COMING DOWN: THROWING MECHANICS OF BASEBALL CATCHERS

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Catchers are asked to make quick, highly accurate throws from a deep squat starting position. The purpose of this study was to define the throwing mechanics of catchers. Comparisons of their throwing biomechanics were made with pitching and long toss. Motion data were collected on collegiate catchers (n=8) and pitchers (n=22) making such throws in game-like situations. Catchers exhibited a significantly different stride pattern, greater elbow flexion through arm cocking, and less forward trunk tilt at ball release. The stresses on the shoulder and elbow during catchers' throws were similar to pitching and long toss, but produced significantly less ball velocity, suggesting a less efficient motion. This inefficiency is most likely compensation in order to complete the throw in less time. Coaches should be aware of this tendency when teaching catchers throwing mechanics.

KEYWORDS: compensation, efficiency, footwork.

INTRODUCTION: Catchers make more throws in a baseball game than any other player on the diamond, and many professional scouts believe throwing ability is a catcher's most important skill (Walter, 2002). While a pitcher essentially has an unlimited amount of time to prepare and make a pitch, a catcher must catch a pitched ball from a deep squat position and deliver the ball nearly 40 m in 2.0 seconds when an opposing baserunner attempts to steal second base (Walter, 2002). The pitches they receive are often thrown at a high velocity with an unknown trajectory. Rarely does the ideal condition, known as a "pitch-out", occur. In this case, the pitch is delivered at the catcher's standing chest height in the opposite batter's box. This allows the catcher to smoothly rise from his crouched position and make an unimpeded throw to second base. More commonly, a catcher must receive a low pitch thrown over the plate or a pitch in an even less desirable location, and if necessary, wait for the batter to complete his swing. As the baserunner begins advancing from first to second base, the catcher must attempt to deliver the ball as quickly and accurately as he can, using appropriate footwork and smoothly transferring the ball from glove to throwing hand. Catchers must also overcome the innate limitations of their protective gear: a facemask that obstructs their vision and a chest protector and shin guards that restrict their motion and weigh them down. Even though stolen bases are often ultimately out of their control (e.g. fast runner, slow pitching delivery, and/or poorly located pitch), many still look to the abilities of the catcher to determine the fate of the baserunner.

Most of the available literature on the throwing mechanics of catchers has been produced by coaches (Stallings, 2000; Johnson, Leggett, & McMahon, 2001). Some main coaching points are to have quick feet, align the front shoulder with the target, and have an abbreviated arm path to expedite ball release (BR) (Johnson, Leggett, & McMahon, 2001) While numerous biomechanical studies have described pitching mechanics (Dun *et. al.*, 2008; Fleisig *et. al.*, 1999; Fleisig *et. al.*, 2006; Matsuo *et. al.*, 2001; Stodden *et. al.*, 2001), only one study has attempted to quantify the throwing mechanics of catchers (Sakurai, Elliot, & Grove, 1994). Therefore, the purpose of the current study was to thoroughly describe the biomechanics of catchers' throws to second base. To put these mechanics into better context, the well-established parameters of pitching mechanics and the throwing mechanics of pitchers performing "long-toss" at a similar distance to the catchers' throws were used for comparison. Long-toss is a skilled throw used by many baseball players in practice and is commonly used in games by outfielders. It was hypothesized that because of the time demands and their initial squat stance, catchers would have significantly different mechanics than the other throwing styles. Under duress, they may sacrifice biomechanical efficiency to conserve time. Results from this study will help biomechanists and coaches better understand and teach proper throwing mechanics for catchers.

