

GENERATING VERTICAL VELOCITY AND ANGULAR MOMENTUM DURING SKATING JUMPS

Deborah King

Biomechanics Lab, Montana State University, Bozeman, Montana
Email: dking@montana.edu

INTRODUCTION

As figure skaters continue to perform increasingly difficult jumps, the importance of understanding the mechanics of skating jumps increases as well. Two critical parameters to the completion of these jumps are vertical velocity and angular momentum.

Albert and Miller (1997) performed an analysis of vertical velocity and angular momentum for single and double Axels. Their results indicate that both radial and tangential motion of the skater are critical to the generation of vertical velocity throughout the take-off of single and double Axels. In generating angular momentum during the take-off, the movement of the free leg was most critical. The authors surmised that the movement of the free leg creates an eccentric horizontal ground reaction force with a moment consistent with the rotational direction of the jump. The purpose of this study was to expand upon the study of Albert and Miller (1997) and investigate the techniques used by athletes in generating vertical velocity and angular momentum in single, double, and triple Axels.

PROCEDURES

Seventeen elite skaters gave their written informed consent to participate in this study. Video footage of the take-offs of single, double, and triple Axels were taken with three video cameras placed around the ice rink. Each jump was manually digitized at a

sampling rate of 60 frames/second. The raw two-dimensional data were filtered then the Direct Linear Transform Theory was used to calculate the three-dimensional coordinates (PEAK5, Peak Performance, CO).

The primary variables of interest were vertical velocity (V_v), angular momentum about the vertical axis through the COM of the skater (H_z), and moment of inertia about the vertical axis through the COM of the skater (I_{zz}). Vertical velocity was sub-analyzed by determining the contribution from tangential motion (angular velocity of the COM about the ankle joint of the take-off foot) and radial motion (linear velocity of the radius between the ankle and COM). Two-way analyses of variance were calculated to determine whether the differences between the two main effects, jump type and gender, were significant for the selected variables. Tukey's pairwise comparison was performed when an F-value was statistically significant ($p < 0.1$).

RESULTS AND DISCUSSION

Tangential motion contributed between 9 and 12 percent of overall V_v gain (Table 1). There was no significant difference in V_v between jump types; though, the males did have significantly greater vertical velocities than the females. These results indicate that skaters do utilize forward and upward rotation during the approach as a means for

generating vertical velocity during the approach.

Neither H_z nor I_{zz} at take-off were significantly different between jump type. However, I_{zz} values at take-off were significantly smaller for females as compared to males. The average H_z and I_{zz} values are presented in Table 1. Figure 1 illustrates the typical pattern for gaining H_z throughout the approach of the jump. During the period in which the largest gains in H_z are observed, the skater is driving forward with the free leg and arms.

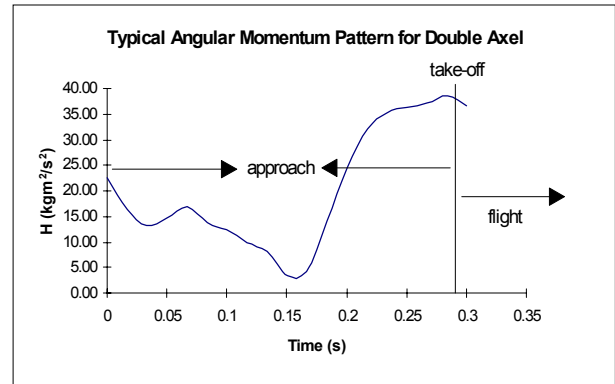


Figure 1. Characteristic angular momentum curve for a skater during the approach of a double Axel.

Table 1. Angular momentum, moment of inertia, and vertical velocity values at take-off (with percent contribution from tangential motion). Values are means \pm SD.

	Singles		Doubles		Triples
	Females	Males	Females	Males	Males
V_v at take-off (m/s)	1.84 \pm 0.62	2.76 \pm 0.95	2.62 \pm 0.49	3.32 \pm 0.95	3.23 \pm 0.95
V_v tangential (% gain)	9 \pm 0.1	10 \pm 0.1	8 \pm 0.2	11 \pm 0.1	11 \pm 0.1
H_z at take-off (kgm^2/s^2)	18.0 \pm 7.8	17.7 \pm 6.3	13.2 \pm 7.0	21.0 \pm 6.5	21.1 \pm 8.9
I_{zz} at take-off (kgm^2)	2.63 \pm 0.9	3.31 \pm 0.6	2.29 \pm 0.7	3.46 \pm 0.8	3.5 \pm 0.4

These results are similar to those found by Albert and Miller (1997), who indicated that the movement of the free leg is critical to generating necessary H_z for the jump. Interestingly, the results from this study do not support the findings of Albert and Miller (1997) that I_{zz} decreases as jump type increases. A possible explanation is the level of skaters involved in each study, with the more experienced skaters in this study maintaining larger I_{zz} at take-off during their multi-revolution jumps. These two different techniques of manipulating I_{zz} at take-off and in flight have been discussed in detail by Aleshinsky (1986, 1987).

CONCLUSIONS

The results of this study provide further insight into techniques used by skaters to

generate the necessary vertical velocity and angular momentum to complete multi-revolution jumps. The primary findings indicate 1: that skaters utilize both tangential and radial motion to generate vertical velocity for take-off, and 2) that angular momentum values are not significantly different between single, double, and triple Axels.

REFERENCES

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