



RELATIVE CONTRIBUTIONS TO BASEBALL CATCHER POP TIMES: HIGH SCHOOL AND MAJOR LEAGUE BASEBALL COMPARISON

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Abstract:

Pop time (POP) is the measure of how long it takes a catcher to throw to 2nd base calculated from when the ball arrives in his mitt to when it arrives in the fielder's glove at 2nd base. It has recently been suggested that greater emphasis should be placed on throwing velocity development instead of the ball exchange and throwing motion. The present study determined if the differences in POP characteristics between high school (HS) and Major League Baseball (MLB) catchers indicate a greater contribution from throwing velocity. HS catchers had slower POP characteristics in both exchange and throw phases. Exchange and throw times relative to pop times were nearly identical for HS and MLB, 36.6% and 36.0%, and 63.4% and 64.0%, respectively. The exchange phase exhibited the greatest variability and the most room for improvement. POP percent contribution from the exchange and throw phases between HS and MLB catchers did not change and their absolute values both improved equally. Therefore, it may be beneficial for coaches to design programs that not only strengthen the arm, but also develop efficient ball exchange and catcher throwing mechanics prior to ball release.

Keywords: catching; velocity; sport science; performance; kinematic sequence

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1. Introduction

The catcher is arguably the premier defensive position in baseball. Not only is the catcher involved in each pitch thrown within a game, but a diverse technical skillset is required to play the position. Receiving and throwing - two distinct skills - are demanded in combination whenever opposing baserunners attempt to steal a base. Within this context, the most skilled catchers execute the exchange (i.e., receiving to ball release) and throw in as little time as possible. The way that this is traditionally evaluated by coaches in baseball is through the catcher's "pop time" (POP), which is how long it takes a catcher to throw to 2nd base calculated from when the ball arrives in his mitt to when it arrives in the fielder's glove at 2nd base.

Because of the tactical offensive advantage associated with having runners in scoring position, it is also of utmost importance for coaches to know the relative proportion of time spent by the catcher executing each of the POP components. Conventionally, coaches have often focused on improving the ability of the catcher to transfer the ball from his mitt to his throwing hand and then make a rapid release of the ball, collectively termed the "exchange". Contrary to the traditional approach, it has recently been suggested that improving throwing velocity is the most important when aiming to reduce POP (Brady & Caravan, 2018). However, these authors exclusively examined a sample of Major League Baseball (MLB) catchers, which may not inform player development, as the players used were already of a world-class level. Therefore, it may be useful for coaches if the distinguishing POP characteristics between amateur and world-class level catchers were identified.

The purpose of the present study was to determine the differences in POP characteristics between high school (HS) level and professional baseball players competing on the MLB level of baseball competition.

2. Methods

The current investigation used an observational design in which ten former HS catchers ($\bar{x} \pm SD$; age= 21.9 \pm 5.0 years, height= 1.80 \pm 0.05 m, catching experience= 5.4 \pm 1.0 years) volunteered as participants. Game data of MLB catchers (n= 57) were obtained from a publicly available database (<https://baseballsavant.mlb.com/poptime>). Catching POPs were determined in the lab while subjects received simulated pitches from a pitching machine (First Pitch Baseline, Maple Plain, MN, USA) with an entrance velocity of approximately 70 mph (Figure 1). Only MLB catchers with at least 10 measured POP times from the 2019 season were included for analysis. All testing procedures performed in the study were previously approved by the University's Institutional Review Board and all participants signed an Informed Consent Document.

The receiving and throws to second base were video recorded (Casio Exlim-ZR1000, Tokyo, Japan) at a frame rate of 240 Hz (4.167 ms/frame). The video was subsequently processed and analyzed using an open-source video analysis software

(Kinovea, v0.8.15) to determine transfer duration (t_{TR}), release duration (t_{REL}), and exchange duration (t_{XCH}) in milliseconds (ms). Transfer duration was defined as the time from ball arrival in the catcher's mitt to the transfer to the hand. Release duration was defined as the time immediately following t_{TR} to release of the ball. Exchange duration was defined as the sum of t_{TR} and t_{REL} . Radar accuracy was verified by a certified and calibrated tuning fork with a frequency of 24.15 Hz. A radar gun (Sports Radar, Gays Mills, WI, USA) was used to measure throwing velocity, which was then used to derive throw time (t_{THR}) for the ball to arrive at 2nd base. Throw time was determined by dividing the distance from home to first (i.e., 127 feet and 3³/₈ inches) by the throw velocity. The POP was the sum of t_{XCH} and t_{THR} . Relative percentages of POP were calculated for t_{TR} ($\%t_{TR}$), t_{REL} ($\%t_{REL}$), t_{XCH} ($\%t_{XCH}$), and t_{THR} ($\%t_{THR}$). These values were then compared to the game data of MLB catchers from the publicly available database that contains the throw velocity, t_{XCH} , and POP. The throw velocity reported for the MLB catchers is the average above the player's 90th percentile; thus, the sum of derived $\%t_{THR}$ and given $\%t_{XCH}$ would be less than one hundred percent. Instead, throw time for the MLB catchers was determined by subtracting the t_{XCH} from the POP. Values for the HS catchers were to three decimal places due to the resolution of the camera frame rate, whereas the values for the MLB players were to two decimal places as reported. It should be noted that data for HS catchers was from a single testing performance in the laboratory, whereas MLB data were verified from actual regular season games.