METHOD: Healthy college baseball catchers (n=8) and pitchers (n=22) were recruited for participation. Eight motion analysis cameras recording at 240 Hz (Motion Analysis Corp., Santa Rosa, CA) were initially placed in a ring around home plate. Starting from their typical crouched position, catchers received pitched balls and made ten maximum effort throws to a fielder standing at second base (approximately 40 m away). On a subsequent day, the cameras were positioned around an area along the right field foul line, and pitchers made five maximum effort "long toss" throws from flat ground at a distance of approximately 40 m to a player standing in center field. On a third day, pitchers delivered ten maximum effort pitches from an indoor mound using standard protocols (Dun *et. al.*, 2008). After signing consent forms, all players were given ample time to warm up and make as many practice throws as necessary. A total of 21 reflective markers were used to track the motions (Fortenbaugh & Fleisig, 2008), and outdoor motion capture sessions for catchers and long toss were done at night to eliminate interference from sunlight.
Relevant selected kinematic and kinetic variables were compared among the three conditions using a one-way ANOVA. Even though the same group of pitchers completed the mound pitches and long-toss throws, they were treated as though they were separate individuals because of the supposed uniqueness of the skills and to help facilitate statistical comparison. Tukey post-hoc comparisons were used to assess differences among groups. To help protect against Type I errors, α=.05.

RESULTS: All participants were approximately the same age (20.6±1.4 years) and mass (90.7±9.8 kg). However, the pitchers (187.6±6.2 cm) were significantly taller than the catchers (181.0±6.2 cm). Kinematic data for the catchers and pitchers, broken down by phase, are shown in Tables 1, 2, and 3. Kinetic data are shown in Table 4.
A number of significant differences were seen between the catchers' throws to second base and the pitcher's mound deliveries, most notably ball speed (36.8 $m*s^{-1}$ to 33.0 $m*s^{-1}$). At lead foot contact (FC), catchers exhibited a significantly shorter stride, more open lead foot position and closed lead foot angle, less pelvis-trunk separation and greater elbow flexion than the pitchers. The catchers maintained this greater elbow flexion throughout arm cocking and extended the lead knee more from FC to BR, but had less forward trunk tilt at BR than did the pitchers. All of these differences, except for pelvis-trunk separation at FC and forward trunk tilt at BR, were also seen comparing catchers to the long-toss throws. Catchers, like mound pitches, also had a more neutral lateral trunk tilt at FC than long-toss.

Table 1. Comparison of Throwing Kinematics at Lead Foot Contact

Variable	C	P - Mound	P – Long-Toss
**Stride length (% height)	67.1 ± 5.5	80.8 ± 4.2	81.9 ± 4.6
**Lead foot position (cm)	2.9 ± 11.7	25.5 ± 12.2	16.6 ± 14.1
**Lead foot angle (deg)	31.9 ± 5.6	14.3 ± 9.2	16.0 ± 10.8
Lead knee flexion (deg)	48.7 ± 6.2	47.7 ± 9.5	45.0 ± 9.4
Pelvis rotation (deg)	24.6 ± 16.8	36.4 ± 12.4	34.1 ± 12.0
*Pelvis-trunk separation (deg)	39.8 ± 8.9	51.5 ± 9.9	48.4 ± 11.7
**Lateral trunk tilt (deg)	2.0 ± 10.0	4.5 ± 7.0	12.3 ± 8.6
Shoulder external rotation (deg)	63.7 ± 30.9	54.5 ± 28.6	53.0 ± 28.8
**Elbow flexion (deg)	110.2 ± 15.2	79.1 ± 16.7	79.8 ± 18.1

*Significant difference among groups, p<.05.
**Significant difference among groups, p<.01.

Table 2. Comparison of Throwing Kinematics at Arm Cocking

Variable	C	P - Mound	P – Long-Toss
Pelvis rotation velocity (deg/s)	585 ± 75	569 ± 67	589 ± 60
Timing of pelvis rotation (%)	32.0 ± 19.2	25.0 ± 20.9	21.1 ± 21.7
Upper trunk rotation velocity (deg/s)	1050 ± 66	1123 ± 85	1123 ± 101
Timing of upper trunk rotation (%)	50.7 ± 15.5	50.3 ± 9.2	48.7 ± 10.8
Shoulder external rotation (deg)	175.3 ± 8.3	174.9 ± 10.8	174.3 ± 10.0
Shoulder horizontal adduction (deg)	20.0 ± 1.9	16.8 ± 6.7	18.7 ± 6.6
*Max elbow flexion (deg)	113.9 ± 12.9	99.2 ± 11.8	100.8 ± 12.1

*Significant difference among groups, p<.05.
**Significant difference among groups, p<.01.

