INTRODUCTION

Within the literature there is no general consensus about the importance of the table contact phase for vaulting performance. Some sources advocate that vaulting performance is largely determined prior to the table contact phase [1] while others suggest that the gymnast has the ability to change the outcome of the vault during the table contact phase [2].

The purpose of this study was to use a torque-driven simulation model of vaulting to investigate the influence of the table contact phase on vaulting performance, in particular post-flight height. Performance in vaulting can be thought of in terms of the score achieved, with a higher score indicating a better performance. As lack of height in the post-flight receives a specific deduction it has a direct influence on the score, hence the focus on this measure.

METHODS

An optoelectronic motion capture system was utilized to collect kinematic data from an elite male gymnast who performed three handspring somersault vaults. A chain model that assumed fixed segment lengths was used to process the data and determine the planar motion of the gymnast during the table contact phase of each vault.

Maximal voluntary joint torque data were obtained using an isovelocity dynamometer for flexion and extension of the wrist, shoulder, hip and knee. Gymnast-specific torque surfaces were subsequently fit to the data based on the relationships between torque, angle and angular velocity [3]. Anthropometric measurements were taken from the gymnast and gymnast-specific segmental inertia parameters calculated, while the inertial parameters of the table were estimated from mass and linear dimensions.

A two-dimensional torque-driven model that simulated the interaction between the gymnast and the vaulting table during the table contact phase was developed. The gymnast was modelled in planar form using seven rigid segments and the table was modelled as a single segment (Fig. 1).
The input to the model comprised the gymnast’s initial configuration and joint angular velocities, together with the activation time histories of the torque generators. The output from the torque-driven model included the gymnast’s configuration, orientation and linear and angular momentum at table take-off.

The torque driven model was evaluated by assessing how closely a simulation matched performance data. A genetic algorithm varied the torque generator activation profiles to minimise an objective function that measured the difference between a simulation and a recorded performance.

The simulation model was then used to determine whether the gymnast’s post-flight height could be improved through changes in table contact phase technique and/or configuration at initial table contact. Firstly the torque generator activation profiles were varied in order to determine the potential improvement arising from changes solely to contact phase technique. Secondly the activation profiles were varied along with the initial table contact configuration in order to determine the influence of also changing this aspect of technique. The configuration of the gymnast at table touchdown was defined by three angles: orientation angle of the upper trunk, shoulder angle and hip angle. The gymnast’s pre-flight angular momentum and centre of mass trajectory were constrained to be the same as those of the recorded performance; in effect the only difference was the table contact configuration which was assumed to be modifiable by the gymnast during pre-flight.

RESULTS AND DISCUSSION

Evaluation of the torque-driven model showed that the model adequately simulated the table contact phase of handspring somersault vaults. The three vaulting performances were matched with overall difference scores of 3.1%, 1.8% and 3.5% respectively. Furthermore close agreement was found between the performance and simulation joint angles which indicated that the torque generators included in the model were strong enough to match the performance torques for this vault.

The vault with the best performance was chosen for further analysis. Optimisation of the table contact phase technique showed there was very little potential for improvement in post-flight height with an increase of only 0.05 m.

When the touchdown configuration was varied along with table contact phase technique there was more potential for improvement in post-flight height with an increase of 0.14 m. This increase was achieved through a higher orientation angle at contact and a more open shoulder angle (Fig. 2).

![Figure 2: Comparison of gymnast’s configuration at initial table contact: upper – actual performance, lower – optimised configuration.](image)

While adjustment of the configuration at table contact had the potential to improve performance there was limited scope for the gymnast to alter the performance through technique modifications during the table contact phase. These results suggest that the table contact phase has little influence on vaulting performance, in agreement with [1].

REFERENCES

2. Smith T. Gymnastics: A mechanical understanding, Hodder and Stoughton, 1982