# A KINEMATIC INVESTIGATION OF ELITE FAST AND FAST-MEDIUM CRICKET BOWLERS

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## ABSTRACT

One of the aims of fast bowling in cricket is to produce a high ball release speed thereby decreasing the time available to the batsman to decide upon and execute a stroke. This study was designed to examine the important kinematic parameters of the delivery stride of the fast bowling action. The delivery strides and ball release of 17 elite bowlers (including 8 international) were filmed during country championship competition using a LOCAM cine camera at 200 frames/s. 7 of the bowlers released the ball at over 36m/s and were hence classified as fast bowlers, the remainder being fast-medium. The relatively low importance of the run-up speed at the time of ball release to the ball release speed was indicated by a poor correlation ($r=0.21$) between the variables. The temporal pattern of the maximum linear speed of joint centres during the delivery stride was the same for all bowlers: the speeds increasing in a temporal sequence from proximal to distal joint centre as the time of ball release approached. A correlation matrix revealed that the maximum linear speed of adjacent joint centres were strongly correlated ($r>0.76$) except between the shoulder and elbow/wrist ($r=0.38/0.41$) indicating the relative independence of the speed of the bowling arm in the kinematic chain. Although a low correlation ($r=0.41$) was discovered between the knee angle at ball release and the ball release speed, the bowlers who did not flex their knee following front foot contact to absorb impact forces released the ball at a significantly ($p=0.02$) greater speed than those who did flex their knee at impact.

## INTRODUCTION

One of the objectives of a fast bowler when he delivers the ball is to generate as much ball release speed as possible, which decreases the flight time of the ball and hence the time available to the batsman to decide upon and execute a stroke. Therefore the main objective of this study was to investigate various kinematic parameters during the delivery stride of the fast bowling action, between back foot contact and ball release, with a view to determining those which most greatly influence the ball release speed.

## METHODOLOGY

### Subjects

The subjects used in the investigation were 17 elite bowlers (listed in Appendix 1) who were filmed during six county championship matches in the 1989 cricket season (also listed in Appendix 1). Eight of the bowlers filmed had international experience playing for England, the West Indies or South Africa.

### Apparatus

A Redlake LOCAM model 51 high speed cine camera running at 200 Hz, verified by an internal timing light, was used to film the delivery stride of all subjects. The cine camera was fitted with a Schneider-Kreuznach zoom lens and mounted on a Kennet tripod. Eastman 7251 daylight ektachrome high speed film was loaded into the camera and scaled to lifesize and referenced to the vertical by including the stumps, of standard height, and a plumb line in the field of view of the camera. A sekonic exposure meter model L-398 was used to determine optimum camera f-stop values.

checked by tilting the camera before filming to ensure that the crease line remained on the cross in the centre of the lens.

After processing, the films were projected by an NAC DF-16C analysis projector onto a TDS HR Series digitising tablet. The subjects on the films were digitised as a 14 segment rigid body, plus the ball, using the digitising tablet linked to an Acorn Archimedes 440 computer with associated software (Bartlett, 1990). The co-ordinate data was smoothed using cross validated quintic splines and its first and second derivatives calculated.

Experimental Procedure

Up to six deliveries by each bowler were filmed. Unfortunately, for some of the bowlers (e.g. PN) only 1 of the filmed deliveries was able to be digitised due to them being partially obscured by the non-striking batsman and-or fielders.

EXPERIMENTAL DATA

The mean and maximum ball release speeds for the 17 bowlers were determined and are shown in Appendix 2. The mean maximum ball release speed recorder of 35.9m/s (S.D.=1.9m/s) compared well with those recorded by ELLIOTT and FOSTER (1984) and FOSTER and ELLIOTT (1985) of 36.3m/s (S.D.=1.7m/s, n=4 internationals) and 34.8m/s (n=1 international) respectively *for bowlers of similar standard.*

