THE VELOCITY DEPENDENCE OF TECHNNIQUES COMMONLY LINKED WITH LOWER BACK INJURY IN CRICKET FAST BOWLING

Kane Middleton, Poonam Chauhan, Bruce Elliott and Jacqueline Alderson

The School of Sport Science, Exercise and Health
The University of Western Australia, Perth, Australia

The aim of this study was to examine the velocity dependence of shoulder alignment counter rotation, maximum hip-shoulder separation angle, maximum front knee flexion angle and maximum trunk lateral flexion. High-performance fast bowlers (n=17) were required to bowl multiple deliveries in a fast, normal and slower ball category. No statistical association was found between bowling velocity and maximum shoulder counter rotation or knee flexion. Significant associations were found between ball release velocity and trunk lateral flexion and maximum hip-shoulder separation angle. Significant differences were found between the bowling categories for separation angle and knee flexion. A regression analysis showed that trunk lateral flexion and separation angle only accounted for 11% of the ball velocity variance, for the normal delivery (31.3 ms^{-1}).

KEYWORDS: biomechanics, alignment, rotation, speed

INTRODUCTION: The fastest bowlers in the world attract large crowds due to the intensity they bring to the game. Mastery of the most appropriate technique, together with other aspects of bowling development are all essential if one is to reach full potential. Understanding what factors enhance bowling velocity without increasing the risk of injury will better equip and prepare bowlers to learn the art of fast bowling, and for coaches to detect and correct flaws in the bowling action. While the rewards of success are easily identified, the stresses and strains placed on the body during fast bowling are a major concern to the bowler. For an impact sport, this means large forces are transmitted through a variety of body tissues via the foot, ankle, knee, hip and various joints of the back. Often concurrently with these high loads, the trunk is flexing laterally and rotating in an endeavour to maximise the speed of the bowling-shoulder. A range of mechanical variables have been commonly linked with lower back injury and include, but are not delimited to: shoulder alignment counter rotation (CR), hip-shoulder alignment separation angle (SA), front knee flexion (KF) and trunk lateral flexion (TLF) (Foster et al., 1989; Burnett et al., 1995; Ranson et al., 2005). The purpose of the present study was to investigate the relationship between ball release velocity and the above mechanical variables.

METHOD: Seventeen male fast bowlers with a mean age 20.9 years (± 2.2), height 187.2 cm (± 6.3) and mass 81.4 kg (± 7.8), currently performing at first grade level or above within the Western Australian Cricket Association competition were recruited. Participants gave their written, informed consent prior to testing and procedures were approved by The University of Western Australia's Human Research Ethics Committee. Three-dimensional kinematics were captured using a 12 camera VICON MX 3-D motion analysis system (Oxford Metrics, Oxford, UK) operating at 250Hz. Static and dynamic calibration of the system was performed prior to the capture of dynamic trials. An abridged version of the UWA full body marker set described by Dempsey et al. (2007) consisting of 62, 12-millimetre retro-reflective markers, were affixed to the trunk, pelvis and the lower and upper limbs.

A cricket pitch was constructed with a rubber mat being laid down the length of the laboratory. Stumps were present at both ends and a bowling and popping crease were marked. Prior to the collection of the dynamic bowling trials, participants performed their personal warm-up. Participants bowled over the wicket and were instructed to aim to hit a target mark 0.3 m above and 0.3 m to the left of the top of the off stump, as viewed from the bowler's end. Each participant bowled five sets of six consecutive deliveries (an over), with a short break between each set in an attempt to replicate match conditions. Within each over, participants bowled four deliveries at their 'normal' match pace, while one delivery was bowled at ‘very fast’ pace, that is; the bowler’s fastest possible delivery speed, and the other a ‘slower’ delivery. The delivery order was randomly allocated.

