COACHING BIOMECHANICS INTERFACE: SIMULATION MODELLING

Michael J. Hiley

School of Sport, Exercise and Health Sciences, Loughborough University, UK

KEY WORDS: optimisation, virtual reality, co-ordination.

INTRODUCTION: Computer simulation modelling is a powerful tool that can be used to gain insight into the mechanics of gymnastics technique. Having identified the underlying mechanics performance may be optimised and new skills developed. As computer processing power has increased so have the applications for simulation modelling. Research is currently being conducted to combine simulation models with virtual reality environments to produce innovative gymnastics training aids.

PARALLEL BARS: In gymnastics there is often more than one technique used to perform the same skill. In these situations the question is “Which is the best technique?”. The ‘best’ technique will depend on many factors including the age and preparation of the gymnast and the long term plan of the coach (i.e. which technique will allow the development of more complex skill variations). Simulation modelling and optimisation can be used to help answer such questions. Two techniques were identified in the coaching literature for the undersomersault to handstand on parallel bars (Davis, 2005). Two optimisations were performed with the score based on (a) minimising joint torques and (b) requiring a vertical path of the mass centre prior to release (Hiley, Wangler & Predescu, 2009). The two optimal solutions closely resembled the techniques identified in the coaching literature (Figure 1). Both techniques may be used by the coach, but at different stages of the gymnast’s development. The back clear circle technique (Figure 1a) is less demanding in terms of strength, and may be adopted during the initial stages of learning. Whereas the stoop stalder technique (Figure 2b), which requires more strength, has advantages for skill progression, for example in the undersomersault to handstand with either a half or full turn.

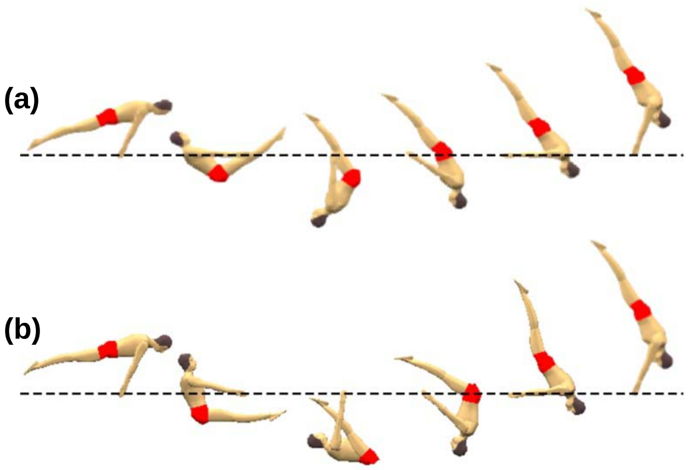

Figure 1. The optimal (a) back clear circle and (b) stoop stalder undersomersault to handstand techniques.

TWISTING SOMERSAULTS: Simulation modelling can also be used to improve performance, whether it is to increase the number of somersaults/twists that can be performed in a dismount or to predict totally new skills. Using a simulation model of aerial movement Yeadon (2009) addressed the following question posed by a national freestyle aerial skiing coach “How can five twists be produced in a triple somersault using asymmetrical arm movements?”. The coach was very specific regarding the constraints placed on the technique, so that minimal changes to the take off and landing phases would be required. Alternative solutions were possible, but would have contradicted the take off technique preferred by the coach. In addition to developing a technique that produced five twists (Figure 2), a set of lead up skills was developed that would allow the athlete to safely build up to the final complex skill. The advantage of this approach is that progressions of skills can be developed with the model, in safety, prior to working with an athlete.

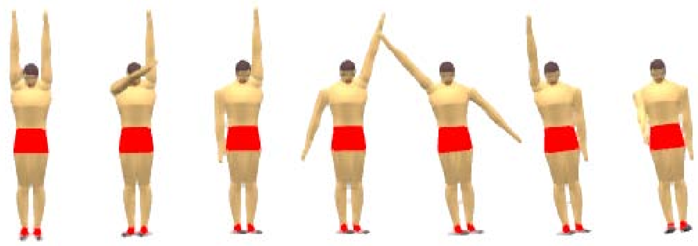

Figure 2. Arm actions required to produce five twists in a triple somersault.

