Biomechanics of the Baseball Swing

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BA (Human Movement Studies)

This thesis is submitted to fulfil the requirements for the degree Masters by Research (Sport Studies) at the University of Technology, Sydney, August, 2010.
Certificate of Originality

I certify that the work in this thesis has not been previously submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledge within the text.

I also certify that the thesis has been written solely by me. Any help that I have received in my research work and the preparation of thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Signature of candidate
Acknowledgements

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Abstract

The purpose of this research was to describe the kinematics of the baseball swing. In particular, this study aimed to determine differences in bat swing kinematics in hitters of varying ability. Further, changes in swing pattern that occur when using bats of varying mass were also observed.

Twenty sub-elite male baseballers participated in the study (22.3 ± 5.3 yr, 1.82 ± 0.07 m, 83.5 ± 10.9 kg). Three baseball bats of equal length (0.838 m) and varying mass (Bat1 = 0.795 kg, Bat2 = 0.847 kg, Bat3 = 0.943 kg) were used. Each subject performed 10 maximal swings with each bat at a ball on a hitting tee replicating a line drive. Infrared cameras obtained high speed three-dimensional data to quantify the biomechanics during the baseball swing. One-way ANOVA was used to determine kinematic differences between conditions. In addition, the participants were ranked prior to testing based on a novel coach’s rating scale and seasonal batting average. They were subsequently separated into a relatively good group of hitters (n=10) and a relatively poor group of hitters (n=10) for comparison. Importantly, the two groups were significantly different in terms of coach’s rating (p<0.01) and batting average (p<0.05).
The results showed a significant difference in maximum bat swing velocity (p<0.05) with good hitters having a higher velocity (36.8 m·s⁻¹) in comparison to relatively poor hitters (33.8 m·s⁻¹). Left elbow maximum angular velocity was significantly higher (35.9%) amongst relatively good hitters (p<0.05). Good hitters also had a right knee angle of 106° at ball contact which was significantly (p<0.05) higher than relatively poor hitters (100°). There were no between-group differences for wrist and hip joint velocities at ball contact.

The results also showed a difference in maximum bat swing velocity (p<0.01) between Bat₁ (36.0 m·s⁻¹) and Bat₃ (34.4 m·s⁻¹). Resultant ball velocity was 17% higher using Bat₁ compared to Bat₃ (p<0.05). Subject head movement was lower using Bat₁ (8 cm) when compared to Bat₃ (10 cm). Maximum linear left hip velocity was significantly higher (p<0.01) when using Bat₃ compared to other bats. In contrast, maximum linear right hip velocity was lower (p<0.01) when using Bat₃.

This study established that bat swing velocity is a key characteristic of the baseball swing when identifying skill level and performance between hitters. Additionally, good hitters display greater lead elbow maximum angular velocity. Future research should develop and evaluate specific baseball training programs designed primarily to improve these two aspects of the baseball swing. Further, this study has identified aspects of the baseball swing that differ when using bats of varying mass. Notably, a relationship exists between bat mass and hip linear velocity which could be a
potential mechanism for underlying training effects. Further studies are needed to
determine acute and longitudinal kinematic effects of using bats of varying mass.
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\[ I = \left(\frac{1}{4}\right)MR^2 + \left(\frac{1}{12}\right)ML^2 \]

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\[ I_o = \frac{T^2 \cdot w \cdot r}{4\pi^2} \]

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\[ k = \sqrt{\frac{I_o}{m}} \]

Equation 4 – Centre of Percussion ...................................................... 29

\[ q = \frac{k^2}{r} \]

Equation 5 – Coefficient of Restitution .............................................. 30

\[ e_o = -\frac{v' - V'}{v - V} \]
# List of Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>3D</td>
<td>Three Dimensional</td>
</tr>
<tr>
<td>ANOVA</td>
<td>Analysis of Variance</td>
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<tr>
<td>BP</td>
<td>Batting Practice Group</td>
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<tr>
<td>BSV</td>
<td>Bat Swing Velocity</td>
</tr>
<tr>
<td>$BSV_{\text{con}}$</td>
<td>Bat Swing Velocity at Contact</td>
</tr>
<tr>
<td>$BSV_{\text{max}}$</td>
<td>Maximum Bat Swing Velocity</td>
</tr>
<tr>
<td>$BV_{\text{max}}$</td>
<td>Maximum Resultant Ball Velocity</td>
</tr>
<tr>
<td>CG</td>
<td>Control Group</td>
</tr>
<tr>
<td>COP</td>
<td>Centre of Percussion</td>
</tr>
<tr>
<td>COR</td>
<td>Coefficient of Restitution</td>
</tr>
<tr>
<td>$^\circ$</td>
<td>Degrees</td>
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<tr>
<td>$^\circ \cdot s^{-1}$</td>
<td>Degrees per second</td>
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<tr>
<td>DS</td>
<td>Dry Swing Group</td>
</tr>
<tr>
<td>Hz</td>
<td>Hertz</td>
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<tr>
<td>ICC</td>
<td>Interclass Correlation</td>
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<tr>
<td>in</td>
<td>Inches</td>
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<tr>
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<td>KP</td>
<td>Kilopond</td>
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<tr>
<td>$\text{LEAV}_{\text{max}}$</td>
<td>Maximum Left Elbow Angular Velocity</td>
</tr>
<tr>
<td>m</td>
<td>Metres</td>
</tr>
<tr>
<td>$m \cdot s^{-1}$</td>
<td>Metres per second</td>
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<tr>
<td>MLB</td>
<td>Major League Baseball</td>
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<tr>
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<td>Description</td>
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<tr>
<td>--------------</td>
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</tr>
<tr>
<td>MOI</td>
<td>Moment of Inertia</td>
</tr>
<tr>
<td>NCAA</td>
<td>National Collegiate Athletic Association</td>
</tr>
<tr>
<td>NSWML</td>
<td>New South Wales Major League</td>
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<tr>
<td>oz</td>
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<td>RPM</td>
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<td>SD</td>
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<tr>
<td>SPSS</td>
<td>Statistical Package for the Social Sciences</td>
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<td>Technical Error of Measurement</td>
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<td>USA</td>
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<td>World Baseball Classic</td>
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Conference Proceedings
