OPTIMISING INDIVIDUAL PERFORMANCE IN CRICKET FAST BOWLING

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While an experimental approach is suitable to understand the differences between bowlers it is not suitable to understand the changes required to optimise an individual's performance. To optimise individual performance a 16-segment computer simulation model of the front foot contact phase of fast bowling was developed, customised to an elite fast bowler and evaluated. Optimising technique via the torque generator activation timings and the initial body configuration technique found increases in performance of 10% and 22%,respectively, where the optimal technique consisted of a straighter front knee, more delayed bowling and non-bowling arms and increased trunk flexion. The effect of increasing strength by 5% was shown to only increase ball speed by 1%. It was concluded that this individual's performance is limited by technique and this should be his area of focus for improvement.

KEY WORDS: performance, simulation modelling, cricket, fast bowling.

INTRODUCTION: In cricket, fast bowlers utilise the speed at which they are able to deliver the ball in order to be successful. Previous research has taken an experimental approach to primarily investigate the technique parameters linked to ball speed. The effect of individual technique parameters on ball speed has provided contradictory arguments most likely due to a number of technique parameters being fundamental (Bartlett et al., 1996; Worthington et al., 2013). Since experimental research is essentially derived from data averaged over a range of fast bowlers it is difficult to develop a mechanical understanding of fast bowling. In order to develop an understanding of the cause and effect relationships between technique parameters and ball speed a theoretical approach is required. Computer simulation models allow a wider mechanical understanding of a technique to be gathered which can more directly support coaching. The purpose of this research was to investigate the factors limiting an individual's fast bowling performance using a subject-specific computer simulation model.

METHODS: A planar sixteen segment torque-driven computer simulation model of the front foot contact phase of fast bowling (Figure 1) was constructed using Autolev^{TM} (Kane and Levinson, 1985). Fourteen rigid segments represented the: head + trunk, two upper arms, two thighs, two shanks, two two-segment feet, forearm + hand (non-bowling arm), forearm (bowling arm) and hand (bowling arm) with wobbling masses within the shanks, thighs and trunk. Two massless segments were also used to encorporate non-planar rotations (Felton & King, 2016). One to connect the bilateral hip joint centres and the other to connect the bilateral shoulder joint centres. These segments had variable length and orientation (about the trunk + head segment) which allowed the joint centres to be noncoincident. The length of the trunk + head segment was also allowed to vary with the centre of mass position moving accordingly to incorporate the effect of side flexion. Nine monoarticular joint torque generators were incorporated in the model at the front MTP joint, the front ankle, the front knee, both hips, both shoulders, the bowling arm elbow and the bowling arm wrist (King et al., 2006). The back MTP joint, back knee and non-bowling elbow were angle-driven since it was thought their impact on performance was minimal. Each foot had three points of contact with the ground at the heel, ball (MTP joint), and toe. A ball was included at the end of the bowling arm hand as a point mass.

The simulation model was customised to an elite male fast bowler (age 18 years, mass 85.0 kg, height 1.94 m), who was a member of the England U19 team and identified as having the potential to play for England in the next five years. Subject-specific parameters were determined; segmental inertia (Yeadon, 1990), strength parameters for each joint were measured via an isovelocity dynamometer from which torque-angle and torque-angular velocity relationships were calculated using a nine parameter function (King et al., 2006). A common set of viscoelastic parameters representing the attachments of the wobbling masses and the foot-ground interface were determined using an angle-driven model and three recorded performances (Wilson et al., 2006).

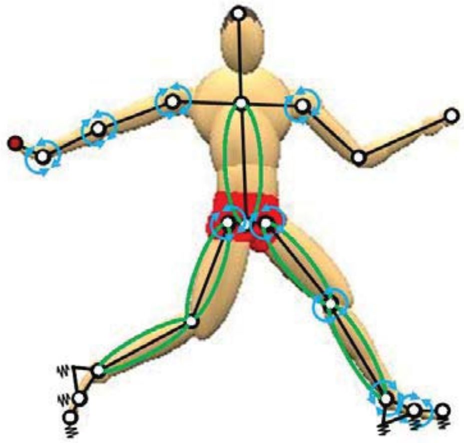

Figure 1 - Sixteen-segment simulation model with wobbling masses within the shank, thigh and trunk segments and spring-dampers at three points on each foot. Nine torque drivers at the joints with circular arrows and angle drivers at all other joints.

The simulation model was evaluated by varying the activation timings of the torque generators using a genetic algorithm (Carroll, 2001) to minimise an objective function representing the difference between simulation and performance. The objective function was a root mean square (RMS) difference between simulation and performance for six components: force, centre of mass velocity, orientation angle, ball speed, time and the nine torque-driven joint angles. Each difference was weighted equally and 1° was equivalent to 1% difference in other measures (Yeadon & King, 2002). Penalties were included to limit horizontal slide and vertical compression of the front foot during impact, wobbling mass movement as well as preventing the joint angles exceeding their anatomical bounds.

Once evaluated the model was optimised to investigate whether technique limited the individual's performance via two differing optimisations: the first varied the activation timings of the torque generators whilst maintaining the initial body configuration from the performance; the second varied both the initial body configuration and the activation timings of the torque generators. The model was then used to investigate whether strength limited the individual's performance by increasing the maximum isometric torques of the ankle, knee, hip and shoulder by 5% and varying the activation timings of the torque generators with the optimal body configuration found in the previous optimisation.

