FORWARD SOLUTION SIMULATION OF THE MIXED ACTION IN CRICKET FAST BOWLING

[1]René Ferdinands and [2]Uwe Kersting
[1]Department of Physics & Electronic Engineering, University of Waikato; email: rene@waikato.ac.nz
[2]Department of Sport & Exercise Science, University of Auckland; email: u.kersting@auckland.ac.nz

INTRODUCTION

The objective of fast bowling in cricket is to deliver the ball with a straight arm so that it reaches the batter at high speed after having first bounced once off the ground. The faster the ball, the less time the batter has to respond. However, fast bowlers require high run-up speeds, generate large ground reaction forces, and produce high joint torques [3]. With the loading placed on the body, it is not surprising that fast bowling is associated with a high incidence of lower lumbar injury. The susceptibility to such injury is correlated with shoulder counter-rotation during delivery stride [2]. The purpose of this study was to develop a forward solution model to predict the causal factors associated with the counter-rotation of fast bowlers. This approach potentially gives the cricket coach a scientific means of modifying the technique of mixed action bowlers to reduce their susceptibility to lower lumbar injury.

METHODS

A three-dimensional (3D) forward solution dynamics model of the human body was used to simulate the motion of fast bowling in cricket. This model provides a mechanical basis for the remediation of fast bowling techniques that are correlated with an increased injury risk. Thirty-four fast bowlers were selected for study and divided into four groups according to ball release speed. An 8-camera 240 Hz motion analysis system (Motion Analysis Corp.) tracked markers placed on the bowler delivering a series of balls at a target approximately on a 'good length' in line with the wickets, and a Bertec force plate was used to measure ground reaction forces. The marker arrangement allowed for the 3D motion tracking of all major body segments. Kinematic alignment factors were calculated to classify bowlers according to bowling type: side-on, front-on, and mixed.

A forward solution model of the bowler was developed using *Mathematica's Mechanical Systems Pack*. This is a set of packages designed for the analysis of spatial rigid body mechanisms by implementing a dynamics formulation with Lagrangian multipliers. The computer model gives a 3D representation of the human body as a system of fifteen rigid body segments with mass and inertia properties. The forward solution model was used to test the effectiveness of technical hypotheses to correct a mixed action.

RESULTS AND DISCUSSION

According to a modified classification for action type [3] only 11.8% were side-on, 27.5% front-on, and 61.7% mixed. The mixed action bowlers had higher shoulder-hip separation angles than the side-on and front-on bowlers (Table 1). Mixed action bowlers also have more lateral flexion and hyperextension of the lumbar spine during delivery stride [1].

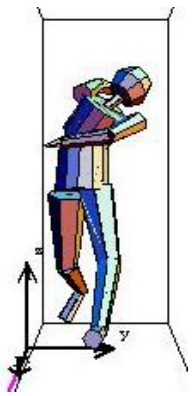

Figure 1: Simulated mixed action

The forward solution was run to test the effects of increasing the shoulder-hip separation angle of a front-on bowler. This was performed by increasing the anticlockwise upper trunk torque about the longitudinal axis and decreasing the corresponding torque of the lower trunk. This was represented by the shoulder to hip torque differential factor (γ) in the forward solution.

The simulation of the bowler under these modified torque inputs (γ = 1.3) increased the amount of lateral lean (15.3º), hyperextension (10.2º), and shoulder counter-rotation (8.0º) at front foot contact. Increasing γ from 1 to 1.3 increases the severity of those factors that constitute a mixed action. As γ was increased more than 1.3 the solution become unstable. The kinematic data and the forward solution simulation suggest that a strong torquing between the shoulders and hips can promote shoulder-counter-rotation in bowling.

CONCLUSIONS

This study showed that the mixed technique can be produced by changing the trunk torques in a forward solution. Despite their inherent stability problems, the further development of forward solutions should be pursued to give biomechanists a tool that not only achieves the objective of reducing shoulder counter-rotation, but that can also be used to improve other areas of performance.

REFERENCES

1. Burnett AF et al. *Clin Biomech* **13**, 574-583, 1998.
2. Elliott BC. *J. Sports Sci* **38**, 983-991 ,2000.
3. Ferdinands RED. PhD thesis (University of Waikato), 2004.

ACKNOWLEDGEMENTS

I wish to thank New Zealand Cricket for funding the post-doctoral component of this study.

Table 1: Shoulder and hip alignment characteristics show that mixed bowlers tend to have higher separation angles.

ACTION TYPE	Shoulder Angle BFC(°)	Shoulder/Hip Separation BFC (°)	Shoulder Counter Rotation (°)
Side-on	21.7 ± 1.8	10.2 ± 3.3	11.0 ± 5.4
Front-on	41.6 ± 3.4	9.07± 3.1	21.5 ± 2.4
Mixed	61.1 ± 2.7	28.4 ± 2.8	36.6 ± 2.3