

RELATIONSHIPS BETWEEN CRICKET FAST BOWLING TECHNIQUE, TRUNK INJURIES, AND BALL RELEASE SPEED

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The Australian Institute of Sport Biomechanics department cricket fast bowling technique data were analysed to: (1) identify the critical technique factors associated with trunk injuries and (2) identify any technique factors associated with a higher ball release speed. Shoulder counter-rotation was significantly higher for lumbar spine stress-fractured bowlers than non trunk-injured bowlers. The stress fractured bowlers were also characterized by a larger hip angle in the sagittal plane at front foot contact and ball release, whereas a more flexed front knee at ball release characterized the non trunk-injured bowlers. A series of weak but significant relationships were evident between kinetic and kinematic technique characteristics and higher ball release speeds.

KEY WORDS: cricket, fast bowling, technique, biomechanics, injury, ball speed

INTRODUCTION: Previous research and coaching literature has classified the broad continuum of cricket fast bowling techniques into four main types: side-on, semi-open, front-on and mixed (e.g. Elliott, Hardcastle, Burnett and Foster, 1992; ACB, 1998). These classifications refer to the orientation of the back foot, hips and shoulders of the bowler when preparing to deliver the ball to the batter. Two-dimensional studies, such as Elliott et al., 1992, have reported the higher risk of lower back injury the mixed technique presents over the front-on and side-on techniques. Shoulder counter-rotation has been identified as the predominant mixed technique factor related to lower back injury. Shoulder counter-rotation is a rapid realignment of the shoulders from a more front-on position at back foot contact (BFC) in the delivery stride, to a more side-on position just prior to front foot contact (FFC) (Figure 1). Due to the lack of three-dimensional fast bowling back injury research it has not been distinguished between bowlers who are counter-rotating their shoulders into alignment with their hips from those bowlers counter-rotating their shoulders out of alignment with their hips. Utilizing a three-dimensional analysis to determine the orientation of the hips, and therefore the hip-shoulder separation angle, should more clearly define injury prone techniques. Limited research has been published on the critical factors associated with higher ball release speeds. It has been inconclusively suggested that a more extended front leg at ball release will enable faster ball release speeds to be attained (Bartlett, Stockill, Elliott and Burnett, 1996). In consideration of this previous research, the Australian Cricket Board (ACB) and the Australian Institute of Sport (AIS) Biomechanics department retrospectively analysed fast bowling data collected between 1996 and 1999 with 2 main objectives: 1) to identify the critical factors in the AIS fast bowling three-dimensional technique data that were related to trunk injuries, and 2) identify if any of the measured technique variables in the AIS Biomechanics fast bowling data were related to higher ball release speeds.

METHODS: Three-dimensional kinematic data for cricket fast bowling sessions between the years of 1996 and 1999 were collated for 42 male fast bowlers (1996 collected at 100 Hz; other years at 50 Hz). Force plate data (1000 Hz) were available for all years for both BFC and FFC in the delivery stride. A series of technique classification criteria were used to classify each bowler's technique. In all cases the hip and shoulder segments are viewed in the transverse plane with the zero line projecting from the leading hip/shoulder down the cricket pitch. The criteria were:

- **SIDE-ON:** a shoulder angle less than 210° at BFC, a hip-shoulder separation angle less than 30° at BFC, *and*, shoulder counter-rotation less than 30°.
- **SEMI-OPEN:** a shoulder angle from 210 to 240° at BFC, a hip-shoulder separation angle less than 30° at BFC, *and*, shoulder counter-rotation less than 30°.

- FRONT-ON: a shoulder angle greater than 240° at BFC, a hip-shoulder separation angle less than 30° at BFC, *and*, shoulder counter-rotation less than 30° .
- MIXED: a hip-shoulder separation angle 30° or more at BFC, *or*, shoulder counter-rotation 30° or more.

