The Control of Twisting Somersaults

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Introduction

Twist may be produced during a forward somersault by extending asymmetrically from a piked position. For a twist to the left the body is flexed over the right hip prior to becoming straight. This asymmetrical hip movement produces a tilt of the longitudinal axis away from the vertical somersault plane and twist results in order to maintain constant angular momentum during flight. The amount of tilt, and hence the resulting twist rate, is sensitive to the amount of side flexion used. Since there will be some variation in the amount of side flexion used in each performance, it will be necessary to make in-flight corrections in order to complete the required amount of twist. This study investigates a method of making such corrections using a computer simulation model of aerial movement.

Methods

An 11-segment computer simulation model of aerial movement was used to produce a forward somersault with 1.5 twists. Asymmetrical hip movement was used to initiate the twist in the first part of the aerial phase and to stop the twist in the final part. During the middle phase of the movement the model twisted with a straight body with arms abducted 90° from the midline of the body. This simulation was used as the target performance in a perturbation study. Another simulation was carried out in which the hip flexion in the side-flexed position was 130° rather than 128°. This resulted in less tilt and a lower twist rate so that the final amount of rotation produced was less than 1.5 twists. A trampolinist is able to sense this lower twist rate by means of the balance mechanisms in the inner ear which detect the centripetal accelerations. A control system with feedback time delay was introduced into the simulation model by reducing the arm abduction angle during the twisting phase as a function of the difference between the twist rate in the simulation and the corresponding twist rate in the target performance. The aim was to increase the twist rate during the middle phase to compensate for the lack of twist in the modified movement.

Results

The simulation with 130° hip flexion resulted in 1.38 twists rather than the 1.50 twists of the target simulation. When the arm abduction angle during the twisting phase was reduced in proportion to the difference between the twist rate and the target twist rate, the final rotation was 1.50 twists. The arm adduction had to compensate for less twist produced in the first and final phases as well as in the middle phase. When a time delay was introduced into the control system this resulted in insufficient twist being produced. This was catered for by reducing the arm abduction angle even more. Time delays of up to 300 ms could be accommodated. The somersault angle was adjusted by changing arm abduction and pike angle near the end of the simulation as a function of the deviation of the somersault angle from the target simulation.

Discussion

The limiting factor in being able to successfully compensate for a slow twist rate and a long time delay using this technique is the amount of arm adduction that is possible.
Figure 1. (a) upper sequence: target simulation of forward somersault with 1 $\frac{1}{2}$ twists, (b) middle sequence: perturbed simulation without correction, (c) lower sequence: perturbation with twist and somersault control.