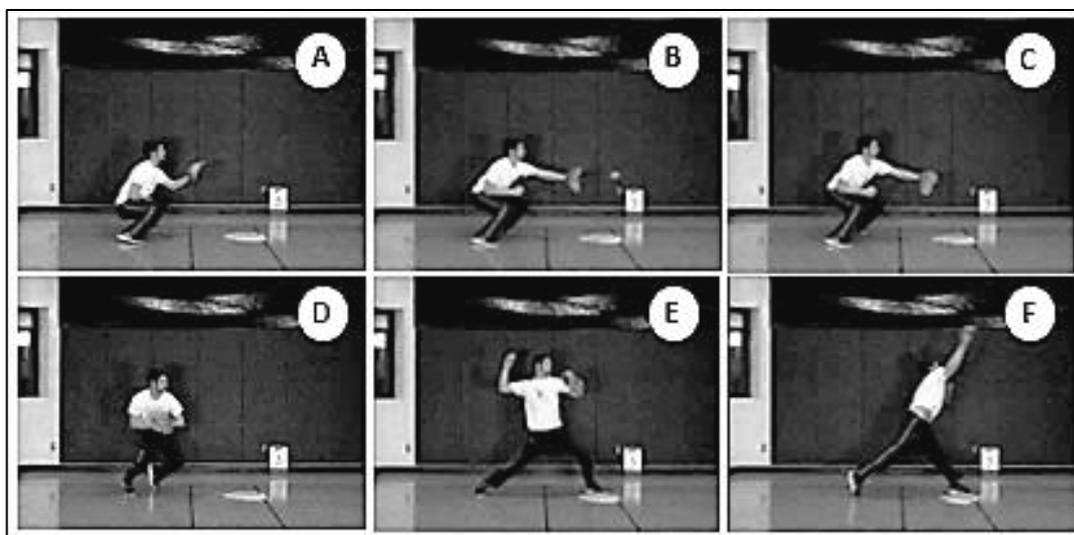


Figure 1: (A) receiving position, (B) ball arriving, and (C) ball in mitt. (C) to (D) capture ball transfer, (D) to (F) capture ball release, and (C) to (F) capture total exchange time

Descriptive statistics, means and standard deviations ($\bar{x} \pm SD$), coefficient of variation (CV%), and minimum and maximum values were calculated for each variable. Independent sample t-tests were used to determine significant differences between HS and MLB catchers for each of the common variables examined in the present study. Statistical significance was set *a priori* to $p < 0.05$. All statistical analyses were completed with SPSS (Version 26.0; IBM Corp. Armonk, NY, USA).

3. Results

HS catchers had significantly longer and more variable POP times relative to MLB catchers. Both groups spent similar relative percentages of time executing t_{XCH} and t_{THR} , as suggested by nearly identical $\%t_{XCH}$ and $\%t_{THR}$. However, t_{XCH} and t_{THR} were both significantly longer for high school catchers compared to MLB catchers. Both variables also displayed greater levels of variation for the HS catchers, although t_{XCH} more so than t_{THR} . Both magnitude and variation in t_{XCH} appear to be driven primarily by t_{REL} (Table 1).

Table 1: Descriptive statistics, means and standard deviations ($\bar{x} \pm SD$), coefficient of variation (CV%), [minimum and maximum], and statistical significance

