

# The influence of ball mass on youth baseball injury potential: A simulation study

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## INTRODUCTION

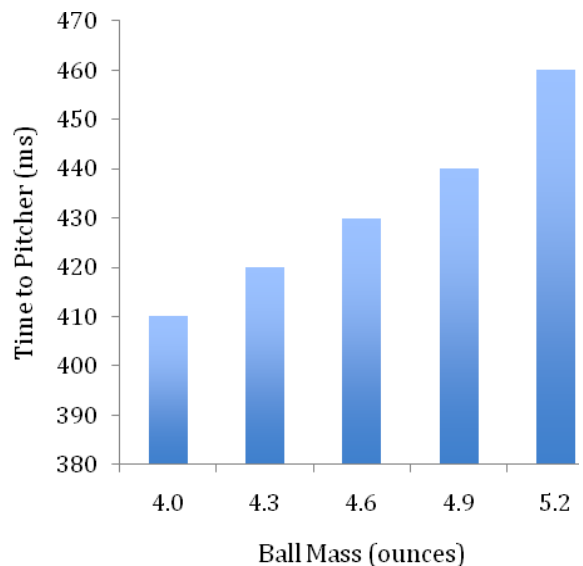
In order to protect their still developing musculoskeletal system, youth athletes commonly use modified equipment and field sizes compared to their adult counterparts. These modifications are designed to provide protection to the youth player without significantly altering the nature of the game. Youth baseball utilizes smaller fields and different bat materials (i.e. aluminum vs. wood) than the adult game, but surprisingly the baseballs used by both are identical. Previous research has demonstrated that a lightweight baseball limits peak torques on the upper extremity in youth pitchers and may reduce arm injuries [1]. However, a lighter ball, when struck in the same manner, will travel both faster and farther than a standard ball. Pitchers are in the most potential danger as they are positioned only 45 feet from the batter and in a compromised follow through position.

## METHODS

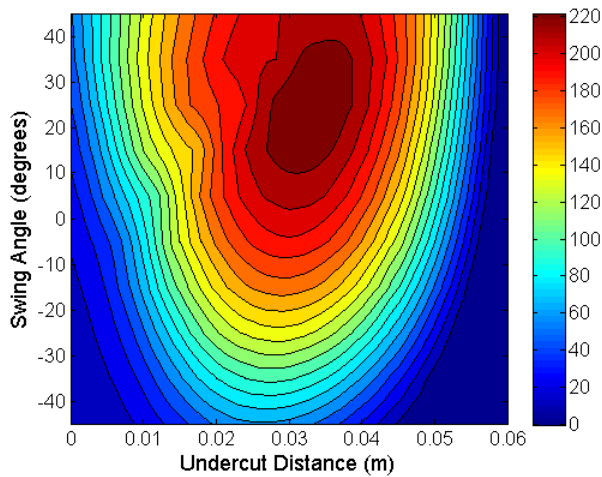
We used a simulation model to compare a lighter ball to a standard ball using (1) the ball exit velocity/reaction time difference for pitchers (2) the difference in pitcher-batted ball impact momentum and (3) the effect of reducing bat-ball coefficient of restitution on exit velocity/reaction time. The simulation included initial conditions for the linear and rotational velocity of the pitched ball, the velocity of the bat at impact, the bat swing angle and the bat-ball undercut distance [2]. These initial conditions were combined with ball and bat properties to determine the linear and rotational velocity of the batted ball, as well as the launch angle of its trajectory at separation. We used the final conditions at separation and a simple aerodynamic model to compute the trajectory of the batted ball.

## RESULTS AND DISCUSSION

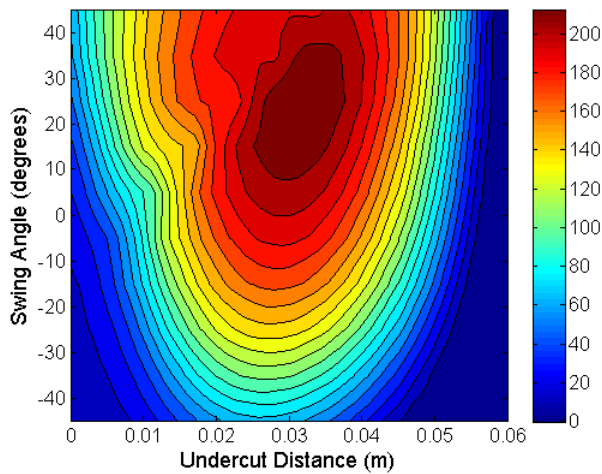
Simulations at the mean bat and ball velocity combination (Fig. 1) indicate that a 4-ounce ball (lightweight) reaches a pitcher standing 45 feet away 11% faster (410ms vs. 460ms) than a 5¼-ounce ball (standard). This translates to a 60 millisecond reduction in available reaction time for the pitcher. Even though the lighter ball travels at a higher velocity than the standard ball, the momentum of the ball at a potential impact with the pitcher is 11% less due to the decrease in mass. Finally, decreasing the coefficient of restitution (COR) from the NCAA and MLB standard range of  $0.525 < \text{COR} < 0.550$  to 0.470 decreases the exit velocity of the lightweight batted ball to that of the standard batted ball, decreases the momentum at a potential batted ball-pitcher impact by 22% (Table 1.) and decreases the batted ball range by less than 3 meters (Fig. 2 & Fig. 3).



**Figure 1:** Flight time for baseballs with varying mass to reach a pitcher positioned 45 feet away.



**Figure 2:** Batted ball range (ft) contour for a standard ball.



**Figure 3:** Batted ball range (ft) contour for a reduced COR lightweight ball.

## CONCLUSIONS

In summary, the implementation of a lightweight ball in youth baseball would result in an increase in batted ball exit velocity, leaving pitchers with less time to react. However, this added danger is offset by reduced impact momentum in a potential batted ball-pitcher collision. Implementing a lighter ball with a reduced COR may be the optimal adjustment to the game as it reduces the loads on the upper extremity of the pitcher, does not increase the exit velocity of the ball, decreases the impact momentum at a potential batted ball-pitcher collision all without significantly altering the maximum range of batted balls.

In future work, we hope to use the modeling framework presented here to examine changes that could be made to bats and balls in order to scale the game of baseball down, so it can be played in areas with space limitations like urban neighborhood parks. Additionally, we hope to examine if standard clinical measurements of reaction time correlate to a youth pitchers ability to avoid balls that are redirected at them after being struck.

## REFERENCES

1. Fleisig, et al. *Sports Engineering* **9**, 155-163, 2006.
2. Sawicki, et al. *Am J. Phys.* **71**, 1152-1162, 2003.

**Table 1:** Comparison of three balls simulated: (1) Lightweight ball, (2) Standard Ball and (3) Lightweight ball with reduced COR.

Ball Mass (ounce)	COR	Exit Velocity (m/s)	Time To Pitcher (ms)	Momentum at Impact (kgm/s)
4.00	0.54	34	410	3.68
5.25	0.54	31	460	4.14
4.00	0.47	31	460	3.21