Pressure to Perform: The Impact of Center of Pressure Metrics on Pitch Velocity in Baseball Pitchers

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Summary

The pitching motion is initiated by a loading phase in which the player balances on one leg before propelling themselves down the mound. It is unknown whether balance during this period has an impact on pitch performance. This retrospective study analyzed the influence of Center of Pressure (COP) metrics, including excursion, velocity, and ellipse area (EA), in the push-off leg from peak knee height to foot plant on pitch velocity (PV) in collegiate pitchers. Those in the High PV group exhibited significantly greater values across all COP metrics. This suggests larger shifts in COP during the push-off phase may facilitate greater weight transfer, torque generation, and forward momentum, ultimately increasing PV. The role of COP movement appears influential in effective weight transfer and pitch performance, warranting further investigation.

Introduction

The influence of biomechanical factors from force plate data on baseball pitch velocity (PV) has been widely studied; research has shown that higher ground reaction forces contribute to increased PV [1]. During the push-off phase of pitching, players lift their stride leg off the ground, balance on their push-off leg, and initiate a forward motion towards home plate. However, few studies have examined the role of center of pressure (COP) metrics – specifically excursion, velocity, and ellipse area (EA) – in the X (+X towards home plate) and Y (+Y towards third base) directions during this period of dynamic balance. The aim of this study is to determine if COP metrics during the push-off phase influence PV in baseball pitching.

Methods

Data from 73 college-aged pitchers (21±2 years) during regular training sessions at Driveline were retrospectively analyzed via the opensource OpenBiomechanics dataset [2]. Pitchers threw fastballs on a Bertec instrumented pitching mound coupled with 3D motion capture. Pitchers were then split into High PV (≥85mph) and Low PV (<85mph) groups. X, Y, and average COP excursion and COP velocity were calculated from peak knee height to foot plant. Foot plant was defined as the moment the stride foot force plate reached a 50N threshold. COP EA was calculated as the 95% confidence ellipse encompassing the COP trajectory [3] during the same period. Normality was assessed via Shapiro-Wilk's test, and Welch's ANOVA was conducted for each metric to compare pitch groups. The alpha level for all statistical tests was .05.

Results and Discussion

No metric was normally distributed (p<.05). A statistically significant difference (p<.05) between pitch groups was found for all COP metrics (Table 1).

Table 1: COP metrics for High PV and Low PV groups. Reported as Mean(±SD).

	Metric	Low PV	High PV	p-value
Excursion (m)	COPx	0.011 (±0.0058)	0.017 (±0.017)	.023
	COPy	0.026 (±0.014)	0.038 (±0.034)	.040
	Total	0.030 (±0.015)	0.045 (±0.038)	.019
Velocity (m/s)	COPx	6.61 (±3.60)	10.3 (±9.04)	.017
	COPy	16.0 (±8.83)	23.3 (±19.3)	.033
	Total	18.3 (±9.07)	27.4 (±20.9)	.014
Area (m^2)	Ellipse Area	0.0002 (±0.002)	0.0006 (±0.001)	.001

The results indicate COP excursion, velocity, and EA could play an important role in overall pitching performance. Larger excursions and velocity in the X direction may indicate a substantial weight shift towards home plate and a more explosive push-off, allowing for efficient force transfer through the kinetic chain. Larger shifts in the Y direction suggest greater lateral weight transfer, which may facilitate torque generation. COP movement in the Y direction may also reflect necessary dynamic balance adjustments to ensure stability during this phase. The larger EA in the High PV group may suggest increased base of support utilization and increased lower body engagement.

Conclusions

This study highlights the role of COP metrics on pitch mechanics. Pitchers in the High PV group displayed significantly higher COP excursion, velocity, and EA in both X and Y directions compared to the Low PV group. Pitchers in the higher group may utilize a greater COP excursion and EA to generate larger torques and forward momentum. These findings emphasize the importance of COP shifts and efficient weight transfer mechanics in maximizing pitch performance. Baseball professionals should consider enhancing stability and movement during the push-off phase for better pitching performance.

Acknowledgments

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References

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