Hitting for Six: Cricket Power Hitting Biomechanics

Drs Stuart McErlain-Naylor, Chris Peploe, Paul Felton and Professor Mark King discuss biomechanical principles underpinning maximising power hitting success in cricket.

Recent years have seen shorter formats of cricket such as One Day Internationals and Twenty20 cricket growing continually in terms of prevalence, popularity, and financial rewards. The Twenty20 Indian Premier League is the sport's richest and highest profile competition, and 2021 saw the introduction of The Hundred in the UK, an even shorter format with each franchise facing only 100 balls. As a result, the risk-reward balance is at an all-time extreme and the ability to score runs at a fast rate by consistently clearing the boundary has never been more highly regarded. This has contributed to an increased focus by players, coaches, and practitioners on the factors associated with maximising power hitting success.

To determine this, we start by considering the factors that affect projectile (i.e., cricket ball) motion following impact with a bat. The distance a projectile travels is primarily determined by its launch angle and launch speed. All else being equal, maximum distance will be achieved with maximum ball speed at a launch angle slightly below 45 degrees above the ground. Through a series of studies, we sought to determine the technique factors associated with launch angle and launch speed (Figure 1).

We recorded 20 male batters from club to senior international standard hitting 'for maximum distance as they would in a match' against a bowling machine, using 3D motion capture at Loughborough University (Peploe *et al.*, 2018a, 2019). It may not come as much of a surprise that the ball launch angle is largely (R^2 = 0.83) determined by the bat angle at impact. We applied a newly validated curve fitting method (Peploe *et al.*, 2018b) to calculate the impact location of the ball on the face of the bat. The two factors explaining the most variation in ball speed were impact location (48%) and bat speed (68% total with impact location). Again, it might not be surprising that the best shots were hit along the midline of the bat. We determined the 'sweet spot' as being 17.5 cm from the toe of the bat along the midline and quantified the margin for error associated with shots impacted outside of this location. Balls impacted away from the 'sweet spot' in any direction resulted in decreased ball launch speeds, whereas medio-laterally (across the bat face) off-centre impacts also resulted in polar rotation of the bat. A cubic relationship (R^2 = 0.89) meant that for the majority of the bat face, an increasingly off-centre impact resulted in an increasing magnitude of bat twist in that same direction, whereas at the edges of the bat a more 'glancing' impact resulted in slightly less bat twist. This bat rotation caused deviations in ball trajectory in that same direction, away from the direction of the bat face prior to impact (R^2 = 0.73). In combination, this means that a ball impacted within 2 cm of the 'sweet spot' in the medio-lateral direction (across the bat) and within 4.5 cm longitudinally (up the bat face) will cause reductions in ball speed of less than 6% and deviations in ball direction of less than 10°. Whilst it is inherently beneficial to generate faster bat speeds, players should not do so at the expense of accurate impact locations (i.e., timing).

But how can players actually increase their bat speed? This is where we get excited as biomechanists. In the same cohort of 20 male batters, we found that three kinematic parameters explained 78% of the variation in maximum bat speed between players (Peploe *et al.*, 2019). The greatest contributor (28%) was the angular separation between the pelvis and thorax in the transverse plane at the top of the backswing (shown visually in Figure 2). Lead elbow extension and wrist abduction/adduction during the downswing also contributed to the explained variation between players. Batters with greater bat speeds achieved greater pelvis-thorax separation, greater elbow extension, and greater 'uncocking' of the wrist. The magnitudes of explained variance in bat speed (pelvis-thorax separation > elbow extension > wrist abduction/adduction) highlight the importance of early central rotations, likely for maximising energy transfer to later distal rotations.

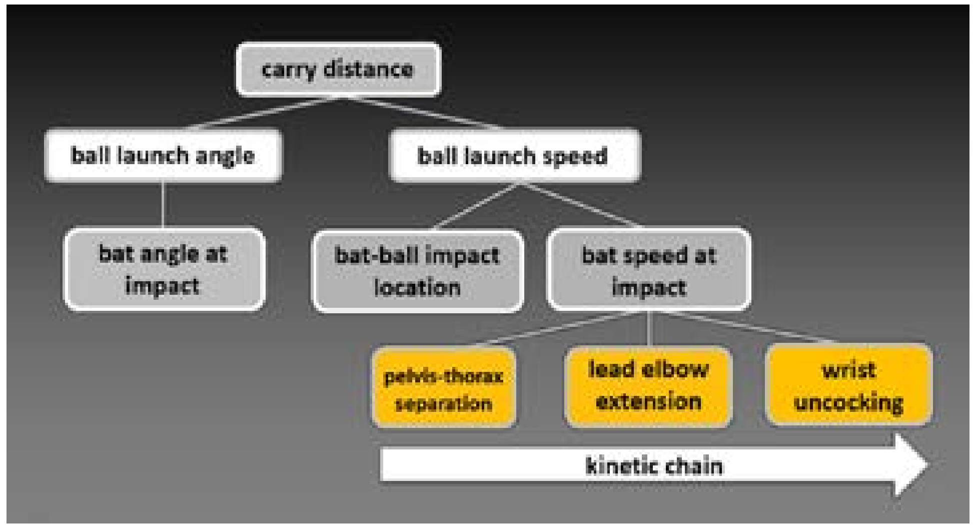

Figure 1. An indicative deterministic model of power hitting, based on Peploe et al. (2018a, 2019). The model currently focuses on bat speed, with future research necessary to investigate factors associated with bat angle and bat-ball impact location.

