AGGRESSIVE INLINE SKATING: BIOMECHANICS OF LANDING AND BALANCING ON A GRIND RAIL

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INTRODUCTION

Aggressive inline skating, or trick skating, is a relatively new sport. Previous studies of aggressive skating have only examined epidemiological data of skate park injuries [1]. This novel biomechanical study of aggressive skating focused on the "stall", a basic balance training activity where the skater repeatedly jumps on an elevated surface (concrete bench edge, metal hand rail, or specially designed skate park "grind" rail). We were interested in understanding how skaters are able to successfully land and maintain balance over such a narrow base of support. Specifically, we examined sagittal-plane biomechanics of the lower extremities to see how impact force, skater experience, and joint behaviors (maximum flexion, net eccentric/concentric contraction and work) were related. We hypothesized that, to smoothly decelerate the body and minimize impact forces, this exercise emphasizes development of muscle control though eccentric contractions of the lower extremity joints. We also hypothesized that more experienced skaters would minimize impact force.

METHODS

Ten male skaters (21.8 ± 8.5 years, 179.0 ± 6.5 cm, 78.3 ± 8.0 kg) performed 10 stalls each. Each subject was instructed to jump onto a grind rail, maintain balance (1-3 s), and jump down. No constraints were placed on landing and balancing techniques, allowing the skater to maintain his unique style of performance. A simply-supported, steel grind rail (5 cm diameter pipe, 178 cm length x 26 cm height) was constructed to sustain no moments at the supporting ends. Load cell data (MTS Systems, Minneapolis, MN; 1000Hz sampling rate) from each end were used to compute vertical impact force (% body weight). Joint flexion at the ankles, knees and hips were determined from kinematic data collected with a 6-camera motion capture system (VICON 460, Oxford, UK; 100 Hz sampling rate). The landing phase was defined as the period between initial contact with the rail (S) and point of greatest flexion of the joint (F_i, where i = L or R) (e.g., Figure 1 for knee). For each joint, maximum flexion during the landing phase was defined as the magnitude difference in flexion between S and F_i; similarly, eccentric work during the landing phase was defined as the area under the negative power curve between S and F_i. Finally, the parameters, maximum joint flexion and eccentric work, were computed from the average of the right and left values. To test our hypotheses, correlation analyses assessed whether peak impact force associated with skater experience or maximum joint flexion.

RESULTS AND DISCUSSION

Peak impact force was found to significantly decrease as skater experience increased (r = -0.842, p = 0.002). Less-experienced skaters were not capable of reducing impact force while successfully landing and maintaining balance. Peak impact force was also found to significantly decrease with increasing knee flexion for six of ten subjects ($p \leq 0.041$). Three of four subjects with no correlation had the least amount of experience. The remaining experienced skater displayed a significant correlation between decreasing peak impact force and increasing ankle flexion. No significant correlation was found between hip flexion and peak impact force for any subject. During the landing phase, skaters utilized eccentric contraction of all lower extremity joints in order to decelerate the body and absorb energy. Of the three lower extremity joints, the knees performed on average the most eccentric work during the landing phase (50.6 ± 12.0% (SD)), followed by the hips (30.1 ± 13.5%) and ankles (20.5 ± 12.9%).

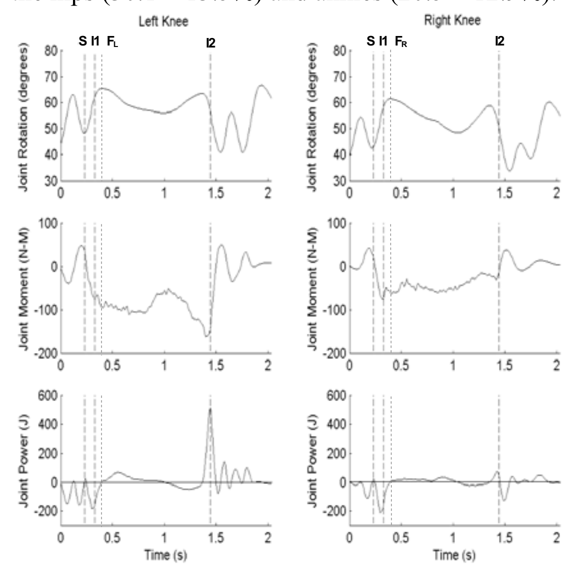

Figure 1: Typical profiles for left and right knee. Vertical lines identify instants of initial rail contact (S), first peak impact force -- used in correlation analyses (I1), greatest joint flexion (F), and second peak impact force (I2). Flexion angle, flexor moments, and concentric contraction are defined as positive.

CONCLUSIONS

Increasing knee flexion (or net eccentric contraction of the thigh muscles) immediately after contact with the rail and throughout the landing phase was extremely effective in reducing peak impact forces. Subjects who did possess a joint flexion correlation with peak impact force had significantly more experience than those who did not. Less-experienced skaters may be more concerned about maintaining balance, rather than refining their technique to (subconsciously) minimize impact force.

REFERENCES

1. Everett, W.W. J Emer Med; 23(3): 269-274, 2002.