COMPUTER SIMULATION OF THE TAKEOFF IN SPRINGBOARD DIVING

Pui W. Kong, Maurice R. Yeadon and Mark A. King
Loughborough University; email: m.r.yeadon@lboro.ac.uk, web: www.lboro.ac.uk

INTRODUCTION

In springboard diving the diver aims to generate sufficient time in the air and angular momentum for somersault and twist, and travel safely away from the board. Since the linear and angular momentum that the diver possesses in the air are determined by the end of the takeoff phase, it is crucial to understand the mechanics of the takeoff in terms of gaining dive height, generating angular momentum and keeping a safe distance. The aim of this study was to develop a computer simulation model in order to investigate springboard diving takeoff techniques in the forward and reverse groups.

METHODS

A planar simulation model of a springboard and a diver was developed using the Autolev 3.4™ software package based on Kane's method of formulating equations of motion [1]. The diver was represented by an eight-segment linked system comprising the head, upper arm, lower arm, trunk, thigh, shank and a two-segment foot. There were extensor and flexor torque generators acting at the metatarsal-phalangeal, ankle, knee, hip and shoulder joint. The torque produced was the product of an activation level and the maximum torque calculated from a torque / angle / angular velocity function. Each activation level was specified using two quintic functions with six parameters.

Input to the model included initial conditions at touchdown obtained using high speed video and activation time histories throughout the simulation. Output of the model comprised time histories of the springboard displacement, the diver's joint angle and angular velocity at each joint, body orientation, CM velocity and whole-body angular momentum. The model was customised to an elite female diver so that simulation output could be compared with the diver's own performance. Model parameters including springboard, strength, inertia and visco-elastic parameters were determined either directly from experiments or indirectly using an angle-driven model. A score was calculated as the average percentage difference in joint angles, orientation, linear momentum, angular momentum, and springboard characteristics. Sixty muscle activation parameters were varied until the best match between simulation and performance was found by minimizing this score using the Simulated Annealing optimisation algorithm [2]. Four dives which required different angular momenta in the forward and reverse groups were selected for this matching process. After satisfactory evaluation, the model was used to optimise takeoff techniques in terms of gaining maximum dive height.

RESULTS AND DISCUSSION

All four simulations matched the performance well with an average score of 6.3%. Graphics comparison of the performance and matching simulation of the forward two and one-half somersault pike (105B) is shown in Figure 1. In the optimisation for height for 105B, there is a 12.7 cm increase in dive height. The good agreement between simulation and performance for all four dives suggests that the model can successfully reproduce springboard diving takeoff movements. The optimised simulation shows that by changing the activation alone the diver can gain more dive height. This model will be further applied to investigate other optimal takeoff techniques.

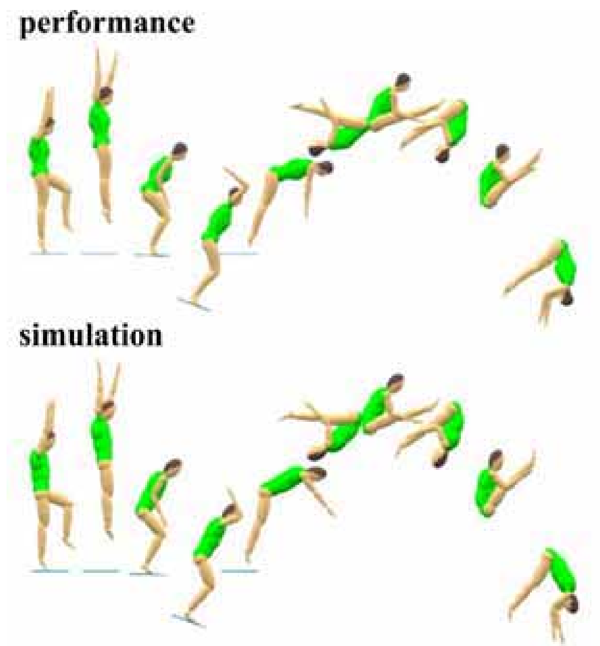

Figure 1: Comparison of the performance and matching simulation of the forward two and one-half somersault pike.

CONCLUSIONS

This study presents a torque-driven simulation model of a springboard and a diver which successfully reproduces realistic springboard diving takeoffs. This model will be used to investigate optimal takeoff techniques in the forward and reverse dive groups.

REFERENCES

1. Kane TR, Levinson DA. *Dynamics: Theory and implementations*, McGraw-Hill, New York, 1985.
2. Corana A, et al. *ACM Transactions on Mathematical Software* **13**, 262-280, 1987

ACKNOWLEDGEMENTS

This study was supported by the International Society of Biomechanics under the Matching Dissertation Grant Program.