = 0.0001, and peak shoulder compressive forces were significantly greater among the softball pitchers, p = 0.0001 (Figure 1). Greater peak shoulder internal rotation (IR) and external rotation (ER) velocity was measured among baseball pitchers in comparison to softball pitchers, p = 0.006, and p = 0.003, respectively. Significantly greater peak shoulder ER torque production was noted among baseball pitchers (p = 0.0001), but there was no difference in the peak IR shoulder torque generation among softball and baseball pitchers, p = 0.221 (Table 1). During pitching, baseball pitchers exhibited greater peak shoulder ER motion, p = 0.001 and there was no difference in peak shoulder IR motion between softball and baseball pitchers, p = 0.39.

DISCUSSION: The biomechanics of the windmill arm motion in softball pitching are inherently different from those of an overhead baseball pitch delivery. However, this study demonstrated striking similarities in IR shoulder torques between baseball pitchers and fastpitch softball pitchers despite distinct differences in ball velocity. Softball players were also found to experience significantly greater shoulder joint compression force. Maximum shoulder compressive forces and IR torque have been noted during the acceleration phase of softball’s windmill pitch when the shoulder girdle, especially the pectoralis major and subscapularis, flex to facilitate underhand ball release and stabilize the anterior shoulder (Flyger, 2006). Although anterior shoulder pain near the origin of the long head of the biceps tendon is reported for both sports, baseball injury prevention strategies have largely focused on conditions associated with the deceleration phase of the baseball pitching motion that typically involve posterior shoulder structures and more frequently require surgical repair. However, these injuries such as superior labral tear anterior to posterior (SLAP) and ulnar collateral ligament tears are observed less frequently in softball players (Oyama, 2016). This difference in injury patterns is also consistent with our observations of greater ER shoulder torque and shoulder distraction force in baseball pitchers. The baseball pitcher’s iconic externally rotated (cocked) shoulder posture with elbow flexion has shown to contribute to ER torque development at the shoulder and a larger distraction force is expected to retard the comparatively greater arm velocity during the deceleration phase of baseball pitching. Sport specific differences in glenohumeral joint positioning at the time of peak shoulder torque events could also result in application of distinct structural forces across the joint surface for softball and baseball pitchers.

SIGNIFICANCE/CLINICAL RELEVANCE: While softball and baseball players report similar rates of shoulder injury, comparative pitch analyses identify biomechanical mechanisms that differentiate potential types of shoulder injuries between softball and baseball pitchers. This study draws attention to the importance of developing injury prevention strategies that focus on sport specific acceleration and deceleration phases of the pitching motion and highlights the need for future biomechanical softball studies.

Table 1: Peak Shoulder Internal and External Velocity and Torque.

<table>
<thead>
<tr>
<th>Pitchers</th>
<th>Peak Shoulder ER Torque N-m</th>
<th>Peak Shoulder IR Torque N-m</th>
<th>Peak Shoulder IR Velocity °/s</th>
<th>Peak Shoulder ER Velocity °/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fastpitch Softball n= 15</td>
<td>1013.41 ± 670.94</td>
<td>4725.18 ± 1163.27</td>
<td>21.14 ± 16.44</td>
<td>25.89 ± 11.54</td>
</tr>
<tr>
<td>Baseball n= 11</td>
<td>1764.47 ± 382.67</td>
<td>5955.10 ± 794.22</td>
<td>28.23 ± 10.39</td>
<td>68.02 ± 15.09</td>
</tr>
<tr>
<td>P</td>
<td>0.003*</td>
<td>0.006*</td>
<td>0.221</td>
<td>&lt;0.001*</td>
</tr>
</tbody>
</table>

* p< 0.05 met established level of significance.


Figure 1. Comparison of Peak Shoulder Distraction and Compression Force Between Softball and Baseball Pitchers.