Linear Momentum During Sprinting and Exit Ball Velocity in Major League Baseball Players

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Introduction

Considerable amounts of Major League Baseball (MLB) performance data have become publicly available and accessible in recent years. This includes hitting performance measures such as ball exit velocity (BEV) and sprint performance data. While sprint performance measures, such as time and velocity, have frequently been used as key performance indicators, recent research has indicated that linear momentum (L) is likely a superior measure (Mann, et al., 2022). Furthermore, measuring velocity out of the batters' box in MLB is problematic as left-handed hitters will finish their swing in a more advantageous position facing the direction they will eventually run as compared to their right-handed counterparts who must begin the sprint with a change-of-direction. This has been shown previously where left-handed hitters were described as faster than their right-handed counterparts when sprinting from home to first base (Coleman and Amonette, 2015). To the current authors knowledge, no study has evaluated the relationship between BEV and sprint performance measures. Therefore, the purpose of this study was to evaluate the predictive value of velocity and linear momentum for predicting ball exit velocity in MLB players while controlling for swing side.

Methods

Data for this study came from combining data from MLB's publicly available Statcast database (sprint and hitting data) and individual MLB team websites (body mass) and included data from the 2022 season. Sprint data was only included for players who completed a minimum of 10 sprints classified as "competitive," which excludes home runs and other situations where a player may not be exerting a strong effort. BEV inclusion criteria included a minimum of 2.1 plate appearances per game. This resulted in a sample size of 282 players. Maximum BEV was used for this study. Sprint interval velocities were calculated at 0 m to 3.0 m (0 to 10 ft), 0 m to 9.1 m (0 to 30 ft), 9.1 to 18.3 m (30 to 60 ft), and 18.3 to 27.4 m (60 to 90 ft). L was then calculated from this as the product of mass and velocity at the intervals previously mentioned. Mean velocity and L were also calculated. Linear regression with partial correlation was used to quantify the predictive value of both velocity and momentum for BEV at the various intervals while controlling for swing side. All statistical analyses were completed in R.

Results

Sprint velocity was a poor predictor of BEV when controlling for swing side, predicting between 0.8 to 2.3% of the variance in BEV and no models being statistically significant. L performed better, predicting 20.6 – 27.2% of the variance in BEV and all models were statistically significant. L at the 9.1 to 19.3 m interval was the strongest predictor (r^2 = 0.272) but mean L was not far behind at (r^2 = 0.257). Full results are shown in Table 1.

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Mean **Linear Momentum** During Sprinting **Predicts 25.2%** of the Variance in **Ball Exit Velocity** of MLB Players

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Predictor Variable	Variance Predicted	Predictor Variable	Variance Predicted
Mean V	0.8%	Mean L	25.7%
V @ 0 to 3 m	2.3%	L @ 0 to 3 m	20.6%
V @ 0 to 9.1 m	1.6%	L @ 0 to 9.1 m	22.9%
V @ 9.1 to 18.3 m	0.8%	L @ 9.1 to 18.3 m	27.2%
V @ 18.3 to 27.4 m	1.0%	L @ 18.3 to 27.4 m	26.0%

Table 1. Variance accounted for by each predictor variable. V = velocity (m/s), L = linear momentum (kg*m/s).

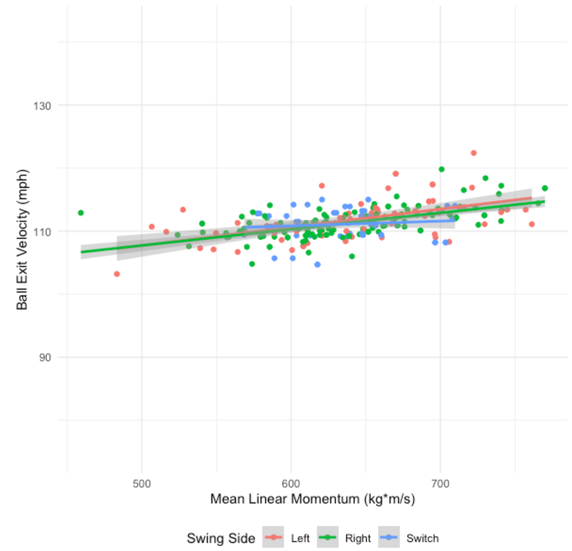

Figure 1. Scatter plot representing the relationship between ball exit velocity and mean linear momentum while also indicating the differences in this relationship by swing side.

Discussion

The primary finding of the present investigation demonstrated the importance of linear momentum as a performance measure in Major League Baseball (MLB) players as it may aid in the prediction of ball exit velocity (BEV). Our study revealed that sprint velocity proved to be a poor predictor of BEV when controlling for swing side, explaining only a trivial percentage of the variance in BEV. Conversely, linear momentum (L) showed superior predictive capabilities, explaining 20.6% to 27.2% of the variance in BEV. While the 2nd 9.1 m (30 ft) interval produced the best predictive value, it was only marginally better than the mean L (1.5%). This is important from a practical standpoint as breaking sprint ability down into intervals may not be necessary if the goal is to predict BEV. The results from this study align with research conducted on NCAA Division I football athletes, which indicates that momentum outperforms velocity as a performance measure across different sport domains (Mann, et al. 2022). We encourage future researchers to explore the associations between linear momentum (L) and other performance measures, such as on-base percentage, slugging percentage, or advanced other advanced statistics (i.e. wOBA, wRC+, etc.).

Practical Applications

Linear momentum (the product of mass and velocity) is a better predictor of BEV than velocity alone and should likely be utilized as a performance indicator over some of the traditional measurements that have historically been used in baseball. BEV is not the only measure of interest for hitting performance and the associations between L and other measures should also be evaluated.

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