RELATIONSHIP BETWEEN PRE-DELIVERY STRIDE AND FAST BOWLING PERFORMANCE IN CRICKET

Hamish G. Bull[1], Peter Alway[1,2], Mark A. King[1]

[1]School of Sport, Exercise and Health Sciences, Loughborough University, UK
[2]Department of Science and Medicine, England and Wales Cricket Board, UK

This study aimed to investigate fast bowler biomechanics during the pre-delivery stride and how they associate with variables previously linked with faster ball release speeds. Kinematic bowling data were collected from 29 elite fast bowlers using 3D motion capture. Pre-delivery stride technique showed multiple significant associations with performance-related variables: more vertical take-off angles correlated with slower run-up velocity; and a larger downward landing velocity associated with less thoracolumbar flexion during the bowling action. Shallower pre-delivery stride take-off angles might therefore be recommended but physical capacity of the bowler should be considered due to the undesirable association between faster run-up velocity and greater front knee flexion at front foot contact.

KEYWORDS: gather, kinematics, speed, transition.

INTRODUCTION: One strategy of fast bowlers in cricket is to deliver the ball at high velocity to reduce the reaction time batters have and increase the likelihood of taking a wicket or reducing run scoring opportunities (Zhang et al., 2011). Bowling as a skill is usually divided into three phases: a run-up, a pre-delivery stride, and a delivery stride phase. The pre-delivery stride is a transition phase following the run up, where the bowler leaps and rotates their trunk away from the target, simultaneously organising individual body segments ahead of the delivery stride phase. Key technical traits associated with higher ball release speeds have been identified during the delivery stride and run up phases but no research to the author's knowledge has examined the pre-delivery stride and how technique during this transition phase may influence subsequent bowling biomechanics and ball release speed. The delivery stride phase contains the movements that facilitate the bowler converting linear momentum, generated from the run up, into angular momentum and transferred through the trunk and arm to the ball during the bowling action (Worthington et al., 2013). Technical traits that are suggested to improve the efficiency of this momentum conversion and reported to explain 74% of the variance in ball release speed include faster run-up velocity immediately prior to back foot contact (BFC), more extended front knee angles at ball release (BR), greater thoracolumbar flexion between front foot contact (FFC) and BR, and a more delayed bowling arm (FFC and BR; Worthington et al., 2013). It is currently unknown how these variables might be influenced by pre-delivery stride technique, and it stands to reason that technique during the pre-delivery stride affect delivery stride technique. Therefore, this study aims to explore the techniques employed by elite male fast bowlers during the pre-delivery stride and identify how these variables associate with kinematics previously linked with faster ball release speeds.

METHODS: Twenty-nine male elite fast bowlers participated in this study (Mean ± SD. Age: 22.5 ± 3.8; Height: 1.86 ± 0.07 m; Mass: 85.2 ± 10.7 kg). All participants provided written informed consent, completed a health screening questionnaire prior to participating in the study, and were declared fit to bowl by a physiotherapist. The study protocol was approved by the Loughborough University ethics committee. Testing was performed in a full length indoor artificial cricket pitch with space for a full-length run-up. Kinematic data were collected using an 18-camera Vicon Motion Analysis System (OMG Plc, Oxford, UK) recording at 300 Hz. All participants completed a self-directed warm up preparing as they would normally for a match. Ninety-five anthropometric measurements were taken enabling bowler-specific segmental inertial parameters including centre of mass locations to be determined (Yeadon et al., 1990). Forty-seven retro-reflective markers were attached to bony landmarks on each fast bowler in accordance with previous techniques (Worthington et al., 2013). Two 20 x 20 mm² pieces of reflective tape were attached to the middle of the faces of the ball to calculate ball release speed. Each participant was instructed to bowl a minimum of six maximal velocity deliveries on a good length (between four and seven metres from the batter's stumps).

