

Batted Ball Speed as a Function of Swing Speed and Impact Location

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■ Introduction

Performance = batted ball speed

- Increased performance with metal bats suggests:
 - increased severity and frequency of injury from the batted ball, most likely to pitchers.
 - imbalance between offense and defense.
- Regulation of baseball bats is an inherent role for governing bodies of baseball.

- # Purpose

The purpose of this study was to determine the performance of two wood bat models and five metal bat models in a batting cage study.



Experimental setup in batting cage (Frozen Ropes, Franklin, MA)

Bats and balls with various reflective markers.
Final marker design on wood bat.



Methods

- **Bats**

Model	L (in.)	W (oz)	W-L	Mass Center (in.)	Barrel Diam. (in.)
W [W1 + W2] (n = 12)	34	31	-3	22.8	2.5
M1 (n = 6)	33	30	-3	20.6	2.625
M2 (n = 6)	33	28	-5	20.4	2.75
M3 (n = 6)	33	28	-5	20.8	2.75
M4 (n = 6)	33	28	-5	21.5	2.75
M5 (n = 6)	34	30	-4	21.3	2.625

- **Balls**

- Wilson A1001 (n = 120)

Methods

- Commercial batting cage facility (50 ft x 16 ft x 12 ft , Frozen Ropes, Franklin, MA)
- Rotating arm pitching machine (Iron Mike, Kansas City, MO.)
 - 45 ft from home plate
- Players (n = 19: 9 professional, 6 college, 4 high school)
 - Bat selection randomized
 - Players rotated hitting sessions (approx. 15 pitches per hitting session)
 - 3 days of data collection
- Ball and bat markers tracked with 4 x 500 Hz infrared cameras (Qualisys, CT)

Results

- - Data from all players pooled.
 - Pitched ball speeds varied 48 mph – 65 mph
 - No differences found with ball speed, data pooled.
 - A total of 1079 pitches recorded, but foul balls, pop-ups and strikes excluded from analysis.