Variable	HS	MLB	p-value	Difference compared to HS
t_{TR} (sec)	0.250 ± 0.016 (6.6) [2.17, 2.81]	—	—	—
t_{REL} (sec)	0.545 ± 0.096 (17.6) [0.431, 0.698]	—	—	—
t_{XCH} (sec)	0.796 ± 0.106 (13.4) [0.675, 0.979]	0.72 ± 0.04 (5.56) [0.64, 0.83]	<0.001	- 9.5%
t_{THR} (sec)	1.372 ± 0.108 (7.9) [1.271, 1.627]	1.29 ± 0.05 (3.88) [1.18, 1.44]	<0.001	- 6.0%
POP (sec)	2.167 ± 0.181 (8.4) [1.969, 2.497]	2.01 ± 0.06 (2.99) [1.89, 2.14]	<0.001	- 7.7%
$\%t_{TR}$ (%)	11.6 ± 0.8 (7.0) [10.1, 12.4]	—	—	—
$\%t_{REL}$ (%)	25.0 ± 2.9 (11.5) [21.9, 29.2]	—	—	—
$\%t_{XCH}$ (%)	36.6 ± 2.8 (7.6) [33.8, 41.0]	36.0 ± 1.8 (4.95) [32.06, 40.29]	0.349	—
$\%t_{THR}$ (%)	63.4 ± 2.8 (4.4) [59.0, 66.2]	64.0 ± 1.8 (2.78) [59.71, 67.94]	0.349	—

Note: t_{TR} = transfer time; t_{REL} = release time; t_{XCH} = exchange time; t_{THR} = throw time; POP= pop time; $\%t_{TR}$ = transfer time relative to pop time; $\%t_{REL}$ = release time relative to pop time; $\%t_{XCH}$ = exchange time relative to pop time; $\%t_{THR}$ = throw time relative to pop time.

4. Discussion

The findings of the present study indicate that level of play may be a differentiating factor in POP, as MLB catchers had significantly better POP times than HS catchers. This difference in POP appears to be driven by both longer t_{XCH} and t_{THR} for HS catchers, indicating that MLB catchers are more skilled in both pre-throw actions (i.e., transfer, release) and possess greater arm strength. Therefore, HS catchers with aspirations of advancing to higher levels of play would benefit from improving both t_{XCH} and t_{THR} .

Although it has been suggested that improving catcher throwing velocity should be the primary emphasis when attempting to improve their pop time (Brady & Caravan,

2018), the present data do not support that judgment. First, the differences in both t_{XCH} and t_{THR} between HS and MLB players were significant. Additionally, the absolute differences in mean values for both measures were very similar, with mean values for MLB t_{XCH} being 0.076 sec faster, and for t_{THR} being 0.082 sec faster than for the HS catchers. So, the absolute differences were almost identical, being within 0.06 sec of each other. When one considers that the % t_{XCH} is only 36.6% of the total POP time for HS catchers, the 0.076 sec difference between HS and MLB catchers takes on greater importance. In other words, based on the present data, for a HS catcher to improve POP times to match their MLB counterparts, they need to decrease t_{THR} by only 6.0%, whereas they need to decrease t_{XCH} by 9.5% (Table 1). Additionally, the high variability of t_{REL} (a component of t_{XCH}) for the HS catchers suggests that this phase of the total POP time may possess the most room for improvement and consistency.

Improvements in t_{REL} would likely coincide with improved efficiency in arm stroke while throwing. This is seen in older catchers that elevate their arm less than younger catchers to make an abbreviated throw leading to a faster t_{XCH} (Plumer & Oliver, 2013). It has also been reported that older catchers have greater pelvis-trunk separation than younger catchers, which allows them to generate and transfer a greater amount of energy from the lower to the upper body when throwing (Plumer & Oliver, 2013). This improvement in kinematic sequencing allows for less shoulder external rotation to minimize time and thus improve t_{XCH} . Furthermore, proper sequencing would improve throwing velocity and reduce t_{THR} without requiring an increase in arm strength. An improvement in kinematic sequencing has been shown to result in less torque production and stress across body parts while still improving ball velocity (Scarborough et al., 2021a). When catchers throw from their knees instead of from a standing position, the lower body's kinematic sequence to generate force is lost and the upper body attempts to compensate to maintain throw velocity (Plummer & Oliver, 2015). Kinematic sequencing (i.e., pelvis-trunk-arm-forearm-hand) is also seen in pitchers and becomes more efficient and less variable with experience (Scarborough et al., 2021b). Therefore, it may be most advantageous for coaches to design programs that not only strengthen the arm, but also promote self-organization that drives the development of efficient throwing kinematics for the exchange phase to improve POP.

In conclusion, although improvements in both t_{XCH} and t_{THR} are important for HS catchers to develop faster POP times, it appears that there is considerably more potential for improvement in t_{XCH} . This is contrary to recent suggestions (Brady & Caravan, 2018) that propose throwing velocity should be the primary focus for young catchers to improve POP times. Regardless, faster times for both t_{XCH} and t_{THR} can enhance POP times for the typical HS baseball catcher. Results from this study can be used to evaluate catchers to determine where there are deficits in a catcher's transfer and/or throw to second base. The information can help coaches to determine the best exercises to develop and optimize the complex combination of kinetics and kinematics in HS baseball catchers to help them reach the next level of play.

Conflict of Interest Statement

The authors declare no conflicts of interest.

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