Vicon Workstation software (Oxford Metrics, Oxford, UK) was used to track, label and complete marker trajectories for each bowling trial. Data were filtered in Vicon Workstation using a Butterworth low pass filter at a cut-off frequency of 15 Hz. Filtered data were modelled using custom static and dynamic UWA models. The shoulder joint centre was calculated as the midpoint between a marker placed on the acromion process and markers on the anterior and posterior aspects of the shoulder overlying the glenohumeral joint with shoulder alignment defined as the line joining these points. The hip joint alignment was calculated as the line joining the left and right hip joint centres. SA was defined as the difference in the shoulder and hip alignments in the transverse plane. The knee joint centre was identified as the midpoint between the medial and lateral femoral condyles and the KF angle was calculated with 0° representing a straight limb. The maximum flexion angle between front foot impact (FFI) and ball release was recorded. TLF was calculated as the maximum relative angle between the vertical trunk axis and the horizontal pelvic axis in the frontal plane during the delivery action.

Means of the three ‘very fast’, three ‘slower’ and 12 ‘normal’ deliveries from the 3rd, 4th and 5th overs of each bowler were used for analysis. Pearson’s product moment correlations were calculated and used to identify associations between each dependent variable and ball velocity within each of the three velocity categories. A one-way ANOVA with repeated measures was used to determine whether there were differences between the bowling categories for each dependant variable. Where main effects were found, post-hoc tests with a Bonferroni correction were used to identify where these differences occurred. A stepwise linear regression was used for the pooled normal deliveries (n = 17 x 12 trials) to determine the influence of the independent variables, as predictor variables, on bowling velocity.

RESULTS: The mean value of the normal deliveries (n=17; 31.31 ms^{-1} ± 1.4) and the very fast deliveries (n=17; 32.46 ms^{-1} ± 1.26) were shown to be significantly different ($t = 6.59$, $p < 0.001$). No significant associations were found between ball release velocity and CR and KF in any of the ball velocity categories. There was a moderately significant positive relationship found between SA and ball release velocity in the slow bowling category (Table 1). Additionally, moderately significant negative relationships were found between TLF and ball release velocity in the normal and very fast bowling categories.

Table 1 Mean correlations (r) for ball velocity category and mechanical variables

Mechanical Variable	Bowlers (n)	Slower Delivery	Normal Delivery	Very Fast Delivery
CR (degrees)	10	0.162	-0.177	-0.114
Maximum TLF (degrees)	17	-0.400	-0.528*	-0.458*
Maximum SA (degrees)	17	0.453*	0.175	0.307
Maximum KF (degrees)	17	0.113	-0.164	-0.114

*Correlation is significant at the 0.05 level (1-tailed)

No significant differences were found for CR and TLF between the slow, normal and very fast bowling categories. For SA, significant differences were found between the slow and very fast bowling categories, as well as between the normal and very fast categories. Similarly for KF, significant differences were found between the slow and very fast bowling categories, as well as between the slow and normal bowling categories (Figure 1).

