PICKING THE LENGTH: INVESTIGATING HOW BOWLING LENGTH INFLUENCES BATTER DECISION-MAKING IN INTERNATIONAL MEN'S 50-OVER CRICKET

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Abstract

In this study, 19,587 balls bowled by fast bowlers across two One-Day International (ODI) cricket tournaments were analysed, with the aim of exploring the relationship between bowling lengths and foot-based batter decision-making. Initially, a Chi-Square test of independence was used to determine if bowling lengths were associated with the foot-based decision-making of batters. Subsequently, the relationship of specific foot-based strokes with different bowling lengths were further examined through a Logistic Regression. Post-Hoc analysis of standardised residuals from Chi-Square tests suggest an association between foot-based decision making and dot balls ($\chi^2(1) = 99.798$, $p < .001$). Furthermore, Logistic Regression results reveal that all length zones except the half-tracker length show statistically significant association with front-foot and back-foot strokes. Respective coefficients of these length zones also show an organisation of specific strokes with front-foot stroke dominating lengths close to the batter (yorker, full-toss, half-volley and good length) and back-foot strokes dominating zones further away from the batter (back of a length and short length). The results confirm interdependence between batter-bowler performances and suggest that batters in ODI cricket prefer meeting the ball on the front foot in their search of scoring runs.

Keywords: Decision-Making, Bowling Length, Cricket, Cricket Batting, Flexible Decision-Making.

Introduction

The dynamic interceptive action of optimally intercepting a ball in cricket batting requires high levels of decision-making performed in considerably little amount of time and it necessitates accurate anticipatory skill as well as the pick-up of advanced information (Müller et al., 2006; Weissensteiner et al., 2009). While each format of cricket involves its own game-specific stipulations, in limited-overs cricket the aim is to score more runs than the opponent within a stipulated number of balls (Mehta & van der Kamp, 2021). With 11 players formulating a team, bowlers are tasked with taking all 10 wickets (when a batter gets out or is dismissed, leading to be replaced by the next batter in the team) to end an innings or finishing the required balls to be bowled, whilst conceding as few runs as possible. A team tries to take wickets by using a combination of bowlers who use different bowling styles, bowling hands, bowling speeds as well as subtle variations in trajectories to get batters out. (Jamil et al., 2022, 2023; Mehta et al., 2022). At the highest level of the sport, batters can face a ball regularly traveling over 140 kilometres per hour, which affords a temporal tolerance of only between 2 and 5 milliseconds to optimally intercept the moving ball (Sarpeshkar & Mann, 2011; Regan, 1997). Additionally, skilled bowlers at the highest level will also enforce trajectory deviations after ball-release such as swinging the ball in the air (conventional or reverse swing) as well as seaming the ball after it bounces or pitches (moving towards or away from the batter), thereby increasing the difficulty of the interceptive task even further (Mehta et al., 2022). These trajectory modifications either pre- or post-bounce lead to late deviations in the ball trajectory and require stroke adjustments in extremely short amounts of time (R. A. Stretch et al., 2000). Such task constraints alongside ever-changing environmental constraints like pitch and ball deterioration requires batters to exhibit functional variability in their motor responses and accuracy in their decision-making (Connor et al., 2020; Phillips et al., 2010, 2012), consequently making the sport an ideal vehicle to study this variability. Batters must use numerous informational cues to determine their optimal response or batting stroke that range from anticipating point of ball release, predicting ball-bounce location or bowling length as well as picking up other specifying cues from the environment. These could include specific positioning of the fielders to gauge the upcoming ball (Müller et al., 2006), postural cues in bowler delivery style (Williams & Jackson, 2019), as well as specific match situations (such as powerplay and death overs) (Jamil et al., 2023). While these informational cues have been studied in isolation, they have not been extensively examined from the perspective of interactions between batter and bowler, especially not with elite competitors performing in their natural environment.