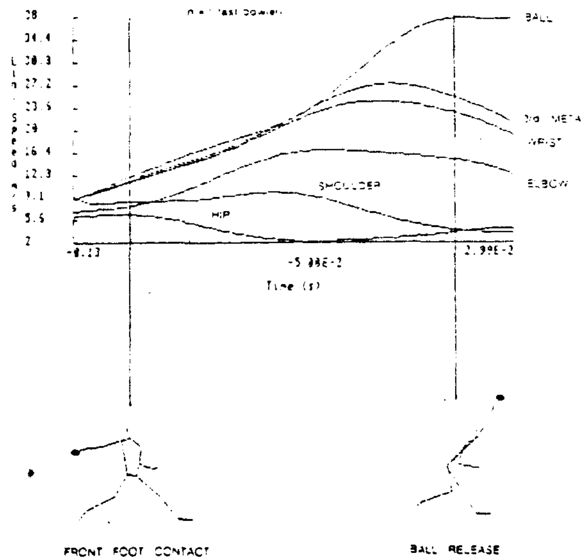


Figure 1 : Linear Speed of Joint Centres and Ball

From the maximum ball release speeds 7 bowlers released the ball at or over 36m/s and were hence classified, under the guidelines of ABERNETHY (1981), as fast bowlers. The remaining 10 bowlers were classified as fastmedium.

Selected kinematic parameters obtained from the maximum ball release speed trial of the 17 bowlers are shown in Tables 1 and 2. Figure 1 shows the temporal pattern of the linear speeds of joint centres and the ball throughout the delivery stride, from front foot contact until ball release, of the fastest bowler analysed.

TABLE 1
Run-up Speed and Front Knee Angle at Ball Release (data obtained from the maximum ball release speed trial)

| Subject | Run-up Speed [m/s] | Knee Angle [degrees] |
|---|---|---|
| GD | 3.71 | 185* |
| PS | 3.38 | 153 |
| AD | 2.90 | 196 |
| GS | 4.17 | 190* |
| DL | 2.76 | 164 |
| AJ | 3.91 | 177* |
| PP | 3.65 | 167 |
| PD | 4.51 | 135 |
| CC | 3.93 | 128 |
| MB | 3.09 | 176 |
| NF | 3.49 | 170 |
| AM | 2.66 | 176* |
| MW | 5.23 | 147 |
| KC | 3.03 | 165 |
| IB | 2.54 | 136 |
| SB | 2.43 | 175* |
| PN | 2.82 | 178 |

* Denotes a bowler who did not flex his knee following front foot contact.

TABLE 2
Maximum Linear Speeds [m/s] of Joint Centres During the Delivery Stride (data obtained from the maximum ball release speed trial)

| Subject | Hip | Shoulder | Elbow | Wrist | 3rd Metacarpophalangeal |
|---|---|---|---|---|---|
| GD | 6.56 | 11.5 | 16.8 | 24.4 | 26.8 |
| PS | 6.28 | 10.5 | 15.8 | 25.0 | 28.2 |
| AD | 5.92 | 9.60 | 17.5 | 25.0 | 27.4 |
| GS | 5.71 | 9.95 | 15.9 | 24.0 | 27.1 |
| DL | 6.06 | 8.33 | 16.4 | 26.3 | 29.3 |
| AJ | 7.07 | 9.44 | 16.7 | 24.6 | 27.1 |
| PP | 5.37 | 8.49 | 16.6 | 23.9 | 26.2 |
| PD | 6.82 | 10.3 | 16.1 | 23.8 | 27.1 |
| CC | 6.14 | 9.13 | 14.2 | 22.4 | 25.0 |
| MB | 5.52 | 8.47 | 14.9 | 23.0 | 25.1 |
| NF | 5.92 | 8.44 | 14.8 | 22.8 | 25.9 |
| AM | 5.31 | 8.92 | 15.3 | 22.5 | 25.7 |
| MW | 4.03 | 7.23 | 15.8 | 23.4 | 25.4 |
| KC | 5.02 | 8.59 | 16.4 | 23.9 | 26.5 |
| IB | 4.42 | 8.04 | 13.1 | 21.9 | 25.0 |
| SB | 5.25 | 8.54 | 14.7 | 22.6 | 25.7 |
| PN | 5.38 | 9.26 | 13.5 | 22.1 | 24.4 |

ANALYSIS OF EXPERIMENTAL DATA

To determine any relationship between the run-up speed at ball release (Tab.1) and the ball release speed (Appendix 2) a scattergram was plotted between the variables (Fig.2). A regression line was subsequently calculated and superimposed over the data points in Figure 2. A Pearson product moment correlation coefficient, r, was also calculated for the data and is shown in Figure 2. The data was both normally distributed and homoscedastic thus allowing the above statistical test to be applied to it.
To determine any relationships between the maximum linear speeds of joint centres (Tab.2) and the ball release speed (Appendix 2), multiple Pearson product moment correlation coefficients were perfomed between the variables. As before the assumptions of normality and homoscedasticity were satisfied. The calculated correlation coefficients are presented in the form of a correlation matrix in Table 3.