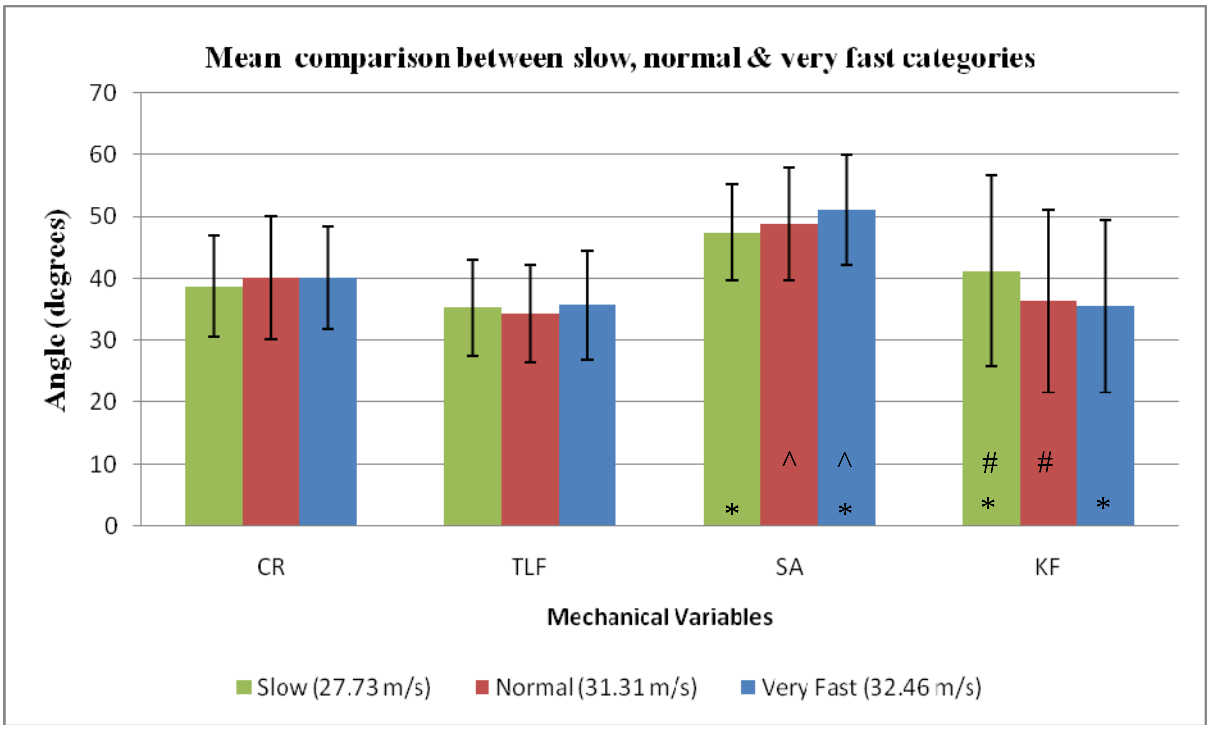

Figure 1 Mean comparison between slow, normal and fast category deliveries for mechanical variables. Matching symbols denote significant differences between pairs at the following confidence intervals: * p ≤ 0.001, ^ p = 0.031, # p = 0.01

Only two variables remained in the stepwise linear regression as significant predictors of ball velocity. The results indicate that both TLF and SA together predict 11% of variance (R^2=0.110, SEE=1.623, F (2, 197) = 12.114, p < .001). That is, only 11% of the variance in ball velocity was explained by these two variables, for the normal delivery.

DISCUSSION: The results from this study, when combined with previous results (Portus et al., 2004; Salter et al., 2007), indicate that variations in bowling velocity are not significantly linked with an increase in shoulder alignment CR. Elliott et al. (2005) had previously shown that bowling over greater pitch lengths resulted in an increase in CR for young fast bowlers. Therefore there may be a trend for CR to be positively correlated with ball release velocity for young fast bowlers; however the results of this study suggest matured fast bowlers may produce extra ball velocity from other means when trying to bowl as fast as they can.

The significantly moderate negative correlation between ball release velocity and TLF in the normal and very fast categories seems to suggest bowlers who 'fell away' less were able to bowl at higher ball release velocities. This finding is in opposition to the results of Salter et al. (2007) who found a non-significant negative relationship between ball release velocity and ball release height (r = -0.283). The comparison between this study and that of Salter and colleagues is made with caution as ball release height is predominantly the summation of knee flexion, trunk flexion and upper arm abduction angle. Therefore arm abduction angle may have been a contributing factor to this negative relationship as it has been previously shown that lower arm abduction angles are significantly associated with ball release speed (Hanley et al., 2005).