Regardless of the number of informational cues, or the quality of these, they must all be used by batters to produce a singular batting stroke. While there are over 25 different batting strokes (based on human annotations of stroke types commonly used in performance analysis), most of them are classified as front-foot or back-foot strokes based on the batter's gross body movement - whether the batter moves forward or backward from their original stance (Khan et al., 2017). These front-foot or back-foot strokes have been studied in relation to the biomechanical and kinematic determinants of individual strokes such as the front foot drive (Stretch et al., 1998; Peploe et al., 2014), but have not been studied together in an interactive, competitive environment where they serve as decision-driven actions. Moreover, there is also a clear dearth of research within decision-making literature relating to the study of discrete decisions taken at the highest competitive level of team sports (Araújo et al., 2019). This paper attempts to examine whether batter decisions elicited in front-foot or back-foot strokes is related to, or influenced by, the bowling length (ball-bounce location) of the deliveries they face. By using the discrete nature of balls bowled in cricket matches, and analysing front and back-foot strokes played by top international cricket batters, this paper intends to fill the gap in literature regarding interactive decision-making at the elite level of performance.

Accurate pick-up of information regarding bowling length or ball bounce location is considered a fundamental skill for successful batting as the bowling length will often determine the height at which the ball will arrive at the batter. Consequently, the time batters have to adjust to post-bounce movement will also adjust depending on the bowling length – the balls pitched further from the batter will deviate post-bounce earlier than those pitched closer to batter (Leamon & Jones, 2021; Renshaw & Fairweather, 2000). By affecting the height at which the ball arrives, bowling length could also determine the types of strokes that a batter can play for a specific ball, which logically makes it an important determinant in deciding whether a front of back-foot stroke is optimal. Previous research has revealed that some ball-pitching lengths allow for limited stroke types, for example the "yorker" (which traditionally pitches near the batter's feet) is generally regarded as the hardest for a batter to strike (Moore et al., 2012; Jamil et al., 2023), whereas other lengths could be met with multiple strokes, for multiple outcomes (Leamon & Jones, 2021; Renshaw & Fairweather, 2000). This notion has been reinforced by a recent study by Jamil et al. (2022) where certain bowling lengths (one full and one short) and bowling lines (outside off stump) were revealed to be significantly associated with the direction of power-hitting strokes that resulted in a maximum of 6-runs being scored. Furthermore, stroke variety has also been related to bowling length, which shows that balls bowled very close or very far from the batter often offer only one or two stroke solutions whereas areas in between these zones allow for multiple strokes, often called monostable and metastable zones respectively (Pinder et al., 2012). While this has been studied in a lab setup from a batter's perspective with several control measures and junior cricketers, the same has not been examined at the highest level of competitive cricket over thousands of balls bowled. It is also critical to note that this dependence of stroke availability according to the location of the ball bounce (bowling line and length) – something initiated by the bowler for every new delivery in a cricket match, makes this a highly interactive event, thereby making it even more interesting to study decision-making. Keeping this in mind, this paper examines whether a relationship exists between bowling length and type of strokes exhibited by elite batsmen across two international 50-over cricket competitions.

Method

Data and Sample

The study of a relationship between bowling lengths and batter stroke types is divided into two parts. First, we test whether a front-foot or back-foot stroke is required for successful batting in international cricket. This is conducted through chi-square tests between stroke type and outcomes of batting success – boundaries (4 or 6 runs scored on that ball) and (the lack of) dot balls (0 runs scored on that ball). This would help understand whether front-foot and back-foot stroke selections contribute to batting success. Next, a binomial logistic regression is conducted with the different bowling lengths as predictors and batting stroke type (front-foot or back-foot) as the outcome variable. A pattern of distribution of stroke types would indicate the existence of a relationship between bowling lengths and batter strokes. The required notations for this study were obtained from Opta (London, UK) - high levels of reliability have been previously reported (Jamil et al., 2021), and these notations were further cross-validated with ball-by-ball commentary logs of corresponding cricket matches which are available on the official database of the International Cricket Council (ICC). Notations of bowling length were provided by the data supplier and include classifications developed from commonly used categories of approximate bounce distance from the batters' stumps; full toss (does not bounce), yorker (approximately 0-2 m), half-volley (approx 2-5 m), length ball (or good length, approx 5-8 m), back of a length (approx 8-10 m), short length (approx 10+ m) and the half-tracker (also approx 10 m, but the ball bounces below waist height as it approaches the batter). Foot movements were provided for each ball through the batting stroke types that were exhibited by batters in intercepting each ball (see Table 1 for a description of all batting strokes). A minority of strokes (<10% of total strokes analysed) that were not discernible as front- or back-foot strokes, or those that denoted no movement were excluded from the analysis. Moreover, only the bowling types ‘fast’ and ‘medium pace’ were included in this investigation, as spin bowlers formulate a different category of bowling types with different effects of bowling lengths and heights, thereby being characterised by interactions that may be starkly different from pace bowling and require a separate analysis (Leamon & Jones, 2021). Finally, illegal balls were also excluded from further analysis. After elimination and data cleaning, a total of 19, 587 balls bowled in 60 cricket matches (120 innings) from two one-day international cricket tournaments held in England were considered for analysis (ICC Champions Trophy 2017 and the ICC Cricket World Cup 2019).