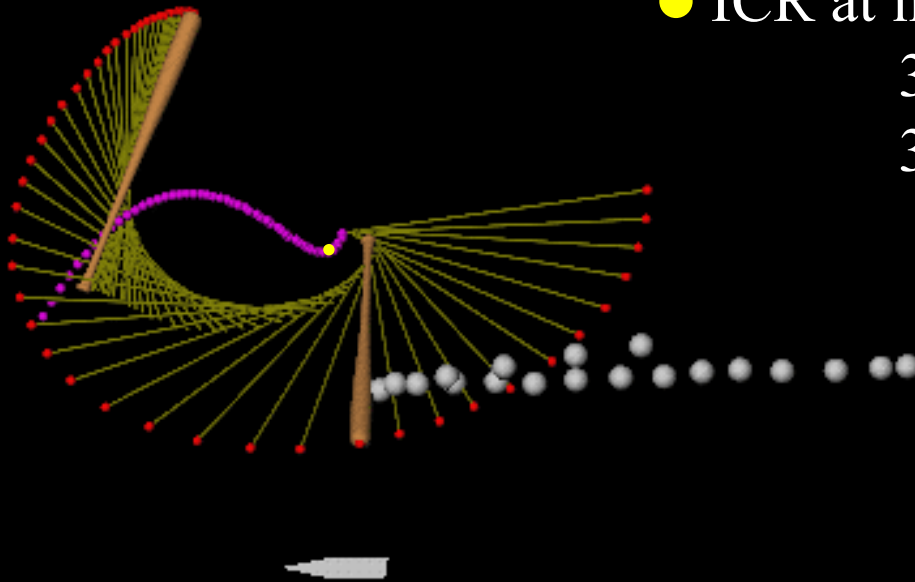
HITS ANALYZED

W	M1	M2	M3	M4	M5	Total
158	88	78	99	50	65	538

3D Kinematic Data

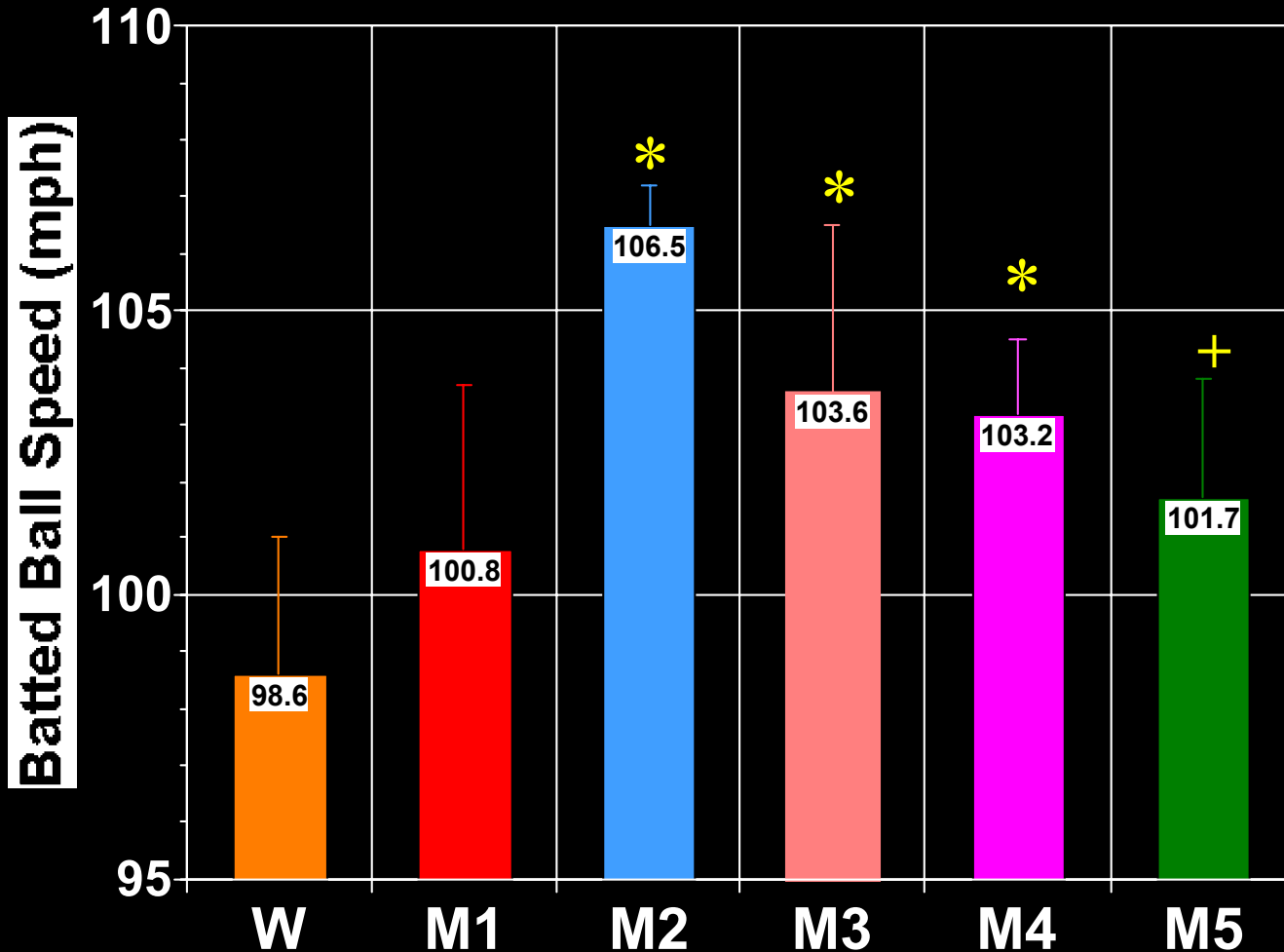


- Instantaneous center of rotation (ICR)
- ICR at impact (n = 533)
 - 32 ± 3 in. from tip
 - 3 ± 2 in. off of long axis



- 0.004 sec between rendered frames
- ICR is intersection of HAM rotation axis with instantaneous plane of bat motion

