Kinetic Analysis of Jumps with Different Number of Rotations in Youth Figure Skaters

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Summary

Biomechanical research on figure skating have mostly focused on kinematic analysis of figure skating jumps, and very limited number of studies assessed plantar pressure patterns and impact on the lower limbs in figure skating. This study provides new insights into kinetics of figure skating jumps, to optimize youth skater's performance and to reduce potential injuries.

Introduction

Figure skating is a popular Winter Olympic sport. Overuse injuries are common among junior elite skaters with poor movement technique and high impact from repetitive jumps [1]. Despite its difficulty and high risk of injury, very few studies explored the force generation, plantar pressure pattern and lower limbs impact [2]. This study aimed to explore the kinetics of jumps with different number of rotations in youth skaters.

Methods

Three youth figure skaters (17.33±1.70 y; 167.67.±8.73.cm; 55.73.±4.09kg) performed Waltz Jump (0.5 rotations) and Axel Jump (1.5 rotations). After a warm-up, skaters performed each jump three times in total. Two high speed cameras (Sony FDR-AX700, 100Hz) were used to record skaters' kinematics. W-INSHOE system from Medicapteur (8 sensors per foot, 100 Hz) was used for plantar pressure measurements at jump's take-off and landing.

In this study, each foot was divided into 8 regions based on the location of the sensors. The foot regions were divided into big toe (BT); lateral toe (T3-5), medial forefoot (MF), central forefoot (CF), lateral forefoot (LF), lateral midfoot (LM), medial heel (MH), and lateral heel (LH). Ground reaction force (GRF) data obtained using plantar pressure insole were normalized using body weight (BW). Due to limited data, only descriptive analysis was conducted.

Results and Discussion

The takeoff leg's force- time curve shows a bimodal shape. The first peak occurs as the lower limb bends and the foot presses downward. The second peak appears as big toe area provided the final push for upward and forward jumping motion. The landing leg's GRF spikes upon impact at the landing, then slightly decreases as the hip, knee, and ankle bend to stabilize the body and to absorb force (Figure 1).

When completing Waltz jump, the peak GRF of LH of the takeoff foot was the highest (1.97BW), followed by BT (0.70BW). The landing leg also showed high GRF at LH (1.22BW) and MF (1.18BW). The overall GRF peak of the takeoff foot was 3.22±1.49BW, which is 0.09BW lower than the landing foot of 3.31±1.02BW. When completing Axel jump, the peak GRF of LH of the takeoff leg was again the highest (1.95BW), followed by BT (0.91BW). At the landing, MH of the landing leg was the highest (1.15BW), followed by MF (0.86BW). The overall GRF of the takeoff foot was 3.63±0.81BW, which is 0.31BW higher than the landing foot of 3.32±1.19BW. Takeoff foot plantar pressure slope (force-time slope) of Waltz jump and Axel jump were 2.59±0.82BW/s and 3.17±0.62BW/s, respectively, at takeoff. Landing foot plantar pressure slope of Waltz jump and Axel jump were 13.07±3.54BW/s and 13.60±4.03BW/s, respectively, at the landing.

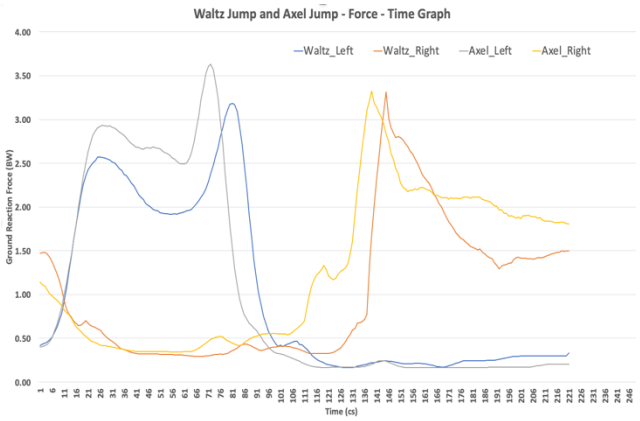

Figure 1: Force – Time Curve of Waltz jump and Axel jump

Results emphasized the use of BT at takeoff to successfully complete jumps with more rotations and apply slightly different landing mechanisms to counter-rotate and stop high speed rotation. Skaters experienced average 3 times the body weight at both takeoff and landing of the jumps. Axel jump showed bigger peak impact force, shorter preparation time before takeoff, and higher plantar pressure slope than the Waltz jump. Thus, as the difficulty of the jump increases, the GRF during jumps and plantar pressure slope also increase, potentially leading to foot and leg muscle fatigue and an increased risk of lower limb injuries when performing difficult jumps. More subjects should be included, and different jump kinetics should also be investigated in the future.

Conclusions

As the difficulty of jump increases, impact on legs also increased, indicating a higher risk of foot injury with difficult jumps. It is recommended that skaters first train the lower extremity muscles for better explosiveness, speed, and strength, and make full use of the hip and knee flexion to dissipate the impact forces on the legs during jump practices.

References

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