*****Insert Table 1 here*****

Statistical Analysis

In order to understand whether a foot-based decision was required for batting performance, Chi-Squared (χ^2) tests of independence were conducted in order to determine whether there was any association between the front and back-foot strokes and batting outcomes of 0 runs scored, as well as boundaries (4 or 6 runs) scored. The data was largely formulated by nominal notations for each ball. Each ball bowled was treated as an independent event due to the numerous factors of variation exhibited ball-by-ball (i.e. the timing of the delivery, the condition of the ball – as it deteriorates with each ball bowled, the xy landing location/direction of the ball, bowling speeds, the level of bounce post pitching, the degrees of lateral movement/trajectory, the xy location of fielders and even environmental factors such as humidity, temperature and wind speed). Each ball bowled therefore contributed to one and only one cell in each of the χ^2 tests conducted in this study and passed McHugh’s (2013) assumption conditions. In the case of statistical significance (alpha = 0.05), standardized residuals were calculated to identify those cells that made the greatest contribution to the test statistic (Sharpe, 2015). Moreover, given the dichotomous outcome variable as well as the two foot-based responses, a 2x2 Fisher's exact table was used to understand whether there was a significant association between foot-based movement and batting performance indicators of dots and boundaries. To account for the number of cells present in the contingency tables, Bonferroni corrections were applied (Sharpe, 2015) resulting in the adjusted ($p = 0.0125$) with the associated critical values of $\pm$ 2.50. Cramer's V effect sizes were also calculated (McHugh, 2013) and interpreted with the widely used thresholds of $0.1 \leq$ *weak* < 0.3, $0.3 \leq$ *moderate* $<$ 0.5, and *strong* ≥ 0.5 (Cohen, 1988).

To understand whether there is a relationship between the bowling lengths and foot movements shown by batters, the bowling length categories were used as predictors with the front-foot/back-foot dichotomous outcome being the dependent variable in a logistic regression. Coefficients (and p-values) were used to assess the relative differences between the different ball-pitching length zones to the front-foot (and back-foot) outcome. Data pre-processing was performed with the front-foot stroke coded as 1 and back-foot coded as 0, thus a positive coefficient (B) would indicate a front-foot response in the logistic regression. To test for reliability and out-of-sample validity of the resulting models, the performance of the regression models was evaluated using a 5-fold cross validation alongside the traditional method of significance levels. All analyses were performed using custom scripts in Python 3.8 and H2O library.3.14.

Results

As indicated in Table 2, front-foot and back-foot strokes are revealed to have statistically significant associations with weak effects for both batting performance indicators of facing dot balls (scoring 0 runs on that ball) ($\chi2(1) = 99.798$, $p < .001$, Cramer's V = .071) and scoring boundaries (4 or 6 runs) ($\chi 2(1) = 9.111$, $p = .003$, Cramer's V = .022). Although the effect sizes are weak, this is to be expected as cricket performance is determined by various technical, physical, tactical and contextual factors (Jamil et al., 2022). Post hoc analysis through standardised residuals reveal that back-foot strokes present significantly greater than expected dot balls (SR = 5.2), while the opposite is observed for front – foot strokes and dot balls (SR= -5.0). For the performance measures boundaries, however, the standardised residual does not cross the critical value for the adjusted $p = 0.0125$, and are therefore not considered statistically significant.

