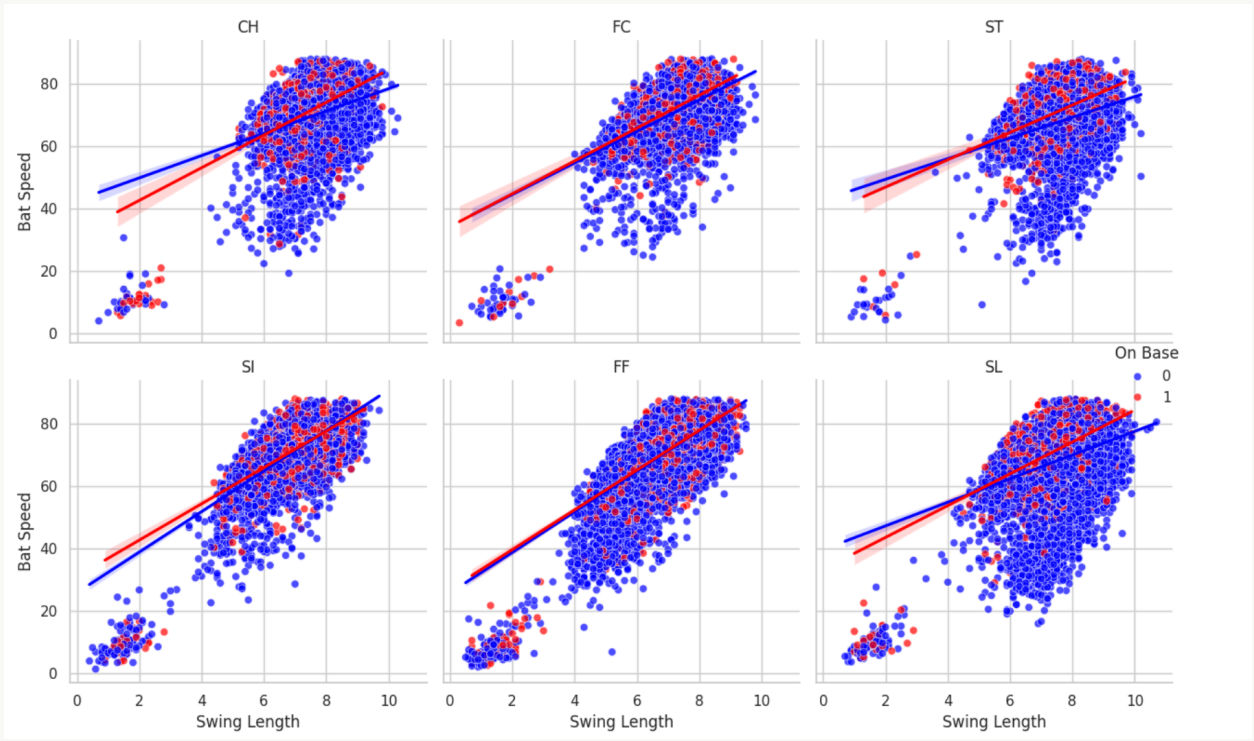
An Investigation of Bat Speed and Swing Length by Pitch Type for the 2024 MLB Season

Swing kinematics is the study of measures on batters' swings in order to determine how adjustments to the swing affect plate appearance outcome (McIntyre and Pfautsch, 1982). For the past 40 years, researchers have used film, digital cameras, and other sensors to capture measures such as launch angle, bat speed, swing length, and contact angle. One study examined the adjustments that 10 experienced baseball batters made during tee-batting. The location of the tee was set to the batter's preferred location within the batter's box at nine different heights within the strike zone. Batters tend to shift the impact locations forward for high and inside pitches and backward for low and outside pitches (Katsumata et al., 2017). Another study involved 13 Division I Collegiate batters, who each took 15 different swings at 3 different places of a tee within the strike zone. The bat speed and angle of contact were recorded by 8 near-Infrared T-series cameras (Williams et al., 2020). Another study of 12 expert (collegiate) batters and 12 novice batters showed that the expert batters demonstrate much better ability in using visual cues from the pitch as it is released from the pitcher's hand to adjust their swing length and bat speed during the final phase of the swing (Gray, 2010). Optimal batting techniques involve choosing the appropriate undercut distance and bat swing angle to maximize ball range, with factors such as ball spin and pitch type influencing the optimal hit (Sawicki et al., 2003).

