EVALUATION OF A COMPUTER SIMULATION MODEL OF TRIPLE JUMPING

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INTRODUCTION
While there have been a number of experimental studies on the triple jump, none has attempted to simulate any portion of it computationally. In light of this a whole-body torque-driven computer simulation model of triple jumping was constructed. This model was then used to match performance data in order to evaluate it for future use in the optimisation of performance.

METHODS
A two-dimensional whole-body torque-driven computer simulation model of triple jumping was developed using Autolev™. The model consisted of 13 rigid, pin-linked segments and wobbling masses at the shank, thigh and torso. Simulations were driven by ten torque generators situated at the hip, shoulder, knee, ankle and ball joints (Figure 1). Kinetic and kinematic data were collected from a triple jumper using a force plate and Vicon motion analysis system respectively. Strength characteristics were measured using an isovelocity dynamometer from which torque-angle and torque-velocity relationships were calculated using a nine parameter function [1]. Anthropometric measurements were also taken, from which segmental inertia parameters were calculated [2].
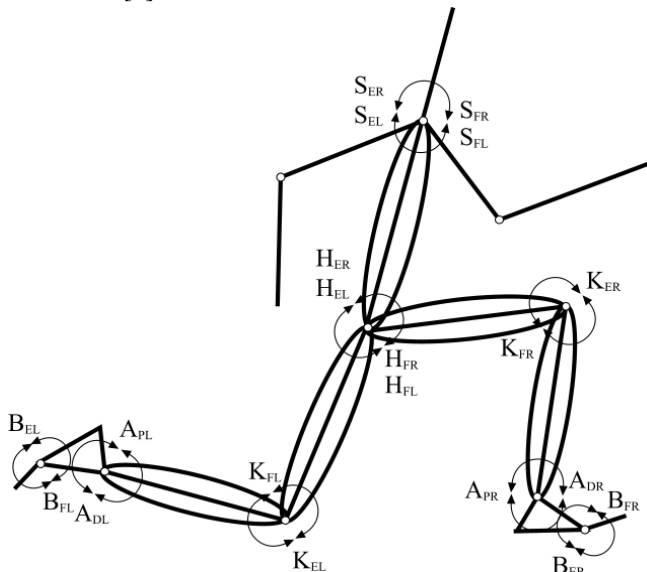

Figure 1: Structure of a computer simulation model of triple jumping.

A simulated annealing algorithm (SAA) [3] was used to match an angle-driven model to performance data by varying viscoelastic parameters governing the stiffness and damping of wobbling masses and foot-ground interface springs. These viscoelastic values were used in a torque-driven simulation. This was matched to performance data for each phase individually by varying the activation timings of torque generators in order to minimise a root mean square (RMS) difference between simulation and performance using SAA. This difference comprised percentage horizontal and vertical velocity, RMS orientation angle, RMS configuration angles and percentage time of contact, with one degree considered equal to one percent.

RESULTS AND DISCUSSION
A good match was shown between the model and performance over all three phases, with scores of 2.2%, 1.6% and 0.8% for the hop (Figure 2), step and jump phases respectively (Table 1).
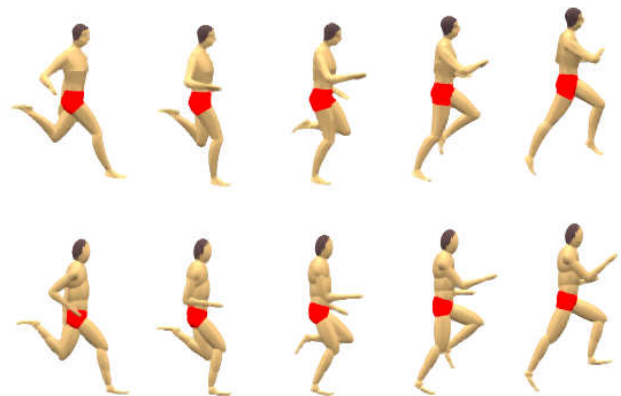
Figure 2: A comparison between performance (top) and simulation (bottom) of the hop phase.

CONCLUSIONS
The model showed good agreement with performance data, demonstrating sufficient complexity for simulation of the triple jump. In future the model will be used to investigate factors contributing to performance in triple jumping.

REFERENCES
1. King, MA, et al., *J Appl Biomech.* **22**:264-274, 2006.
2. Yeadon, MR. *J Biomech.* **41**:1809-1812, 1990.
3. Corana A, et al., *ACM Trans Mathl Software,* **13**:262-280, 1987.

Table 1: Table showing differences between matching simulation and performance for each phase of the triple jump.

phase	vertical velocity (%)	horizontal velocity (%)	RMS orientation (degs)	RMS configuration (degs)	time of contact (%)	total RMS difference (%)
hop	1.3	3.0	1.2	2.0	2.9	2.2
step	1.4	1.1	2.6	1.8	0.1	1.6
jump	0.1	0.5	0.9	1.3	0.3	0.8