To identify interrelating technique factors, and the relationship between technique and ball release speed, a Pearson product moment correlation procedure was employed with a statistical significance level of 0.05 (SPSS Inc.). To assess the relationships between fast bowling technique and trunk injury, four injury groups were created based on the range of injuries suffered by the bowlers either in the previous or following year to biomechanics testing: (1) stress fracture of the lumbar spine pars interarticularis (2) back sprain, including injury to disc, facet joint or ligaments (3) trunk muscle side strain and (4) no trunk injury. For each group a technique profile was created from the mean of the data. A one-way analysis of variance (ANOVA) and scheffe post hoc analysis was used to assess the significance of group differences. An alpha level of 0.01 was adopted for ANOVA procedures to reduce the probability of making a type I familywise error.

RESULTS AND DISCUSSION: Technique interrelationships. Shoulder alignment at BFC was significantly related to shoulder counter-rotation ($r = 0.72$, $p < 0.001$), which is a relationship that has been previously reported (Portus, Sinclair, Burke, Moore and Farhart, 2000). Bowlers who landed with a more front-on shoulder alignment at BFC were the bowlers who counter-rotated their shoulders the most. This result suggests that bowlers attempting to bowl with a very front-on technique can rarely maintain their orientation throughout the full delivery stride, or, bowlers attempting to bowl with one of the more closed actions, such as semi-open or side-on, are often not aligning their shoulders to match their lower body during the flight phase prior to BFC in the delivery stride. Both these scenarios lead to excessive levels of shoulder counter-rotation, which is strongly linked to lower back stress fractures (Bartlett et al., 1996). Knee angle at ball release had a weak but significant relationship with front foot vertical ($r = 0.31$, $p = 0.05$) and braking impact forces ($r = 0.38$, $p = 0.02$). That is, those bowlers who had a more extended front knee when releasing the ball, as opposed to those who had a more flexed front knee at this time, tended to experience higher braking and vertical impact forces. Further, bowlers who extended their front knee more during the FFC phase to ball release experienced higher braking forces ($r = 0.33$, $p = 0.03$). This supports the notion that knee flexion during the FFC phase helps attenuate front foot impact forces.

Technique and ball speed relationships: A number of technique characteristics had weak but statistically significant relationships with higher ball release speeds. Bowlers who extended their knee during the FFC phase bowled slightly faster ($r = 0.37$, $p = 0.02$) than those who flexed and/or extended their front knee less. Additional support for this is the correlation derived between braking forces at FFC and ball release speed ($r = 0.43$, $p = 0.006$). Bowlers who had higher braking forces at FFC bowled faster than those who had lower braking forces. These results, and the significant correlations between knee action and ground reaction forces reported above, reflect the effectiveness of a front leg that “blocks” and permits a more efficient transfer of kinetic energy to the ball when rotating over an extended or extending front leg. A weak but significant relationship was evident between ball speed and the timing of the maximum hip-shoulder separation angle in the transverse plane ($r = 0.34$, $p = 0.05$). That is, those bowlers whose maximum separation between the hip and shoulder segments occurred after FFC bowled faster than those with it occurring well before FFC. The range of shoulder girdle rotation preceding ball release ($r = 0.30$, $p = 0.05$) and the alignment of the shoulder girdle at ball release ($r = 0.34$, $p = 0.03$) were also weakly but significantly related to ball release speed. These results suggest that there is an optimum sequence for hip and shoulder rotation during the delivery stride for higher ball release speeds to be attained. The maximum hip-shoulder separation angle should occur after FFC and closer to ball release with shoulders being more fully rotated than the hips to generate the maximum separation angle. Shoulder rotation is significantly more important to produce higher ball release speeds than shoulder counter-

rotation, which virtually had a zero correlation with ball release speed ($r = 0.009$, $p = 0.95$).

Technique classification: Thirty-one of the 42 bowlers were classified as mixed which is of concern, especially as most of these bowlers were (are) elite or considered potentially elite fast bowlers. Of the 31 mixed bowlers, 9 had a misaligned hip and shoulder posture at BFC AND an excessive shoulder counter-rotation, 5 had a misaligned hip and shoulder posture at BFC AND DID NOT excessively counter-rotate their shoulders and 17 were mixed due SOLELY to an excessive counter-rotation of the shoulders after having a well aligned posture at BFC (figure 1). From the other 11 bowlers 2 were classified as side-on, 6 were semi-open and 3 were front-on.