After assessing whether front-foot and back-foot strokes are related to successful batting performance outcomes, the results of the logistic regression for the front-foot/back-foot outcome were used to understand whether there is an influence of bowling length on these batter foot movements (front-foot and back-foot strokes). Results presented in Table 3 show that all lengths except the half-tracker length ($p = 0.64$) showed a significant contribution in correctly classifying strokes as front-foot or back-foot. That is, full toss (B = 5.10, $p < 0.01$), yorker (B = 4.12, $p < 0.01$), half-volley (B = 5.18, $p < 0.01$) and length ball (B = 3.71, $p < 0.01$), all significantly predict predominance of front-foot stroke, while back of a length (intercept) (B = -2.31, $p < 0.01$) and short length (B = -0.93, $p < 0.01$) significantly predict a back-foot stroke. This indicates a clear relationship between bowling lengths and foot-based stroke movements, specifically showing front-foot strokes emerging in balls bouncing relatively closer to the batter (approximately up to 8 m) and back-foot strokes emerging in response to balls bouncing further from the batter (further than 8 m). There is also a distinct switch in preferred stroke type between the good length and short of good length zones. The confusion matrix in Table 4 shows per class error rates for predicting front (~79% accurate) and back foot (~93%) accurate strokes. Finally, the cross validation confirms that model was able to predict which foot the shot was played on based on the pitching length of the ball with high accuracy and reliability as shown in the cross-validation score (accuracy = 0.86 +- 0.002 and AUC = 0.88 +-0.005). Given the magnitude of coefficients and associated p-values, it can be stated that there is a clear influence of bowling length on batter's front-foot and back-foot decisions.

*****Insert Table 2 here*****

*****Insert Table 3 here*****

*****Insert Table 4 here*****

Discussion

The aim of this paper was to examine whether a relationship between bowling lengths and batter decisions of front- and back-foot was observed in elite One-Day International cricket tournaments. Chi-squared test results were used to explore significant associations between front-foot and back-foot strokes and batting outcomes of boundaries and dots to first assess whether any relationship between batting outcomes and foot-based batting decisions existed. A logistic regression for foot-based batting strokes with different bowling lengths as independent variables was subsequently used to further determine if (and how) specific batter movements are related to different bowling lengths. Results from the chi-squared distribution revealed a statistically significant relationship between successful batting outcome of run-scoring (conceding or avoiding dot balls) and foot-based movements. Post-hoc results of the standardised residuals show values that exceed the threshold of significance (± 2.50) as seen in Table 2, showing greater than expected dot balls on the back-foot, and fewer than expected dot balls on the front-foot. These results could indicate that batters prefer to meet the ball on the front-foot in limited overs cricket, something that has been observed as a general pattern by professional analysts in the sport (Leamon & Jones, 2021). Bowlers, on the other hand, may prefer pushing batters on the back-foot where batting outcomes exhibit greater than expected dot balls and fewer than expected boundaries, which aids in limiting run-scoring. However, as there are no bowling length related insights in the chi-square output, the logistic regression results are required to further understand this. Moreover, the results also showed weak effect sizes for both dots balls and boundaries, which could be related to the high sample size and subsequent effect of this on the p-value and effect size calculations. This is also why the chi-square test results do not sufficiently inform us about the relationship between batting strokes and bowling lengths. These results only show the general connection between successful batting and foot-based decisions, and require results from the logistic regression to understand the relationship of different bowling lengths with specific foot-based movements.

As shown in Table 3, all lengths except one (half-tracker) show a statistically significant effect on the outcome variable of front-foot or back-foot stroke. The non-significant result of the half-tracker zone may be explained by the relatively low sample size (N=103, 0.5% of total balls) of balls bowled in this zone as compared to all the other zones included in the study. Furthermore, this result could be partially explained by batter's responding to deliveries on this length with deliberate movements made to avoid any contact with the ball that do not constitute either a forward or backward movement (i.e. ducking or swaying out of the way), particularly as this length has been known to cause injury (Pardiwala et al., 2018).

