OPTIMAL PATHWAY IN INNER LANE CURVING DURING MAXIMAL EFFORT SPRINT SPEED SKATING

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The purpose of this study was to investigate experimentally the optimal pathway in the inner lane curving during maximal effort sprint skating with reference to changes in skating speed and crossover cycle motion for three different types of pathway by using wide-range three-dimensional motion analysis. This study suggests that the optimal pathway to enter the first inner curve might be to pass through the center of a 4m-wide lane or across a slightly more outer position at the inflection point of the skating oval. Taking the recommended pathway, skaters would improve their crossover technique, especially for the left stroke, and their final lap time could be faster in spite of the disadvantage of the roundabout way.

KEYWORDS: three-dimensional motion analysis, clothoid curve, Olympians, radii of curvature, crossover technique

INTRODUCTION: It is known that skating speed during a 500m race accelerates quickly on the home-straight from start position, continues to increase up to the back-straight (300m mark from start), and then slightly decreases after the second curve (300-500m). Yuki (2006) found that this deceleration at the second curve was larger in the inner lane than in the outer. It seems that acceleration even at the first curve might be more difficult in the inner lane than the outer. Therefore how to skate in the inner lane should be important in order to achieve an excellent performance in 500m speed skating competition. Racing lanes are regulated to widths ranging from 4m to 5m with radii of curvature for the inner and outer lanes ranging from 25m to 26m and 29m to 30m respectively. Gliding pathway over the curve area might vary especially for the inner lane (i.e. from inner at entrance to outer at exit, or from outer to close to the line at top of curve to outer again). However there is little information about the optimal pathway to achieve high speed in sprint racing. The purpose of this study was to investigate experimentally the optimal pathway in the inner lane curving during maximal effort sprint skating with reference to changes in skating speed and crossover cycle motion for three different types of pathway.

METHODS: Nine well-trained skaters, including two Olympians and two other international competitors, participated in this experiment in which they were asked to achieve their own maximal speed at the end of the inner curve along three different pathways, beginning to accelerate from start area of 500m in the straight way. Three trials were performed with sufficient rest intervals and were defined as follows: Trial 1: Normal inner curve (radius 26m); Trials 2 and 3: Clothoid pathway from 1m (radius 27m) and 2m (radius 28m) outer positions respectively so as to transit gradually to normal inner curve (radius 26m). Three-dimensional coordinates of each skater's segment end-points (23points) and tip of each skate blade (4points) were collected with three digital video cameras (60fps). Target range was set up from straight way 20m before the inflection point of the skating oval, and followed the inner lane 47.2m along the curve (total length 67.2m), to analyze two straight strokes and three successive cycles of crossover step motion on curvilinear movement. Twenty reference points and 765 control points were used with a panning DLT method. Coordinates obtained were smoothed by Butter-worth digital filter (cf: 3.0 to 5.4Hz). Center of mass (CM; Ae et al.,1992), velocity vector of CM, and joint angle and angular velocity of the lower limb for each subject were calculated. Statistical significant levels are 5%.

RESULTS AND DISCUSSION: Required skating time between inflection point to 90deg. in polar coordinates for Trial 3 (3.33±0.23s) was larger than that of Trials 1 (3.24±0.20s) and 2

(3.24±0.19s). Fig.1 shows the horizontal CM pathway (solid line) and gliding skate (dotted line) average of all subjects for each trial. L1 and R1 indicate the last left and right straight strokes, then crossover step cycle begins from L2, R2, continuing to L5. Mean CM velocities are written in parentheses and mean radii of CM curvature movement for each stroke are described with R. There were no significant differences in CM velocities of L1 and R1 among trials. Mean CM velocities of L2 and L3 strokes for Trial 3 were larger than those of Trial 1. Little difference in mean radii of CM curvature movement was observed. Changes in CM velocity direction related to the previous stroke at R3 and L4 strokes for Trial 1 were smaller than those of Trials 2 and 3. The hip and knee angular velocities during L2 stroke for Trial 2 and 3 were larger those of Trial 1. In subsequent R2, the knee and ankle joint angles at the onset of stroke for Trials 2 and 3 were observed in more flexed positions than those of Trial 1. Comparing Trials 2 and 3 with Trial 1, it might be thought that since a skater takes some space on their left side during the first crossover (R2, L2) to drive CM inward (left side for skater), CM velocities could be accelerated effectively with more explosive push-off of L2 stroke. There is a trade-off relationship: skating speed could be much increased with large curvature pathway, but it requires longer displacement. By using the obtained mean required time over the first quadrant of curve and mean CM velocity at the end of this area, the lap time (400m) after this curve that can be estimated is 29.03s for Trial 2, faster than 29.27s for Trial 1 and 29.24s of Trial 3.

CONCLUSION: This study suggests that the optimal pathway to enter the first inner curve might be to pass through the center of a 4m-wide lane or across a slightly more outer position at the inflection point of the skating oval. Taking the recommended pathway, skaters would improve their crossover technique, especially for the left stroke, and their final lap time could be faster in spite of the disadvantage of the roundabout way.

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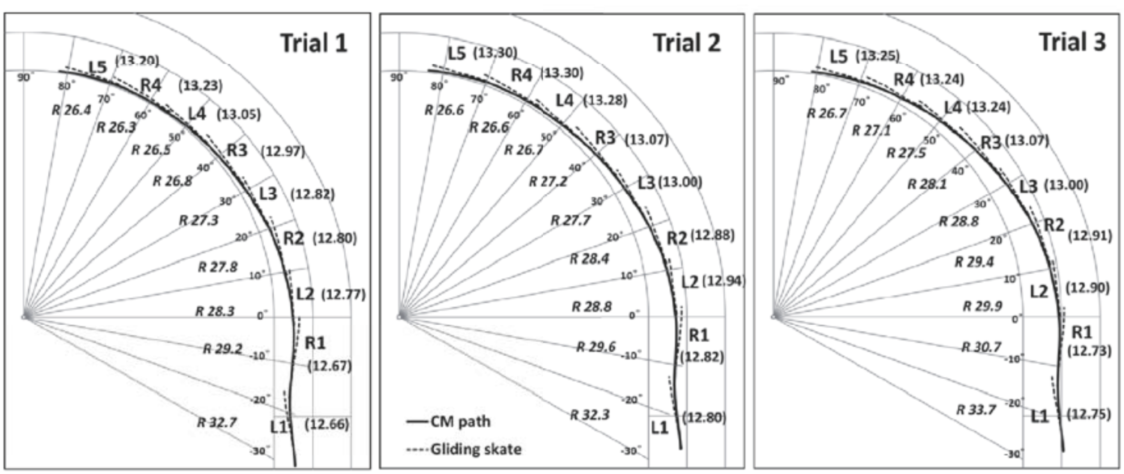

FIGURE 1: CM and gliding skate pathways in the horizontal plane averaged for all subjects in each trial.