SIMULATION OF THE AIRBORNE PHASE OF THE GRAND JETÉ IN BALLET

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INTRODUCTION

Jumping is a fundamental human movement that requires complex coordination between both the upper and lower body segments. The grand jeté is considered one of the most memorable jumps in ballet. The body of a dancer during the grand jeté can portray elegant grace, appearing to glide across the floor and travel linearly through the air (Laws, 2002). This study was conducted to examine the dancer's movements in the air. The main purpose of studying the aerial phase was to determine if the subjects could create the illusion of non-parabolic movement while airborne.

METHOD

Two experienced dancers who were also instructors volunteered for the study. Each subject was outfitted with 12 reflective markers (Figure 1) in specified locations (ear, greater tubercle, medial epicondyle left, medial epicondyle right, ulnar styloid process right, ulnar styloid process right, greater trochanter, apex of head of fibula, lateral malleolus, heel, head of first metatarsal, tip of first phalange). The subjects were videotaped (60 Hz) while performing five grand jetés onto a force platform (Kistler) using a running start. BioWare software collected the force platform data at 240 hertz. APAS and Biomech software was used to digitize and compute segmental and joint kinematics and the segment and total body angular momenta throughout the jumps (http://www.health.uottawa.ca/ software).

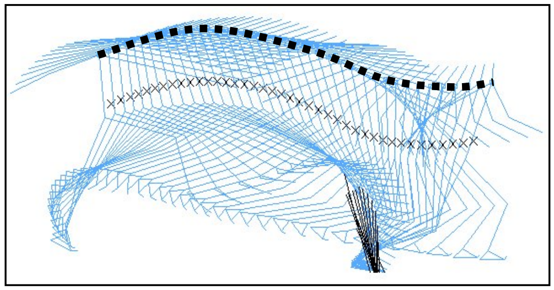

Figure 1. Stick-figures of a typical grand jeté (Xs identify path of centre of gravity, asterisks mark path of the shoulder, black lines show ground reaction forces at landing).

Custom software (Lemaire & Robertson, 1990) was used to derive a simulated version of the jump that closely mimicked the original jump. The simulated model was a simplified planar model consisting of ten segments (head, trunk, 2 thighs, 2 legs, 2 arms and 2 forearms). The simulation was given the same initial orientation as the actual data, the same initial takeoff velocity vector and the same joint motions as the actual data. The simulated model's total angular momentum was manipulated until the simulation landed at the same time as the actual jump. The only unknown was the actual orientation of the trunk. This was iteratively obtained one frame at a time from the relative motions of the joints and the total body angular momentum throughout the airborne phase of the jump until landing occurred.

Lastly, the simulated motions of the two dancers were artificially modified by adding 0.1 radians per time interval to the two hips until they reached an angle of 180 degrees ("the splits") with respect to each other.

Then the same was done to each shoulder until the path of the shoulder marker obtained a linear horizontal trajectory. At this point the simulated motion was deemed successful at producing the illusion of a linear trajectory during the flight.

RESULTS

Figure 2 shows the simulated motion of one of the dancers before any modifications were made to achieve a linear trajectory. Notice that the shoulder marker followed an approximately parabolic path similar to the path of centre of gravity.

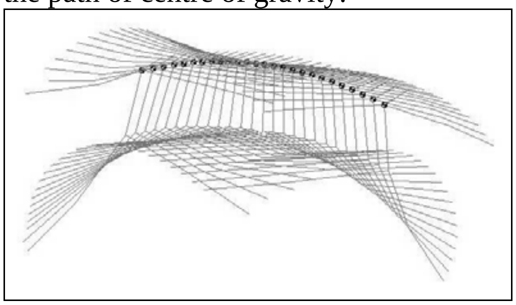

Figure 2. Stick figures of the simulated grand jeté. Path of shoulder marker is parabolic.

Figure 3 shows the same data modified to achieve linear motion of the shoulder during the first third of the airborne phase of the jump. Notice that the lower extremities are in the "splits" position and that the arms are no longer parallel to the ground during the flight.

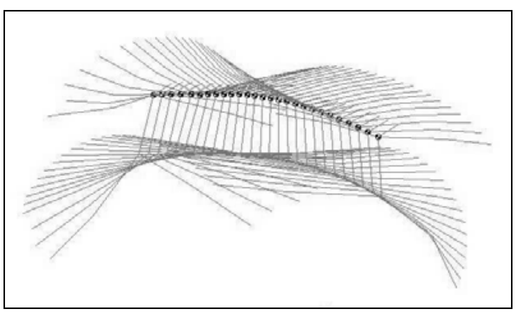

Figure 3. Stick figures of the modified simulated grand jeté. Path of shoulder marker is linear during first third of flight.

DISCUSSION

The dancers did not produce the illusion of a linear trajectory of the shoulders and trunk during the grand jeté. Essentially the shoulders followed the same trajectories as the paths of the centre of gravity. To create the linear motion illusion, modifying the hip motions alone to obtain a full split positions (180 deg) was inadequate. In both dancers, to achieve the illusion it was necessary to raise both arms so that they passed the horizontal. These changes created linear trajectories of the shoulders for the first 0.6 seconds or approximately 1/3 of the flight phases. To achieve longer durations the arms would have had to swing almost to the vertical, which was deemed ascetically unappealing.

REFERENCES

Laws, K. *Physics and the Art of Dance.* New York: Oxford Press, 2002.

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