With regards to the remaining length zones, the findings clarify that accurately gauging bowling length is a critical measure in determining front-foot and back-foot batting strokes. Furthermore, a look at the sign of coefficients (positive sign indicates front-foot dominance and negative sign a back-foot dominance) indicates the structure of front-foot and back-foot strokes: when facing pace bowlers, front-foot strokes dominate all bowling lengths near the batter, up to the good length zone, after which all the lengths exhibit a negative coefficient indicating back-foot strokes. These findings involving elite batters are similar to results of a lab study with junior-level batters facing balls bowled on different bowling lengths (Pinder et al., 2012). The clear organisation of balls bowled closer to the batter being hit on the front-foot and those further from the batter being hit on the back-foot show a coordinated organisation of decisions (and subsequent actions) based on specific constraints initiated by the bowler (bowling length). Such coordinated or interpersonal decision-making has been observed in combat sports as well as certain dyads of team sports at a training level in the past (Krabben et al., 2019; Kimmel & Rogler, 2018; Travassos et al., 2011; Hristovski et al., 2006), but rarely at the elite competitive level, specifically in team sports. Studies that look at interactive decision-making often also mention functional variability being exhibited in metastable zones – a perceptual-motor state where multiple solutions can be used to arrive at the same outcome, often situated between two monostable zones. In cricket, Pinder and colleagues (2012) found this to be around the 6.5-7.5 m from the stumps in a lab study with junior cricketers, where both front-foot and back-foot strokes are equally likely to occur. While this was not replicated in the current study (largely due to different notations of length as well as no control measures for body-scaling), the switch from front-foot to back-foot stroke is observed generally around the same zone of bowling length – the length ball zone (approx. 6-8 m away from the stumps). This finding warrants further inquiry as specific body-scaled dyads performing at the international cricket level might display varying levels of functional variability as exhibited in different stroke types – thereby serving as rare evidence of dynamic, interactive and functionally adaptive decision-making at the elite team sport level (Araújo et al., 2019; Davids et al., 2013).

The dominance of front-foot stroke observed in this length ball zone, often called the "good length" zone in cricket parlance, may also reflect the need of batters to get on the front-foot to score more runs in limited overs cricket (Leamon & Jones, 2021). It would be highly informative, in this light, to examine how batters strategically adapt to varying formats of cricket. This study included only one-day international matches where each team bats for a maximum of 300 (legal) balls, but other cricket formats include batting for a maximum of 120 (legal) balls (Twenty20 cricket) or batting for unlimited balls (Test cricket) (See Mehta & van der Kamp, 2021 for more information on formats). It is possible that batting strategies differ in different formats and may be visible in batting outcomes, foot movement but also other measures reflected batter choices such as stroke control or quality of contact. These choice-driven measures can be used to compare batting strategies as well as transference between formats – some of which may require a greater attacking impetus due to lesser time, such as Twenty20. Similarly, analysts in professional cricket settings may benefit from such analyses being performed for different locations across the world as atmospheric conditions could potentially impact batting performances (Irvine & Kennedy, 2017; Mehta et al., 2022). The analysis of these interactive outcomes can be viewed from the side of batter as well as bowler decision-making, and can be used to on multiple levels like inter-player match-ups within an over, an innings, but also between formats and locations.

In today's highly crowded and condensed cricket calendar, analyses of player interactions at multiple levels could help the growth of strategic performance insights to develop interventions that help players excel against specific players, match situations, formats and conditions. Practical applications of this study could range from comparing effectiveness of certain batters or bowlers in various conditions around the world to guiding training in build-up to facing a certain opponent. Furthermore, coaches have been known to train batters to execute specific strategies when facing balls bowled at certain bowling lengths such as the length ball (often termed the good length ball) where their batting choices should exhibit high levels of control (Connor et al., 2020). Studies like this could help understand how such aims can be achieved and further improved upon, such as developing potential specifications for stroke execution that integrate attacking or defensive outcomes while maintaining a focus on control. This study was not without its limitations, this dataset included two competitions played in England, and therefore warrants a similar inquiry in other cricketing hotspots around the world. It included only competitions of the One-Day International format, while suggesting the extension of such research into T20 and Test formats, as it would be difficult to integrate these formats within the scope of this paper. Furthermore, data specifications of the bowler and batter's dominant hand, trajectory specifications such as side of wicket and height of release were also not available for this study, and were also not part of the aims of this study which only looked to study the relationship between foot-based batter decisions and bowling length. These variables could provide valuable information and could be studied separately in future research.

Conclusion

This study aimed to understand whether a relationship between bowling lengths and foot-based batter decisions existed in elite One-Day international cricket. By examining 19,587 balls bowled in two one-day international cricket tournaments, it was found that there was a clear association between the occurrence of either front-foot or back-foot strokes based on the bowling length initiated by the bowler. Specifically, the results of this study suggest that batters in ODI cricket prefer front-foot strokes in their quest to score runs, which could in turn inform bowling strategies during matches. Furthermore, the coordinative interdependence of foot-based batting decisions and different bowling lengths discovered in this study signifies that batting decisions are partly based on the bowler and the characteristics of the ball bowled. The study sets a foundation of studying interdependent actions at the elite level, and can be applied in studying elite batting in greater depth through a perspective that recognizes the interactive and co-dependant nature of successful batting at the elite level of performance.

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