Table 3. Comparison of Throwing Kinematics at Arm Acceleration and Ball Release

Variable	C	P - Mound	P – Long-Toss
Shoulder internal rotation velocity (deg/s)	6351 ± 761	7538 ± 1188	7288 ± 1462
Elbow extension velocity (deg/s)	2281 ± 195	2411 ± 288	2399 ± 306
*Lead knee extension (FC to BR) (deg)	19.8 ± 12.0	8.6 ± 10.5	8.2 ± 11.2
**Forward trunk tilt (deg)	23.4 ± 8.9	34.9 ± 7.6	27.5 ± 7.8
Shoulder abduction (deg)	90.7 ± 6.0	88.2 ± 7.1	88.7 ± 8.6
Elbow flexion (deg)	26.8 ± 5.3	24.1 ± 5.0	23.6 ± 5.9
**Ball velocity (m/s)	33.0 ± 1.6	36.8 ± 2.0	36.6 ± 2.1

*Significant difference among groups, p<.05.
**Significant difference among groups, p<.01.

Table 4. Comparison of Throwing Kinetics

Variable	C	P - Mound	P – Long-Toss
Shoulder proximal force (N)	1038 ± 137	1189 ± 170	1088 ± 177
Shoulder horizontal adduction torque (Nm)	94 ± 18	96 ± 18	98 ± 17
Elbow varus torque (Nm)	92 ± 17	93 ± 18	90 ± 19
Elbow flexion torque (Nm)	40 ± 9	47 ± 7	47 ± 7

*Significant difference among groups, p<.05.
**Significant difference among groups, p<.01.

DISCUSSION: It was believed that having to make an accurate long distance throw as quickly as possible would dictate that catchers have significantly different throwing mechanics than other players. Based on the results of this study, catchers clearly utilize a unique set of mechanics when making throws to second base during steal attempts. They are unable to replicate the long stride, foot placement, and pelvis-trunk separation used in long-toss and pitching. Catchers also immediately bend the elbow excessively, bringing the wrist close to the ear, and maintain this extreme position throughout the arm cocking phase. While not quite statistically significant, catchers have noticeably less rotational velocities of the upper trunk and shoulder. All of these adaptations lead catchers to have a significantly lower ball velocity despite nearly identical stress as mound pitches and long-toss on the shoulder and elbow joints. Since the catchers did not have any additional forward trunk tilt at BR, the larger amount of knee extension was attributed to them standing up out of the crouch rather than pushing the hips back to facilitate hip and trunk flexion. All comparable variables in this study were found to be similar to those reported in the Sakurai, Elliott & Grove (1994) study.

While it appears that catchers are emulating the throwing mechanics taught by coaches (Stallings, 2000; American Baseball Coaches Association, 2001), it is unclear whether a more efficient motion is feasible. It is reasonable to assume that the pitching and long-toss motions represent more biomechanically efficient alternatives, but their implementation may cost too much time to throw out runners attempting to steal second base. Further research, including measurements of total movement time and throwing accuracy, may wish to explore the possibility of different styles of throwing to determine which combines the greatest amount of biomechanical efficiency with the greatest amount of time efficiency.

CONCLUSION: Baseball catchers have a significantly different throwing motion than other positions. The most notable kinematic differences include a shorter stride, open foot position, closed foot angle, and reduced pelvis-trunk separation angle at FC; excessive elbow flexion during arm cocking; and less forward trunk tilt at BR. A clinically significant reduction in upper trunk rotation and shoulder internal rotation velocities lead to a statistically significant reduction in ball velocity, suggesting a biomechanically less efficient throwing motion than other players. It is likely that these biomechanical changes are done in the interest of minimizing the total time it takes to the deliver the ball to second base.

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