HIGH BAR: When optimising performance gymnast-specific strength limits are normally used to prevent solutions exceeding the strength characteristics of the gymnast (King & Yeadon, 2004). However, optimum technique is often sensitive to timing errors, producing sub-optimal performances when perturbed (Hiley & Yeadon, 2008). Twenty giant circles prior to release for a Tkatchev were analysed to determine the level of timing variability at the instants of maximum and minimum hip and shoulder flexion and extension. The mean and standard deviation were calculated for each measure. The range of deviations from the mean ranged between ± 30 ms with a standard deviation of approximately 12 ms. Optimisations including the sensitivity of the technique to variations in timing have been shown to produce optimum technique closer to the actual performance of the gymnast (Hiley & Yeadon, 2007). Hiley & Yeadon (2005) used a simulation model of the gymnast and high bar to investigate the feasibility of performing a triple layout somersault dismount from the high bar. Starting from the 2000 Olympic high bar champion's giant circle technique and using appropriate strength limits it was found that the model could produce sufficient angular momentum and time of flight to produce a triple layout somersault dismount. However, the time window within which the model could release the bar and successfully perform the dismount was unrealistically small compared to double layout somersault dismounts (Hiley & Yeadon, 2003). When the release window and timing variations were incorporated into the optimisation (Hiley & Yeadon, 2008) the model was only able to produce sufficient angular momentum to perform a triple piked somersault dismount (Figure 3). Since gymnasts are not able to precisely co-ordinate skills each time, the techniques they use will have been developed to cope with the level of timing variation present in the system. If optimisation is to produce realistic solutions that can be reproduced in the gymnasium by the gymnast considerations regarding the limits of co-ordination must be included.

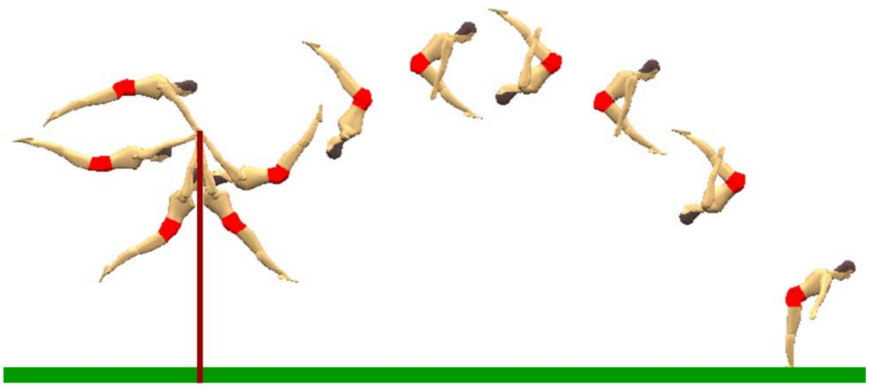

Figure 3. The triple piked backward somersault from high bar.

VIRTUAL REALITY: Simulation models have been combined with a head mounted real-time virtual reality display in order to train viewing skills during aerial movement (Yeadon & Knight, 2006). It might be expected that training gymnasts to view the landing area during flight may lead to more consistent landings. The system incorporates a three dimensional motion sensor attached to the gymnast's head which provides real time input to the simulation model. The view of the virtual environment from the model's head is then fed back to the gymnast through the virtual reality display. By programming the simulation model with the appropriate skill the gymnast can learn to view the landing area during the aerial phase before attempting it in the gymnasium. The system was tested on an experienced artistic gymnast who was about to learn a new skill on high bar (a double layout somersault with a full twist in the second somersault). The gymnast had not previously attempted to view the landing during high bar dismounts. After learning the appropriate head movements the gymnast undertook a progression of twisting somersault skills in the gymnasium, resulting in the desired high bar dismount (Figure 4). The gymnast provided positive feedback that the virtual reality training system had helped him learn to view the landing area during the new skill.

Figure 4. Gymnast using head movements to view through a twisting double somersault dismount.

CONCLUSION: The main benefit simulation modelling can provide gymnastics coaches with is an understanding of the underlying mechanics of specific movements. It is important that the knowledge gained from gymnastics research finds its way into coach education resources and practical application. It is also important that gymnastics research has input from coaches so that the right questions can be asked and addressed.

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Acknowledgement

The author would like to acknowledge the contribution of the Biomechanics and Motor Control research group at Loughborough University