Top 10% Hits



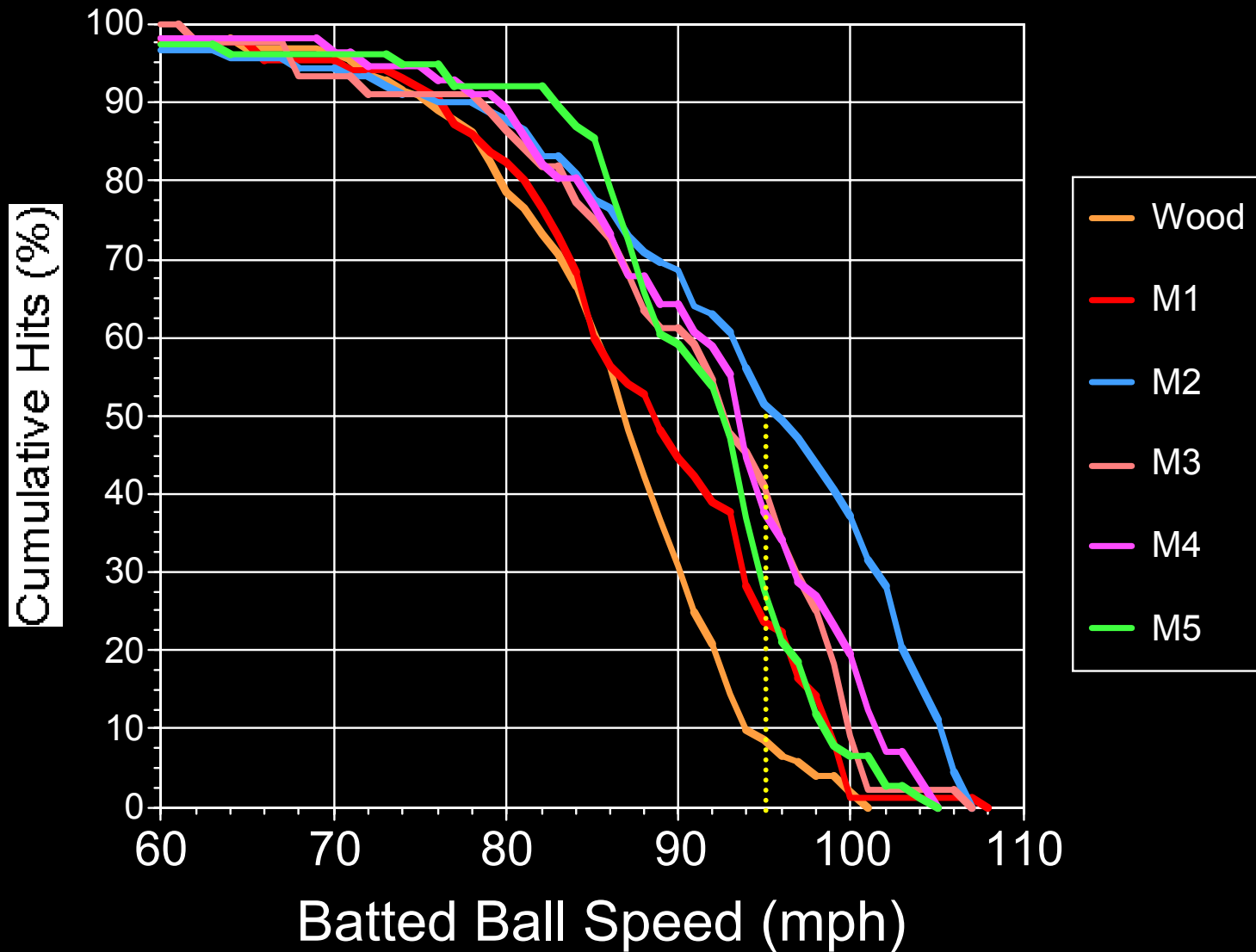
	n
W	15
M1	8
M2	11
M3	7
M4	10
M5	8

Different from wood

* $p < 0.01$

+ $p < 0.05$

