A COMPARISON OF PITCH LENGTH VARIATIONS AND THE ABILITY TO CONTROL LENGTH IN CRICKET FAST BOWLING

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This study aimed to identify differences between ball release parameters and different pitch length deliveries in cricket fast bowling. A total of 707 fast bowling trials (bouncers, yorkers, stock balls) performed by 21 male fast bowlers were recorded and used to investigate the variations in ball release parameters. Ball release angle ($p < 0.05$) was significantly different between all three deliveries, while resultant ball release speed, and ball release height of the bouncer deliveries were significantly different ($p < 0.05$) to yorker and stock deliveries. Furthermore, the success rates of bowlers achieving their intended variation highlighted a difficulty in delivering yorker deliveries compared to bouncer and stock deliveries. Results provide a foundation for coaching and future research, in particularly investigating the kinematic and kinetic factors linked with different length fast bowling deliveries.

KEYWORDS: fast bowling, pitch length variations, Yorkers, Bouncers

INTRODUCTION: The game of cricket consists of three main skills; batting, bowling, and fielding. Fast bowling is a movement consisting of a sequence of activities: starting with a run up and finishing with a follow through after releasing the ball, which utilises the speed of the delivery to increase the difficulty for the batter. Most studies, therefore, have targeted ball release speed as a performance characteristic with kinematic and kinetic changes investigated throughout the fast-bowling sequence (Bartlett et al., 1996; Worthington et al., 2013). In addition to using ball speed to deceive the batter, fast bowlers can also change the length of the delivery, the orientation of the ball's axis, and the amount of spin. These variations may lead the batter to feel unsettled and result in a miss, or mishitting the ball, and potentially their wicket. Although more limited than ball release speed, previous research has investigated the variations in ball axis orientation and spin, which lead to movement in the air defined as 'in swing' and 'out swing' deliveries, and their effect on reducing batting performance (Sarpeshkar et al., 2017; Woolmer et al., 2008). Although kinetic measures, such as ground reaction force (Callaghan et al., 2021) and EMG activities of the shoulder and wrist musculature (Ahmed, 2014; Hazari, 2015), have been investigated for different length deliveries, there remains a lack of understanding of the kinematic variations associated with delivery length in cricket fast bowling. This knowledge could help future bowlers to improve their skill by understanding the changes required to alter pitch length and improve batters' ability to perceive these differences and interpret the ball correctly. The aim of this study was to identify the ball specific parameter differences between different length deliveries and identify how well the bowlers can change their length according to their intention.

METHODS: 21 male county academy fast bowlers (mean ± standard deviation: height 1.87 ± 0.05 m, weight 81.40 ± 9.74 kg) participated in this investigation. Each bowler bowled 36 deliveries using their normal run-up in an indoor practice facility with an artificial surface. The 36 deliveries were split into 12 "bouncers" classified by their pitching distance being greater than 7 metres from the batter's stumps, 12 "yorkers" classified as pitching in an area 0 to 2 metres from the batter's stumps, and 12 stock balls classified as pitching in an area 4 to 7 metres from the batter's stumps (Figure 1). The deliveries were bowled in a randomized order and appropriate rest was provided between deliveries to replicate normal match conditions. All trials were recorded using an 18 camera (MX13) Vicon motion analysis system operating at 250 Hz. In addition, a 2D Bonita camera synchronised with the motion capture system at 250 Hz was used above and behind the bowler's run up to capture ball pitch length location. Ethical approval was granted by Loughborough University's ethics committee and players signed

informed consent papers prior to the data collection. Two markers, in the form of a 15 x 15 mm patch of 3M Scotch-Lite reflective tape were attached to both sides of the ball allowing ball kinematics to be determined. A 14 mm retroreflective marker was attached to the bowling hand so the instant of ball release could be determined.