RESULTS & DISCUSSION: The simulation model matched well with a recorded performance with an overall difference of 4% (Figure 3). The average difference of the kinematic components of the objective function were 1% indicating that the simulation model can accurately reproduce the kinematics of the front foot contact phase of fast bowling. Due to the close agreement between the simulation model and the recorded performance it was concluded that the simulation model is capable of adequately replicating the front foot contact phase of the fast bowling action and can be optimised to investigate the factors limiting this individual's fast bowling performance.

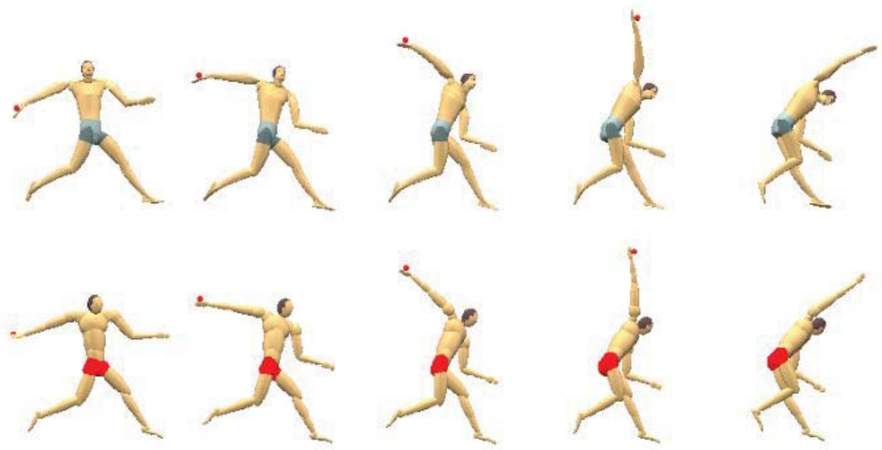

Figure 2: Comparison between performance (top) and evaluated simulation (bottom).

The first optimisation which varied the activation timings of the torque generators but kept the initial body configuration from the recorded performance produced an increase in performance of 10% for this individual. This was achieved by maintaining a straighter front leg and increasing the amount of trunk flexion. The second optimisation which also allowed the initial body configuration to be optimised produced an increase in ball speed of 22%. The most marked difference in the initial body configuration was at the shoulders where the extension was delayed for both the bowling and non-bowling arms (Figure 3). Adopting this initial body configuration allowed the front leg to stay straighter and more trunk flexion to occur during the front foot contact phase of fast bowling.

The factors limiting fast bowling performance in both the technique optimisations indicate that for this individual the front leg should be kept straighter, the amount of trunk flexion should be increased and the onset of the bowling arm circumduction should be delayed. This is in agreement with the experimental research on elite fast bowlers by Worthington et al. (2013) who suggest that elite fast bowlers use a straight front leg to more efficiently convert the linear momentum of the run-up to angular momentum. This results in an increase in trunk flexion and a more delayed bowling arm.

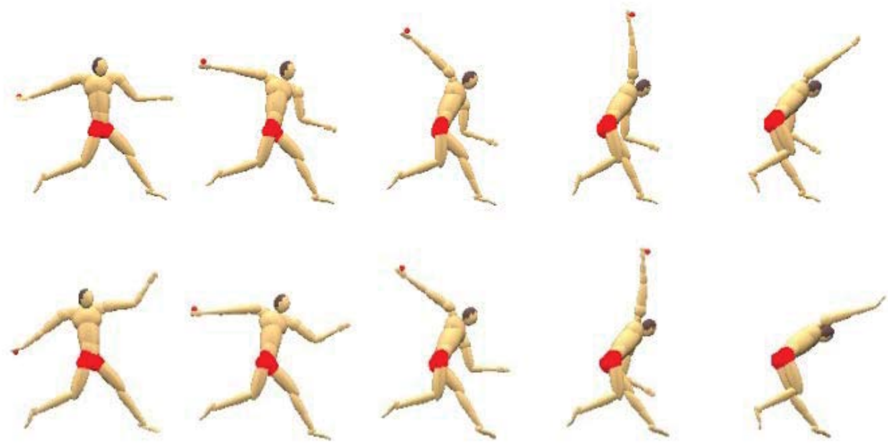

Figure 3: Comparison between matched performance (top) and optimised technique simulation (lower).

The final optimisation where the strength of each joint was increased by 5% produced an increase in performance of 1% compared to the optimal technique optimisation. The increase in strength allowed the individual to keep a straighter front leg, delay trunk flexion and produce more extension of the front arm. The small increase in performance relative to the increase in strength is probably due to the individual being within an elite fast bowling environment with specific strength and conditioning monitoring designed to maximise fast bowling performance.

The aims of this study were to identify the factors which limit an individual's fast bowling performance using a computer simulation model. The simulation model was successfully evaluated and optimised. The technique and strength optimisations indicated that the performance of the individual in this study is limited by his technique rather than strength. It is recommended that the future coaching of this individual is focussed on adapting his technique to keep his front leg straight, delay the bowling and non-bowling arms and increase trunk flexion whilst maintaining his current strength.

In the future the model will be used to investigate the cause and effect relationships which have yet to be understood through experimental research. The recommendations made by this model will be used to shape the future coaching of this individual. The results will be analysed and if positive the model will be developed into a coaching tool to aid the development of future fast bowlers.

CONCLUSION: This study has identified a method in which the factors limiting an individual's fast bowling performance can be identified and coaching recommendations based on a mechanical understanding of the individual provided. If the coaching recommendations are successful and increase performance then this method could be used as a coaching tool to develop future generations of fast bowers.

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