The non-significant correlations between ball release velocity and SA in the normal and very fast categories suggest that there is no significant relationship between the two variables. However in the slower ball category, the positive correlation suggests that the greater velocity at which a bowler bowls a slower ball, the greater the SA. The significant difference in SA between the normal and very fast categories suggests that when bowlers attempt to volitionally bowl at a greater velocity, they are increasing the magnitude of a technique variable that has previously been related to lower back injury (Elliott, 2000).

As there was a significant difference between mean KF between the slow and normal bowling categories, bowlers may inadvertently increase this KF to slow their body's centre of mass when attempting to release the ball at a lower velocity. The non-significant difference between the normal and very fast bowling categories seems to suggest knee flexion may play more of a role in reducing peak impact forces over FFI (Foster et al., 1989) and may not influence bowling velocity. Given that only TLF and SA remained in the linear regression and only predicted 11% of variance, it may be reasonable to suggest that these two variables, along with CR and KF, are not useful when trying to predict ball release velocity. Therefore only one (SA) of the four mechanical variables that are commonly linked with lower back injury increase when bowlers attempt to volitionally bowl at higher velocities.

CONCLUSION: This study addressed the velocity dependence of techniques commonly linked with lower back injury in cricket fast bowling. For practical implications, only one (TLF) of the four variables, linked in the literature to lower back injuries, was shown to be significantly related to ball velocity for this sample of fast bowlers**.** As a negative correlation was found, decreasing TLF could potentially result in an increased ball release velocity as well as a decreased risk of sustaining a lower back injury. Of most interest, there was a significant increase in SA when bowlers attempted to volitionally increase their bowling velocity. Therefore bowlers who attempt to volitionally bowl at a greater velocity while increasing SA may be increasing their risk of sustaining a lower back injury, while not gaining any increase in ball release velocity from this variable. Additionally, bowlers should aim to restrict SA while bowling a slower ball, as this may be beneficial in reducing ball release speed as well as their risk of sustaining a lower back injury. A regression analysis showed that none of the four variables could strongly predict ball release speed and therefore cannot be confidently used in identifying potential fast-bowlers.

REFERENCES:

Burnett, A. F., Elliott, B. C. and Marshall, R. N. (1995). The effect of a 12-over spell on fast bowling technique in cricket. *Journal of Sports Sciences,* 13, 329-341.

Dempsey, A.R., Lloyd, D.G., Elliott, B.C., Steele, J.R., Munro, B.J. and Russo, K.A. (2007). The effect of technique change on knee loads during sidestep cutting. *Medicine & Science in Sports & Exercise*, 39, 1765-1773.

Elliott, B.C. (2000). Back injuries and the fast bowler in cricket. *Journal of Sports Sciences*, 18, 983-991.

Elliott, B., Plunkett, D. and Alderson, J. (2005). The effect of altered pitch length on performance and technique in junior fast bowlers. *Journal of Sports Sciences,* 23, 661-667.

Hanley, B., Lloyd, R. and Bissas, A. (2005). Annual Conference of the British Association of Sport and Exercise Sciences, *Journal of Sports Sciences*, 23, 93-223.

Foster, D., John, D., Elliott, B., Ackland, T. and Fitch, K. (1989). Back injuries to fast bowlers in cricket: A prospective study. *British Journal of Sports Medicine*, 23, 150-154.

Portus, M. R., Mason, B. R., Elliott, B. C., Pfitzner, M. C. and Done, R. P. (2004). Technique factors related to ball release speed and trunk injuries in high performance cricket fast bowlers. *Sports Biomechanics*, 3, 263-283.

Ranson, C., Kerslake, R., Burnett, A., Batt, M. and Abdi, S. (2005). Magnetic resonance imaging of the lumbar spine in asymptomatic professional fast bowlers in cricket. *Journal of bone and joint surgery*, 87, 1111-1116.

Salter, C. W., Sinclair, P. J. and Portus, M. R. (2007). The associations between fast bowling technique and ball release speed: A pilot study of the within-bowler and between-bowler approaches. *Journal of Sports Sciences*, 25, 1279-1285.