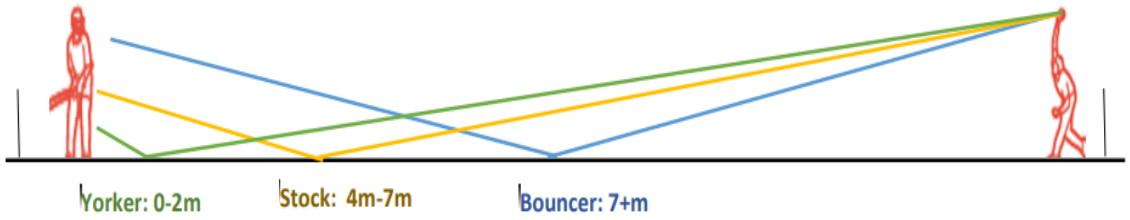

Figure 1: An illustration of different ball pitch lengths

The pitch length of each delivery was calculated using 2D Direct linear transformation method from the video captured by the Bonita camera. The pitch was marked with white chalk lines every 2 m up to 12 m from batting end stumps. Eight known points were digitized along with the ball in the image where ball pitching was visually determined to have occurred. Image coordinates (*x, y*) were then used to determine the ball pitch coordinates (*u, v).* The pixel coordinates of were used in a MATLAB algorithm to convert them to global coordinates of the pitch length.

$$v = \frac{L_4(x) + L_5(y) + L_6}{L_7(x) + L_8(y) + 1} \qquad u = \frac{L_1(x) + L_2(y) + L_3}{L_7(x) + L_8(y) + 1}$$

The markers on the ball and hand were reconstructed and gap filled when necessary using VICON's Nexus software (Version 2.10). The ball release instance was identified using the distance between the hand marker and the ball centre (mid-point of the two ball markers). It was defined as the moment when the distance between the hand marker and ball marker exceeded in more than 20 mm in consecutive frames (Worthington et al., 2013).
Ball release velocity was calculated using the 10 frames immediately after ball release using equations of constant acceleration. Ball release angle was calculated in the sagittal plane using the anterior-posterior and vertical ball release speed. Finally, ball release height was calculated as the height of the ball in the global coordinate system expressed as a percentage of the bowlers normal standing height.
Statistical analysis was performed within the statistical package for the social sciences (SPSS v 25.0). The length differences and ball specific parameters at ball release for successful deliveries in each variation were assessed using a one-way repeated measure ANOVA. Furthermore, a between group analysis was completed using the post-hoc tukey analysis. An alpha value of 0.05 was used to determine whether the difference was significant. Effect sizes were calculated for each interested parameter through ANOVA Partial eta sum of squared – denoted as η2.

RESULTS AND DISCUSSION: A total of 707 deliveries of which 401 successfully matched the bowlers intended target (233 bouncers, 58 yorker's, and 110 stock) were analysed. A ~~between~~ one-way repeated measures ANOVA ($F_{(2,704)} = 499.5$, $P < 0.05$) revealed significant differences between the three ball pitch length variations in this study. The Post- hoc Tukey analysis ($P<0.05$) showed that the pitch length for each variation (bouncer, yorker, and stock) was significantly different from one another (Table 1). Further analysis highlighted that the fast bowlers in this study were able to more successfully complete their intention when bowling bouncers (98.7%) compared to stock (46.4%) and yorker (24.8%) deliveries (Table 1). This resulted in the yorker mean length being short of the shortest margin (2 metres) required, and the stock mean length being right on the shortest margin (7 metres). In contrast, the bouncer

mean was comfortable short of the 7 metres from the batter. Interestingly, there was much less variation in the bouncer deliveries despite the large region to pitch the ball in compared to the other variations (Table 1). It is probable that this is due to the smaller distance the ball must travel reducing the effect on small variations in ball release variables on pitch length (Table 2).

Table 1: Descriptives and frequencies of different ball deliveries

Variation	N	Range (95%)	Mean ±Std	Successful trials	Successful percentage
yorker	234	3.4 – 4.2	3.8 ± 3.3	58	24.8 %
bouncer	236	10.6 – 11.05	10.8 ± 1.4	233	98.7 %
stock	237	6.7 – 7.3	7.0 ± 3.7	110	46.4 %