All markers were reconstructed and manually labelled in Vicon Nexus software (Version 2.11, OMG Plc, Oxford, UK). Marker trajectories were filtered using a recursive fourth-order low-pass Butterworth filter with a cut-off of 30 Hz, determined by residual analysis (Winter, 2009). Whole body kinematics and local coordinate systems were processed using Matlab R2021a (The Mathworks, MA, United States). Joint centres were defined as the mid-point of pairs of markers located over a joint, except for the thoracolumbar spine (Worthington et al., 2013) and hips (Davis et al., 1991). Joint angles were calculated as Cardan angles using an xyz sequence corresponding to flexion-extension, abduction, and longitudinal rotation, respectively.

The trial with the fastest ball release speed, and minimal marker loss from the penultimate step (start of pre-delivery stride) onwards for each participant, was identified and used for analysis. Four kinematic variables previously associated with faster ball speeds by Worthington et al. (2013), as well as ball release speed, were calculated for analysis. This included run-up velocity (mean whole body centre of mass velocity over the 0.06 seconds before BFC), front knee angle at BR (<180° = flexion), thoracolumbar flexion between FFC and BR (<180° = flexion), and bowling shoulder angle at FFC (>180° = flexion behind trunk in sagittal plane). Seven pre-delivery stride kinematics were also calculated: jump height (centre of mass peak height, raw and normalised to bowler height), take-off vertical angle (angle between the global horizontal and centre of mass trajectory), pre-delivery step length (raw and normalised distance between ankle joint centre at penultimate step take-off and contralateral ankle at BFC), landing velocity (centre of mass vertical velocity at BFC), run-up velocity (mean whole body centre of mass velocity over 0.06 seconds before the penultimate step).

Statistical analyses were performed in SPSS (V.27, IBM, USA). Following assessment of normality, Pearson's product moment coefficients (Spearman's rank test if non-parametric) were calculated to determine the relationship between pre-delivery stride variables and variables previously associated with ball release speeds, including ball release speed. An Alpha level of 0.05 was used for all tests.

RESULTS: Descriptive statistics for the variables measured are displayed in Table 1. Ball release speed was not found to directly correlate with any of the pre-delivery stride variables (Table 2). Six significant correlations were identified however between pre-delivery stride and performance-related variables previously linked with ball release speed (Table 2). More vertical take-off angles correlated significantly with slower run up velocities at BFC ($r = -0.400$, $p = 0.032$). Larger penultimate step lengths associated significantly with faster run up velocity at BFC ($r = 0.505$, $p < 0.001$) and more flexed knee angles at BR ($r = -0.436$, $p = 0.018$). Faster run up velocity's pre-delivery stride correlated with two performance variables: more flexed front knee angles at BR ($r = -0.382$, $p = 0.041$), and faster run up velocity at BFC ($r = 0.844$, $p < 0.001$). Greater downward landing velocity at BFC correlated significantly with reduced thoracolumbar flexion ($r = 0.372$, $p = 0.047$). No other pre-delivery stride variables were associated with technical variables previously associated with ball release speed.

Table 1. Range, mean, and standard deviations of pre-delivery stride, and performance associated variables.

Technique Variables	Range	Mean ± SD
Pre-Delivery Stride		
Jump Height (m)	1.11 - 1.40	1.27 ± 0.07
Jump Height Normalised (%)	60.43 - 76.53	68.02 ± 3.81
Penultimate Step Length (m)	1.73 - 3.00	2.27 ± 0.32
Penultimate Step Length Normalised (%)	92.15 - 162.13	122.16 ± 18.31
Run-Up Velocity Pre-Jump (m/s)	4.7 - 7.3	6.0 ± 0.6
Landing Velocity BFC (m/s)	-2.0 - -0.9	-1.4 ± 0.3
Take-Off Angle (°)	5 - 17	11 ± 3
Performance		
Ball speed (m/s)	32.7 – 38.5	35.4 ± 1.3
Run up velocity BFC (m/s)	5.1 – 7.0	5.9 ± 0.5
Front knee angle BR (°)	133 – 196	177 ± 17
Thoracolumbar flexion (°)	18 – 48	31 ± 7
Bowling shoulder angle (°)	158 – 269	243 ± 22

Table 2. Pearson/ Spearman correlation coefficients between pre-delivery stride kinematics and key performance-related technique characteristics.