To discover any relationship between the knee angle at ball release (Table 1) and the ball release speed (Appendix 2) a scattergram was plotted between the variables (Fig.3). A regression line was subsequently calculated and superimposed over the data points in Fig.3. A Pearson product moment correlation coefficient was also calculated and is shown in Fig.3. the assumptions of normality and homoscedasticity were satisfied.

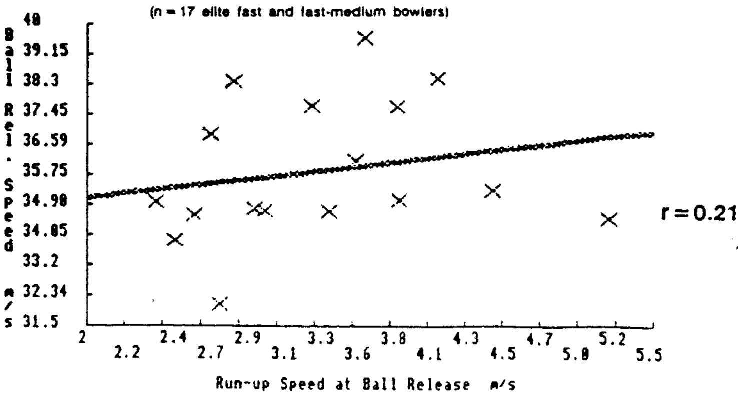


Figure 2: Relationship Between Run-up Speed and Ball Release Speed

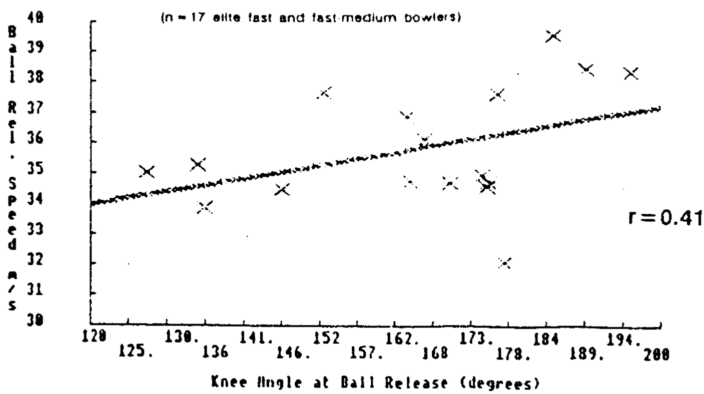


Figure 3: Relationship Between Knee Angle ans Ball Release Speed

**The following directional hypothesis (H1) was also formulated:**

The bowlers who did not flex their knee following front food contact attained a greater ball release speed than those who did.

To test this hypothesis the t-test for independent samples (separate variance) was applied to the data. The assumption of the test, normally distributed populations with heterogenous variances, were again satisfied by the data. The t-value obtained of 2.41 had a propability of 0.02 and was therefore significant at this level.

DISCUSSION

Figure 2 shows that a poor correlation, r=0.21, existed between the run-up speed at ball release and the ball release speed. This indicates that within the group of bowlers analysed those with the highest run-up speed did not necessarily release the ball with the highest speed. The lack of a strong relationship between these two variables is reinforced by the analysis of 9 college standard bowlers by BURDEN (1990). These college bowlers attained a mean run-up speed at ball release of 3.79m/s (S.D.=0.75m/s) which is very similar to the mean of 3.62m/s (S.D.=0.42m/s) recorded from the 7 fast bowlers in this investigation. However the elite fast bowlers released the ball (mean speed=37.0m/s; S.D.=1.03m/s) approximately 9m/s faster than the college bowlers (mean speed=28.2m/s; S.D.=1.14m/s).