To analyse the effect of the variation in ball release parameters the deliveries which landed successfully in the correct regions were selected for further analysis (Table 2). Significant differences were found in all three parameters: ball speed, ball release angle, and ball release height between bouncers and the stock and yorker variations (Table 2). While the only difference between stock and yorker deliveries was observed in the release angle (Table 2). Although the difference in release angle may be expected due to the required ball path, the difficulty in delivering these lengths may be related to the range of release angles available which result in successfully delivering these lengths. Observing the range of each delivery, bouncers can be achieved releasing the ball in a much wider window (16º) compared to stock (9º) and yorker (5º) deliveries (Table 2 and Figure 1). A further aspect which is likely to increase the difficulty is the increase in ball release height as a percentage of standing height associated with yorker deliveries to stock and then bouncers. Not only is the bouncer pitch location closer laterally but also vertically, further increasing the distance the ball must travel and the potential magnification of variations in initial release conditions. Finally, the variation in ball release speed across the delivery lengths adds another level of complexity which impacts ball flight. It is probable the ball speed is higher in bouncers as the bowlers have more time and a greater range of motion to generate speed over. This is likely indicated by the decrease in ball release height, which suggests the arm has circumducted further forwards and down (Table 2).

Table 2: Descriptives and statistical analysis of ball specific parameters at ball release

parameter	*p* - main effect (effect size n^2)	variation	mean ± std (range)	*p* - post hoc
ball speed (resultant)	<0.001 (0.07)	yorker	31.5 ± 2.3 (24.7 - 37.7)	**bouncer – yorker: <0.001**
		bouncer	33.1 ± 2.2 (25.2 - 39.0)	**bouncer – stock: <0.001**
		stock	31.8 ± 3.3 (24.2 - 37.2)	stock – yorker: 0.710
ball release angle	<0.001 (0.79)	yorker	1.9 ± 1.8 (0.01 – 4.8)	**bouncer – yorker: <0.001**
		bouncer	13.0 ± 2.7 (6.6 – 23.1)	**bouncer – stock: <0.001**
		stock	5.3 ± 1.4 (1.5 – 10.2)	**stock – yorker: <0.001**
ball release height as % of standing height	<0.001 (0.22)	yorker	112.2 ± 4.1 (99.7 – 119.2)	**bouncer – yorker: <0.001**
		bouncer	107.4 ± 4.0 (94.9 – 115.6)	**bouncer – stock: <0.001**
		stock	110.7 ± 7.9 (99.0 ± 118.6)	stock – yorker: 0.173

The findings of this study indicate that the initial conditions related to projectile motion (release speed, release height and release velocity) at the instance of ball release were observed to be significantly different across the three deliveries. The main findings highlight that a yorker is more difficult to achieve compared to stock and bouncer deliveries respectively. One limitation may be the environment and the lack of a physical batsman which may visually alter the task. The implications of these results are likely to impact coach development and the understanding that deliveries with increased length have smaller windows of successful release conditions which allow the outcome to be successful, and the identification that release angle can be used

as a surrogate for length when conducting kinematic and kinetic investigations in fast bowling. Future studies for instance may attempt to understand the kinematics which result in variations in release angle and thus delivery length, and if these differences can be perceived by batters.

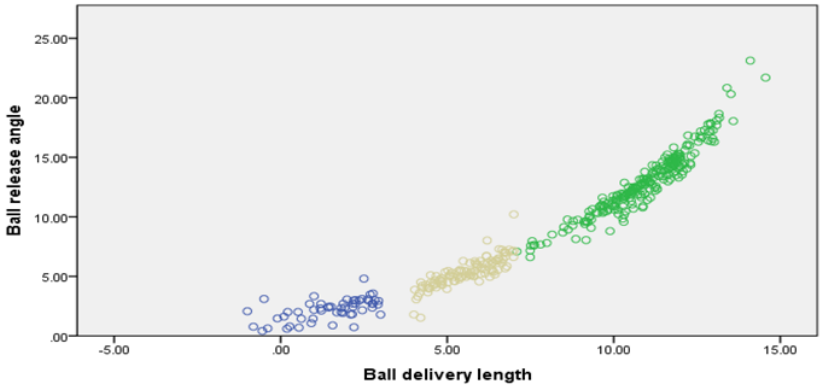

Figure 2: An illustration of ball release angles different ball pitch lengths: blue - yorker; yellow - stock, green - bouncer

CONCLUSION: This study has identified that fast bowling deliveries with increased length are less successfully completed compared to shorter deliveries. Investigating ball release parameters highlighted increased delivery lengths are linked with greater ball release angles. In addition, bouncer deliveries were found to be bowled faster and from a lower height than the other variations. These results provide a foundation for coaching and future research. In particularly, ball release angle could potentially be used as a surrogate for pitch length when investigating the kinematic and kinetic factors linked with different length fast bowling deliveries.

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