	Jump Height (normalised)	Take-off Angle	Penultimate Step Length (normalised)	Run up Velocity (pre-jump)	Landing Velocity
Performance					
Ball speed (m/s)	-0.004	-0.134	0.290	0.262	-0.124
Run up velocity BFC (m/s)	-0.074	-0.400*	0.505*	0.844*	-0.159
Front knee angle BR (°)	-0.247	-0.059	-0.436*	-0.382*	0.262
Thoracolumbar flexion (°)	-0.278	-0.128	-0.137	0.187	0.372*
Bowling shoulder angle (°)	-0.052	-0.268	-0.091	-0.075	0.064

** denotes significant correlation.*

DISCUSSION: This is the first study exploring relationships between pre-delivery stride technique and previously associated performance variables in elite fast bowlers. Despite no significant relationships identified between pre-delivery stride variables and ball release speed directly, normalised jump height, take-off angle, penultimate step length, run up velocity, and landing velocity were all found to be associated with key technical performance characteristics (Table 2). These findings suggest that fast bowling technique could be influenced by pre-delivery stride technique.

Run up velocity has previously been identified as a key variable to produce high ball release speeds (Worthington et al., 2013). With greater run-up velocity, the bowler has more linear momentum to convert into more angular momentum at FFC meaning the body rotates faster producing a larger linear velocity of the hand and ball at release (King et al., 2016). The results of the current study suggest that a shallower take-off trajectory may positively influence ball release speed in two ways: (1) by maintaining more horizontal centre of mass velocity - evidenced by a significant negative association between take-off angles and run-up velocity at BFC, and (2) by promoting more optimal technique during the bowling action - indicated by the link between reduced landing velocity (suggestive of smaller jump heights and shallow take-off angles) and greater thoracolumbar flexion during the bowling action. Whilst maintenance of linear momentum is crucial during the pre-delivery stride, it is equally important that the mechanisms that aid conversion of that linear momentum into angular momentum are not compromised. It is proposed bowlers have an individual optimum velocity based on their physical capacity meaning that greater horizontal centre of mass velocity taken into the bowling action may increase the demand placed on the musculoskeletal system, potentially exceeding these limits resulting in suboptimal bowling techniques being adopted (King et al.,2016). The association found in this study between both run-up velocity pre-jump, and larger normalised step lengths, with more flexed front knee angles at BR appear to support this suggestion. Knee extension might therefore be considered the technical component compromised by increased run up velocities and the accompanying larger braking forces at FFC. Regarding braking forces in fast bowlers, King et al. (2016) found no correlation between knee angle and force measures, this paper however did not directly explore the link between run-up speed and front knee angle at BR. Therefore, the orientation of the ground reaction force vector might instead be the key factor that affects front knee flexion at FFC rather than solely the magnitude of the ground reaction force. Future research should explore this further including additional performance-related variables such as front leg plant angle to better understand the mechanisms compromised by excessive run-up velocity and its potential knock-on effect on other technical aspects. Overall, the benefit that stands to be gained from increased run-up velocity taken into the bowling action due to a lower take-off angle is likely dependent upon the strength capacity of the bowler and might, in part, explain the 12° range in take-off angles observed in the bowlers of this study (5 - 17°; see Table 1).

CONCLUSION: More vertical take-off angles at the pre-delivery stride was associated with a greater downward vertical velocity at BFC. Collectively, these negatively impacted performance characteristics of fast bowling, including horizontal mass centre velocity at BFC, thoracolumbar flexion and front knee flexion. Coaches should consider implementing training practices aimed at decreasing pre-delivery stride take-off angle but must consider the body strength characteristics of the bowler. Future research should explore the influence pre-delivery stride characteristics have on injury-associated technique variables in fast bowlers.

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