Figure 1 shows the temporal pattern of the linear speed of the joint centres and the ball throughout a delivery stride, from front foot contact to ball release, of the fastest bowler analysed. The pattern shown in Figure 1 is typical of all the bowlers analysed. Following front foot contact, at approximately 0.12s before ball release, the hip reached its maximum linear speed whereupon it began to decelerate to allow the shoulder to reach its maximum linear speed. The elbow and wrist joint centres then reached their maximum linear speeds and penultimately the 3rd metacarpophalangeal joint reached its maximum approximately 0.02s before ball release. At the end of the kinematic chain the ball reached its maximum linear speed of approximately 37m/s in this trial. An interesting observation from Figure 1 is the large difference between the maximum linear speed of the 3rd metacarpophalangeal joints and the ball, which appears to be a kinematic trait of the fastest bowlers analysed.

TABLE 3
Corelation Matrix of Maximum Linear Speed (MLS) pf Joint Centres and Ball

| | X1 | X2 | X3 | X4 | X5 | Y1 |
|---|---|---|---|---|---|---|
| X1 | 1.00 | 0.76 | 0.41 | 0.48 | 0.53 | 0.57 |
| X2 | 0.76 | 1.00 | 0.38 | 0.41 | 0.47 | 0.66 |
| X3 | 0.41 | 0.38 | 1.00 | 0.83 | 0.72 | 0.75 |
| X4 | 0.48 | 0.41 | 0.83 | 1.00 | 0.94 | 0.75 |
| X5 | 0.53 | 0.47 | 0.72 | 0.94 | 1.00 | 0.73 |
| Y1 | 0.57 | 0.66 | 0.75 | 0.75 | 0.73 | 1.00 |

X1 = MLS of Hip
X2 = MLS of Shoulder
X3 = MLS of Elbow
X4 = MLS of Wrist
X5 = MLS of 3rd Meta.
Y1 = MLS of Ball (i.e. at ball release)

Table 3 shows a correlation matrix between the maximum linear speeds of the joint centres shown in Figure 1 and Table 1 and the ball. From the matrix it can be seen that the maximum linear speed of the hip is strongly correlated, r=0.76, with that of the shoulder. However if the relationship between the next two adjacent joint centres is examined, the shoulder and elbow, only a poor to moderate relationship, r=0.38, is evident. This highlights the independence of angular speed of the bowling arm in the kinematic chain and indicates that high maximum linear speeds of the shoulder and hip will not necessarily result in a high maximum linear speed of the elbow and wrist and subsequently a high ball release speed. Towards the termination of the chain the maximum linear speed of the elbow is strongly correlated, r=0.83, to that of the wrist, which was to be expected as the bowling arm should remain extended at the elbow to conform to the laws of cricket. A similary high correlation of 0.94 existed between the maximum linear speed of the wrist and adjacent joint centre the 3rd metacarpophalangeal. At the end of the kinematic chain the correlation between the maximum linear speed of the 3rd metacarpophalangeal joint and the ball release speed, r=0.73, is again high indicating that a large ball release speed will result from a high maximum linear speed at this distal joint centre. However the association between the two variables is not perfect and does suggest that variations in the actions of the fingers immediately before ball release may influence the final ball release speed.

From Figure 3 it can be seen that a moderate relatioship, r=0.41, exists between the knee angle at ball release and the ball release speed. However more revealing is the significantly higher (p=0.02) ball release speed attained by those bowlers did not their front knee following front foot contact to absorb the impact forces experienced. The importance of the behaviour of the front knee between front foot contact and ball release to the ball release speed, as indicated above, is gain reinforced by the analysis of college bowlers undertaken by BURDEN (1990). From the 9 college bowlers analysed, who as stated previously released the ball approximately 9m/s slower than the fast bowlers analysed in this investigation, only 1 did not flex his knee following front foot contact. In comparison 4 of the 7 fast bowlers in this study did not flex their knee and the 3 fastest released the ball over an hyperextended knee.

CONCLUSION

The relatively low effect of the run-up speed at the time of ball release on the ball release speed was indicated by a poor correlation, r=0.21, between the two variables. However the high correlations (>0.73) between the maximum linear speed of joint centres of the bowling arm and their adjacent joint centres and the ball indicated the importance of the speed of the bowling arm to the speed of the ball. Similarly the significantly greater (p=0.02) ball release speed attained by the bowlers who did not flex their front knee to absorb the impact forces of front foot contact indicated the importance of behaviour of the knee before ball release to the ball release speed.

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