Figure 2. The angular separation between the pelvis *(red line)* and thorax *(blue line)*. The separation in the transverse plane is mapped onto the ground. Scan the QR code for a lecture on cricket batting biomechanics as part of the Sports Biomechanics Lecture Series on YouTube.

Many factors differ between male and female cricket, including the bat size and mass, the ball size and mass, the boundary size, incoming ball speeds, strength characteristics, biopsychosocial factors, as well as differences in training/coaching histories due to resources and/or perceived or real differences in the aforementioned constraints. Can we simply transfer our knowledge to the women's game, or is it more complicated than that? In a similar protocol to the previous studies, we tested 15 male and 15 female batters ranging from university academy players to senior internationals (McErlain-Naylor *et al.*, 2021). We controlled for differences in body mass and height, and investigated the combined effect of other constraints on the power hitting movement solutions of these skilled male and female batters. The greatest difference between male and female batters was the lead elbow flexion/extension during the downswing. All male batters extended their lead elbow, by an average of 30 ± 12°. In contrast, only 7 of the 15 female batters extended their lead elbow while the remaining 8 flexed their lead elbow during the downswing. Many female batters appeared to choose a different movement solution, more representative of a traditional 'checked drive' than any specific power hitting technique as seen in the male batters. It is currently unclear whether this difference is due to strength constraints, scaling of bat moment of inertia, coaching history, or whether the shorter boundary in female cricket enables those players to select a technique with lower maximum bat speeds but greater consistency and margin for error in timing, impact location and shot direction. This is certainly a topic to be explored further in larger female cohorts.

The rise of power hitting has seen more and more players and coaches dedicating training time to this objective. Due to the high injury risks associated with excessive repetitions by bowlers, it is common to seek alternative delivery methods for batting practice. These include a bowling machine, as used in the above studies to control incoming ball trajectory, and a Sidearm™ thrower (similar to the plastic devices used to throw balls for dogs in the park). We used 3D motion capture to compare batting technique in 14 male batters (from club to international standard) playing pull shots against all three delivery methods (McErlain-Naylor *et al.*, 2020). Pelvis-thorax separation in the frontal plane at the top of the backswing was greatest against the bowler and lowest against the bowling machine. The rear elbow extended most during the downswing against the Sidearm™, and the wrist backswing magnitudes were greatest against the bowling machine. It therefore appears that delaying the availability of visual cues to the batter (i.e., earliest/maximal availability against a bowler, intermediate availability against a Sidearm™, latest/minimal availability against a bowling machine) may result in increasingly distal dominance of the batting technique, perhaps due to timing constraints restricting the important proximal torso rotations. Coaches and players should be aware of this effect when seeking to make evidence-based training decisions, dependent upon the specific objectives of a session.

Summary

As the focus on power hitting continues to grow in tandem with the shorter formats of cricket, it is important for stakeholders (players, coaches, practitioners, and researchers) to consider the various constraints impacting performance in this task. We cannot simply coach all players in the same manner or consider technique in isolation from other factors. If an ideal movement solution exists for an individual then it is through an interaction with the demands of their particular competition, their equipment, the training methods used, and individual characteristics. Whilst we are yet to quantify the effects of manipulating individual constraints, it is an exciting collaborative prospect for multidisciplinary researchers and practitioners over the coming years. ■

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References:

McErlain-Naylor, S.A. *et al.* (2020). The effect of delivery method on cricket batting upper-body kinematics. ISBS Proceedings Archive, 38(1), 664-668.

McErlain-Naylor, S.A. *et al.* (2021). Comparing power hitting kinematics between skilled male and female cricket batters. Journal of Sports Sciences, 39(21), 2393–2400.

Peploe, C. *et al.* (2018a). The relationships between impact location and post-impact ball speed, bat torsion, and ball direction in cricket batting. Journal of Sports Sciences, 36(12), 1407–1414.

Peploe, C. *et al.* (2018b). A curve fitting methodology to determine impact location, timing, and instantaneous post-impact ball velocity in cricket batting. Proceedings of the Institution of Mechanical Engineers, Part P: Journal of Sports Engineering and Technology, 232(3), 185–196.

Peploe, C. *et al.* (2019). Relationships between technique and bat speed, post-impact ball speed, and carry distance during a range hitting task in cricket. Human Movement Science, 63, 34–44.

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