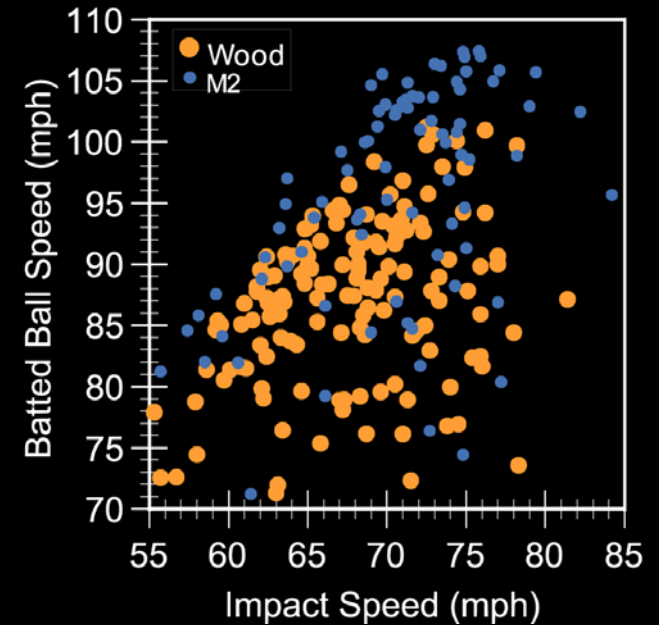
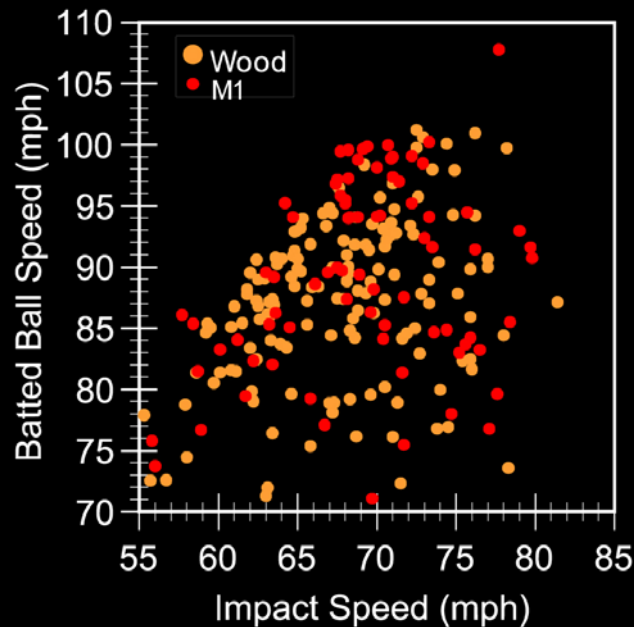
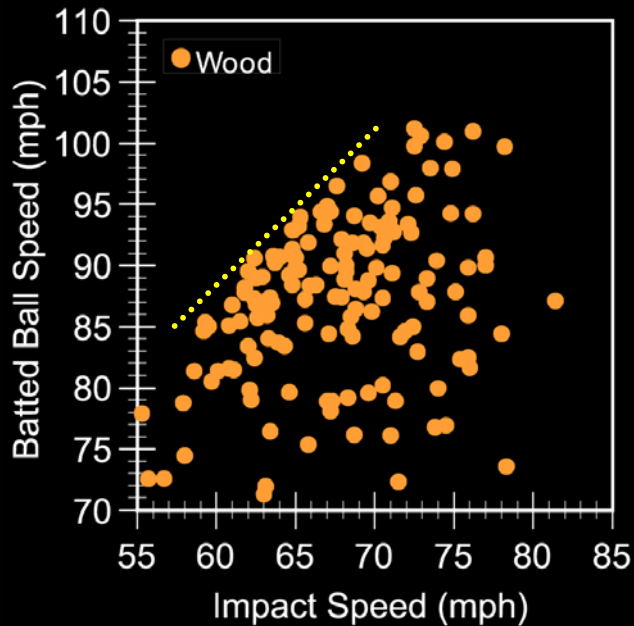
Percentage of Hits Above a Given Ball Speed



