

# **METAL BASEBALL BATS CAN OUT PERFORM WOOD BATS WITH A SIMILAR “SWEET SPOT”**

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## **INTRODUCTION**

Recent advances in metal and composite bat technologies have led to speculation that metal bats largely out perform wooden bats in baseball. With the potential rise in performance from metal baseball bats, used almost exclusively at the collegiate and high school level in the United States, questions arise as to the effects of metal bats on offensive-defensive balance and safety levels in baseball. Despite the amount of controversy generated, there are presently no available data describing the performance of metal and wood bats in the field. The purpose of this study was to compare the performance of wood and metal baseball bats swung by experienced players.

## **METHODS**

Two wood and five metal baseball bat models (six bats of each model) were studied with 19 players in a batting cage facility. Pitched and batted ball velocities, as well as bat motion, impact location, and bat rotation axis were tracked in three-dimensional space using a commercially available system (four cameras at 500 Hz) and analyzed using specifically written computer code. Of the more than one thousand hits recorded, 538 were considered “line drives” and were included as a trial in the analysis. Automated algorithms and user interaction in Track 3D (Qualisys Inc., Glastonbury, CT) generated and exported files containing the 3D coordinates of markers identifying the ball and five positions along the bat. Data files were then processed using a series of custom programs written in Borland C (SPSS Corp, Chicago, IL) and Matlab (The MathWorks, Natick, MA).

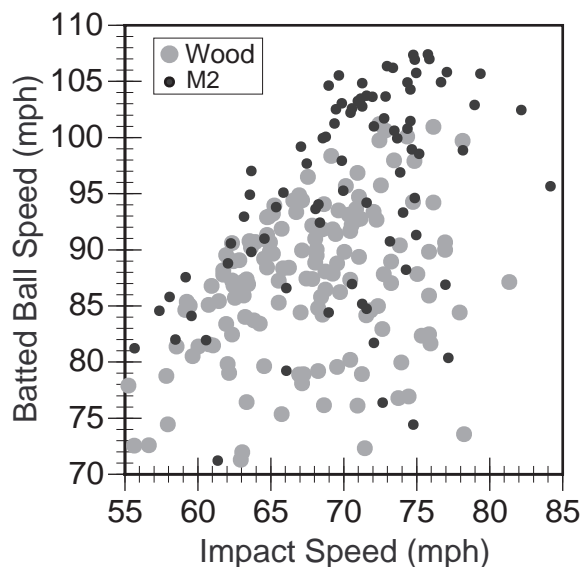
The variables calculated and analyzed included: pitched and batted ball velocities, bat kinematics and impact location of the ball on the bat. To determine ball velocities, the pitched and batted segments of the ball path were defined separately by eliminating data within a 0.004 second window about the time of impact and also near the periphery of the field of view. Ball velocity was assumed to be constant over the pitched and batted segments of the ball path.

The variables describing bat motion were calculated using the two frames just prior to the time of impact, which was defined as the time at the end of the ball inbound segment. The motion of the bat was described using the helical axis of motion (HAM) for rigid bodies. The location of the impact (i.e. where the ball hit the bat) was determined as the intersection of two lines: the long axis of the bat and the path of the pitched ball. The estimate of the error was the shortest distance between these two lines. Once the location of the impact point on the bat was defined, its velocity was then calculated using rigid body transformations. Bat impact speed was defined as the magnitude of bat velocity at the location of the impact. The significance of the difference in the speeds of the batted ball between bat models was determined using an ANOVA and then t tests post hoc (Sigma Stat, SPSS, Chicago, IL).

Of special note is that we have reported all data in U.S. Customary Units because of their long tradition in baseball and the continued use of these units by the sports governing bodies, baseball ball and bat manufacturers, and fans alike.

## RESULTS AND DISCUSSION

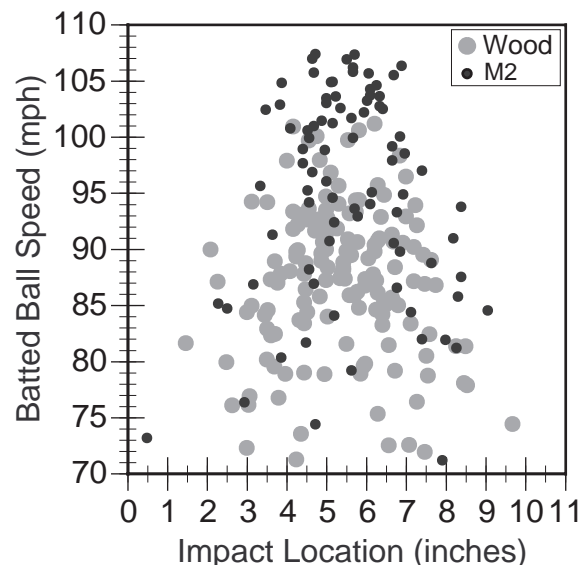
The results clearly indicated that metal bats can outperform wood bats (Figure 1). Of the five metal bat models, one bat model (model M2) statistically outperformed all other models, while one metal bat model (not shown here) was most similar to the wood bats. The data suggest that maximum batted ball speed was generated from two primary components: bat swing speed and barrel efficiency ("trampoline effect"). Furthermore, how much each of these components contributed to batted ball speed varied with bat model.



**Figure 1.** Batted ball speeds for the metal bat M2 exceeded the speeds of balls hit with wood bats (W). Plotting batted ball speeds as a function of bat impact speed accounts for different swing speeds, thus this data suggests that the existence of a "trampoline effect" contributed to the performance of bat M2.

Examination of batted ball speed as a function of impact location revealed a "sweet spot" region, which contrary to popular belief, was not different between metal and wood bat models (Figure 2). While the mechanisms and phenomenon found in this study are deemed valid, it should be noted that the absolute values of and differences in the variables (e.g. batted ball speed) are limited to the experimental environment, the specific bat models used in the study, and the specific players who were

recruited. The findings of this study should dramatically increase our understanding of bat design and performance, and provide an extensive data base for future studies and for comparisons with laboratory test methods presently being proposed for the regulation of bat performance by the governing bodies of baseball.



**Figure 2.** Batted ball speeds of wood (W) and a metal (M2) bats plotted for varying impact locations measured from the tip of the bat. The "sweet spot" was considered to be the length of the bat over which batted ball speeds were a maximum.

## SUMMARY

Batted ball speeds, defined as a measure of bat performance, were determined in a novel study of wood and metal baseball bats. Some metal bats clearly outperformed wood bats, while other metal bats performed more similarly to wood. However, all models appeared to possess similar "sweet spots".

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