These findings highlight the complex coordination and decision-making processes involved in successful batting across various pitch locations and types. However, the studies referenced above, and many others, had the disadvantage that they were done with small numbers of batters in a non-game situation. The 2024 season for MLB baseball was the first season for which bat speed and swing length were captured via Statcast for all plate appearances at all major league games (MLB Advanced Media, 2024). The result is a wealth of data to investigate swing kinematics in real-time, real-game situations.

In this paper, we use regression analysis to assess the relationship between swing length and bat speed while accounting for different types of pitches. We calculate the slope between swing length and bat speed for plate appearances that resulted in the batter reaching base vs. those that did not get on base for six popular pitches. The results show that there is a strong relationship between bat speed and swing length, and the relationship is stronger, regardless of pitch type, when a batter reaches base than when he does not. This finding indicates that batters that are better at increasing swing length while simultaneously increasing bat speed, regardless of the pitch type, have a better chance at reaching base than those that do not.

The figure below shows scatterplots of bat speed versus swing length for the six most popular pitch types, which are changeup (CH), cutter (FC), sweeper (ST), sinker (SI), four-seam fastball (FF), and slider (SL). Each dot on the plot represents a plate appearance. Red dots are for plate appearances in which the batter reaches a base (regardless of the number of bases) and blue dots indicate plate appearances for which the batter does not reach base (regardless of the outcome). For each facet, we have two regression lines drawn on the plot. The red line is the regression of bat speed on swing length for the plate appearances where a base was reached. The blue regression line is for the regression of bat speed on plate appearances where the batter did not reach a base. Because we are looking at plate appearances, each batter in the MLB can be represented by more than one point on the graph.



The table below shows the slope for each regression line by pitch and outcome, as well as the correlation, mean and standard deviation for each pitch and outcome. Each row shows the slope for a different pitch type. Each slope can be interpreted as a unit increase in bat speed for each unit increase in swing length. Note that all slopes are positive, indicating that bat speed and swing length are positively correlated. For the SI, SL, CH, and ST pitches, there is a larger difference between the slopes for on base and not on base outcomes, indicating that a change in the relationship between bat speed and swing length is associated with the outcome of the plate appearance. Getting on base with a four-seam fastball (FF) does not seem to require a change in the relationship between bat speed and swing length since the slopes for each outcome are nearly identical.

Pitch Type (Outcome)	Slope	Correlation	Swing Length Mean	Swing Length SD	Bat Speed Mean	Bat Speed SD
FF (On base) FF (Not on base)	6.37 6.49	0.72 0.72	6.96 6.78	0.77 0.83	71.29 69.81	6.80 7.53
SI (On base) SI (Not on base)	5.8 6.5	0.68 0.72	7.00 6.90	0.74 0.82	71.81 70.73	6.33 7.45
SL (On base) SL (Not on base)	5.1 3.79	0.53 0.35	7.45 7.62	0.76 0.86	71.35 68.56	7.32 9.33
CH (On base)	5.24	0.52	7.53	0.72	71.56	7.16

CH (Not on base)	3.57	0.36	7.70	0.74	70.21	7.43
FC (On base) FC (Not on base)	5.26 5.06	0.61 0.56	7.19 7.15	0.75 0.87	72.09 70.55	6.46 7.83
ST (On base) ST (Not on base)	4.38 3.31	0.46 0.30	7.49 7.67	0.71 0.82	70.91 68.12	6.77 9.12

Discussion and Conclusion:

The analysis of bat speed and swing length across the six most popular pitch types (Sinker, Slider, Changeup, Cutter, Sweeper, and Four-Seam Fastball) reveals important insights to their connection to players' ability to get on base. Pitches like the Slider (SL), Changeup (CH), and Sweeper (ST) show larger differences in slope between on-base and not-on-base outcomes, suggesting that adjusting swing mechanics for these pitches is more critical to getting on base. Four-Seam Fastballs (FF), however, display minimal differences in slopes between outcomes, indicating that swing adjustments for this pitch type may have less influence on reaching base.

This investigation provides an understanding of how swing length and bat speed connect to pitch type and plate appearance outcomes. While bat speed and swing length are important metrics, their relationship varies significantly depending on the pitch type and the outcome, emphasizing the importance of awareness and adaptability for batters. Future studies could expand on this work by evaluating additional metrics, such as exit velocity and launch angle, or examining the relationship between bat speed and swing length for specific outcomes, such as a home run or a strike out. Examining how the relationship between bat speed, swing length and plate appearance outcomes evolves throughout a full season would also be of interest. Furthermore, integrating biomechanical data and machine learning models could enhance the predictive accuracy of swing outcomes, offering even more insights for players and coaches.

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