Percentage of Swings Above a Given Impact Speed

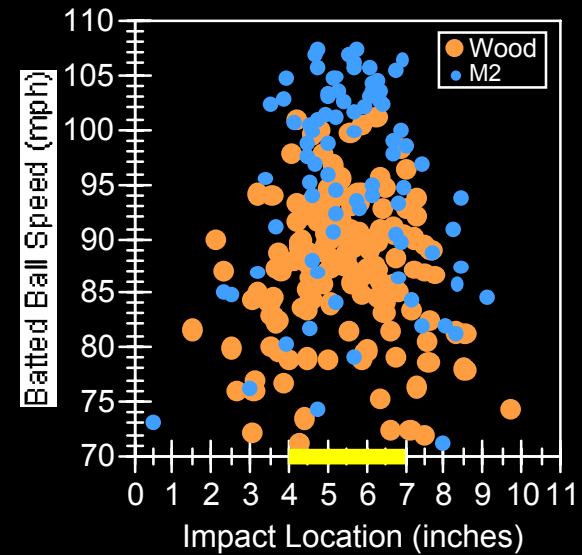
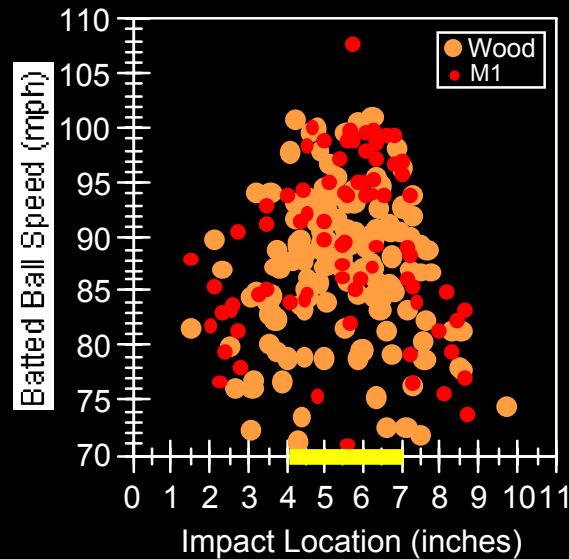
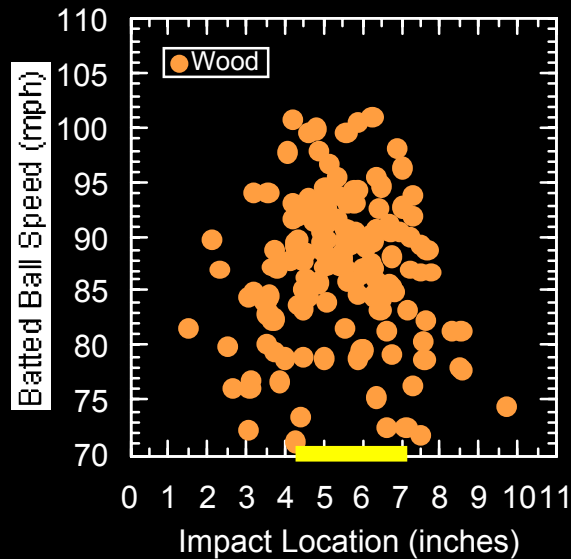


Batted Ball Speed For Various Bat Impact Speeds



- Postulate an **optimal (one-to-one)** batted ball speed exists for a given impact speed (bat speed at point of ball impact) for a “solid hit”
- Hits not “solid” (hits off of “sweet spot” and off of bat central axis) account for lower batted ball speeds
- Difficulty in making solid hits with higher bat speeds may account for observed lower batted ball speeds

Batted Ball Speed at Various Impact Locations



- Impact location measured from tip of bat
- “Sweet spot” — defined as location of maximum batted ball speeds