Figure 1 - A fast bowler being analysed in the AIS Biomechanics laboratory. This technique was classified as mixed solely due to a counter-rotation of the shoulders of more than 30 degrees after BFC. At BFC (A), the shoulders and hips are front-on. The shoulders then counter-rotate to a more side-on position (B), just prior to FFC (C). The shoulders then rotate towards the batter for ball release at (D). Seventeen of the 31 mixed bowlers in the AIS research used the same technique.

Technique and trunk injuries: The technique profile of the four injury groups revealed that mean shoulder counter-rotation was significantly higher in the stress fracture group than the no trunk injury group (Table 1). It seems clear the twisting of the trunk during shoulder counter-rotation is an injury mechanism for the lower back. It may also predispose the bowler to the adoption of a hyper-lordotic and/or hyper-flexed posture at FFC where the ground reaction forces are large (Burnett, Barrett, Marshall, Elliott and Day, 1998). The mean hip-shoulder separation angle was not statistically higher at any point from BFC to ball release for any group. Despite this it is noteworthy that at BFC it was greater in the back sprain group than the no trunk injury and stress fracture groups (Table 1). It seems a larger separation angle at BFC, known as a “mixed set-up” in the coaching domain, was not as strongly related to injury but was almost certainly a pre-cursor to the factors leading to injury. However, these results also illustrate that a technique that was sound at BFC (“in-line set-up”) was still a highly dangerous technique if shoulder counter-rotation occurred after BFC. As the stress fracture group’s hip-shoulder separation angle at BFC was equivalent to the non-injured group, it appears the technique most predisposing bowlers to lumbar spine stress fractures was one where the hip and shoulder girdles were in reasonable alignment at BFC followed by a counter-rotation of the shoulders to a more side-on position before FFC (figure 1). The fact that all injury groups recorded relatively small hip counter-rotation angles (Table 1) indicates that a concurrent counter-rotation of similar

magnitudes of the hip and shoulder segments was not common in these bowlers. No other technique factors were statistically different for any of the groups, though the stress fracture group was characterized by a larger hip angle (i.e. more upright) at FFC and ball release. Further, a more flexed knee at ball release characterized the non-trunk injured group (Table 1). This lends support to previous findings (Elliott et al., 1992), and suggests that impact forces may play a role in back injury, as reported earlier there is a weak but significant relationship between front knee action during FFC and ground reaction forces.

Table 1 Mean (\pm SD) Technique Characteristics (degrees) of the Four Trunk Injury Groups

Technique Characteristic	Trunk Injury Group			
	Stress Fracture	Back Sprain	Side Strain	No Injury
Hip-shoulder separation BFC	16 \pm 8	31 \pm 16	23 \pm 13	15 \pm 7
Shoulder counter-rotation	41 \pm 10*	36 \pm 15	27 \pm 14	19 \pm 10
Hip counter-rotation	9 \pm 9	8 \pm 8	4 \pm 6	2 \pm 3
Hip-shoulder separation FFC ^a	-20 \pm 12	-23 \pm 14	-19 \pm 18	-26 \pm 9
Knee angle at FFC	167 \pm 9	165 \pm 9	167 \pm 7	154 \pm 13
Knee angle at ball release	151 \pm 17	149 \pm 20	155 \pm 20	131 \pm 12

*Significantly higher than no injury group ($p = 0.01$). ^aNegative indicates hip segment is more front-on than shoulder segment.

CONCLUSIONS: Limited evidence has been presented suggesting a large hip-shoulder separation angle at BFC may be related to lower back sprain injuries. However, shoulder counter-rotation has been clearly shown to be the major predisposing technique factor to lumbar spine stress fractures. Indeed, a technique that featured reasonably aligned hip and shoulder segments at BFC and then a counter-rotation of the shoulders before FFC was characteristic of the stress fracture group in this research. A number of factors were identified as relating to higher ball release speeds. They were: a front knee that extended during the FFC phase to ball release; higher braking forces at FFC which was linked to knee extension during the FFC phase; a maximum hip-shoulder separation angle occurring after FFC with the shoulders being more rotated than the hips to generate the maximum separation angle.

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