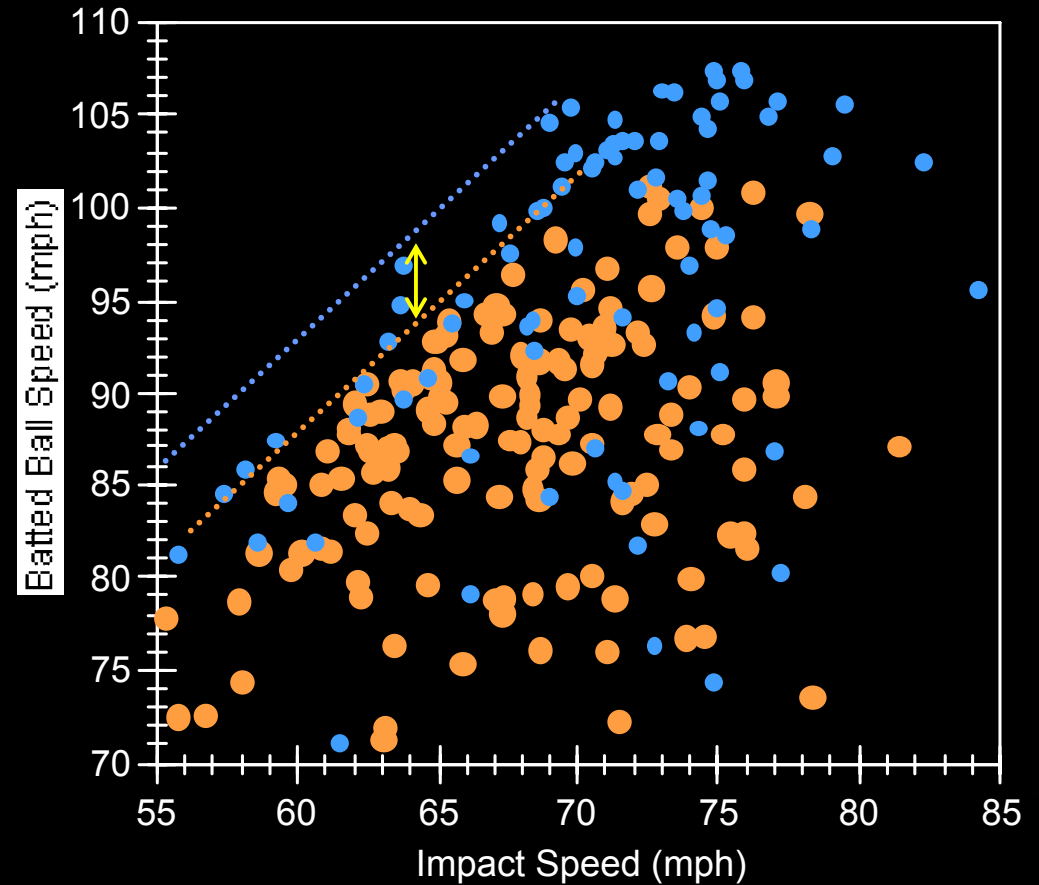
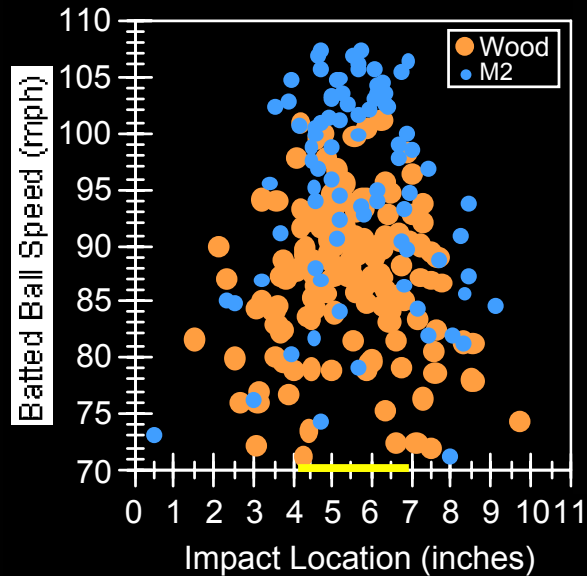
How is Performance Increased?

Hypothesize that increased performance is due to increased swing speed and to a “trampoline” effect.

- Top 10% of batted ball speeds with bat M2 were 106.5 mph, as compared to 98.6 mph with wood.
- M2 swing speeds were 3 mph faster than wood for top 10% hits, accounting for an increase of about 4.5 mph in batted ball speed.
- At the average swing speed, the trampoline effect with M2 contributed about 4 mph increase in performance over wood.

Normalizing for bat swing speed suggests existence of a “trampoline” effect.

“Sweet spots” not different



Discussion



- In this novel study, some metal bats significantly out performed wood bats.
- The performance measured in this study may not be valid for other bats (Four of the five metal bats are now illegal in NCAA play).
- Impact and deformation of ball and bat at impact could not be studied at 500 Hz.
- Kinematics of complete bat swing not analyzed.

■ Conclusions

- Metal bats can clearly out perform wood bats.
- Increased performance attributed to swing speed and trampoline effect:
 - Swing speed influenced by bat weight and weight distribution
 - Trampoline effect demonstrated indirectly only

■ Acknowledgements

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