COURSE ANALYSIS OF APPROACH TECHNIQUES OF 3/4-CUT IN WATER SKI JUMP

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The purposes of this study were to examine differences in how the Japanese elite jumper and the university level jumper executed the 3/4-cut jump technique and use of findings in improving instruction of water ski jumping. The distance obtained from a water ski jump depends heavily on the skier's "approach speed" to the ramp. In maximizing speed to the ramp, jumpers can choose different techniques. In this study the speed and the angular displacement of jumpers using the 3/4-cut technique were calculated by digitizing ski motion. The results are summarized as follows; 1) deceleration in speed during the "Turn phase" was related to the angular displacement of the Japanese elite jumper and the university level jumper, and 2) the timing of the smallest angle at the "Final-cut phase" was different between the good jumps and the bad jumps.

KEY WORDS: course analysis, water ski jump, skiing speed

INTRODUCTION: Jump distance is computed from the point the water skier exits the ramp to the landing point on the water. Distance seems to depend heavily on the skier's speed in approaching the ramp. In reaching their fastest speed off the ramp, skiers generally use one of three water ski techniques: Single-cut, 3/4-cut, Double-cut. Considered an intermediate technique, the 3/4-cut is used by many skiers with the various competition levels from beginner jumpers to elite jumpers. The 3/4-cut is defined as follows: In the direction of a boat, a jumper first skis to the right, then changing direction skis to the left, crossing the boat wake, on his or her approach to the ramp. There seems to be the differences between how the elites and the beginners execute the 3/4-cut technique. For example, Grove (1979) investigated about biomechanics of take-off techniques. However, research focusing on approach techniques has not been reported. Implementing an "approach technique" study is difficult given the large area to be analyzed (approximately 50m × 200m) and issues related to calibration of an unstable surface (water). In considering these difficulties, this study analyzed approach techniques by utilizing course analysis methods that have been previously used in investigations of cross-country skiing (Watanabe, Saito, Wada, Hayashi, Miyasaka, Yano & Onodera, 2014) and sailing (Ishii, Yasuda, Funo, Eiraku, Nakamura & Matsushita, 2013).
The purpose of this study was to examine the differences in how a Japanese elite jumper and a university-level jumper execute the 3/4-cut jump technique and how these findings can be used in improving instruction in water ski jumping.

METHODS: Two subjects, the Japan National 2015 men's Jump winner (Subject A, height: 1.74m, body mass: 78kg, personal best distance: 51.1m) and a university student (Subject B, height: 1.69m, body mass: 60kg, personal best distance: 32.0m), performed 3/4-cut techniques in this experiment. A boat driver had a top grade license to drive boats in Japan tournaments. The driver maintained a speed of 57km/h using a towing boat (MasterCraft 2013 Pro-Star197) equipped with cruise control (Zero-Off system). Video data were recorded using four digital cameras (EXILIM pro-100, CASIO) operating at 30fps. One camera was set up in order to capture the entire range of approximately 50m × 200m. From another side, three cameras captured each 1/3 area. Real dimensional coordinate values were calculated from captured data using two dimensional DLT Method. The two dimensional kinematics data of the subjects' skiing were represented by the trajectory of center of their feet. The trajectories were smoothed by using Butterworth low-pass digital filter. The range of optimum cut-off frequency was between 0.6Hz and 0.9Hz. This study calculated skiing speed and angular displacement of each frame using the smoothing trajectories. Velocity was calculated by differentiating the trajectories, then speed was calculated as norm of the velocity. Angular displacement was defined as the angle between skiing displacement vector and the axis perpendicular to the boat direction. This study analysed four attempts (two attempts by Subject A were indicated as Trial_A_1 and Trial_A_2, two attempts by Subject B were indicated as Trial_B_1 and Trial_B_2). Each attempt was divided into 4 phases. The first phase was from first frame to the timing of the first peak of speed (rightward skiing); Pull-out phase (0% - 25% normalized time). The second phase was from the end of the first phase to the timing of the maximum position toward x-axis (maximum rightward position); Waiting phase (25% - 50% normalized time). The third phase was from the end of second phase to the timing of minimum speed (leftward skiing); Turn phase (50% - 60% normalized time). The fourth phase was from the end of the third phase to the timing when the skiers go into the ramp; Final-cut phase (60% - 100% normalized time).

RESULT: Figure1 shows the changes in the speed of skiing for Subject A and Subject B. Trial_A_1 was faster than Trial_B_1 and Trial_B_2 at the 25% time, the slowest in the others at the 50% time, slower than Trial_B_1 and Trial_B_2 at the 60% time, faster than Trial_B_1 and Trial_B_2 at the 100% time. Trial_A_2 was the fastest in the others at the 25% time, the fastest in the others at the 50% time, the slowest in the others at the 60% time, the fastest in the others at the 100% time. Trial_B_1 was slower than Trial_A_1 and Trial_A_2 at the 25% time, faster than Trial_A_1 and Trial_A_2 at the 60% time, the slowest in the others at the 100% time. Trial_B_2 was the slowest in the others at the 25% time, the fastest in the at the 60% time, slower than Trial_A_1 and Trial_A_2 at the 100% time. Trial_A_2 was the best jump in this study, and Trial_B_2 was better jump than Trial_B_1, because it was recorded faster speed at the 100% time. During the Waiting phase, the decelerations of Trial_A_2 and Trial_B_2 were tended to be smaller than each other attempts. At the Turn phase, Trial_A_2 was recorded the fastest speed in the beginning frame of this phase and the largest deceleration during this phase. At the Final-cut phase, the timing of peak speed in the attempts of Subject A was later than Subject B.
Figure2 shows the changes in the angular displacement of skiing for Subject A and Subject B. Trial_A_1 was larger than Trial_A_2 and Trial_B_2 at the 60% time, smaller than Trial_B_1 and Trial_B_2 at the 100% time. Trial_A_2 was the smallest in the others at the 60% time, the smaller than Trial_B_1 and Trial_B_2 at the 100% time. Trial_B_1 was larger than Trial_A_2 and Trial_B_2 at the 60% time, larger than Trial_A_1 and Trial_A_2 at the 100% time. Trial_B_2 was smaller than Trial_A_1 and Trial_B_1 at the 60% time, larger than Trial_A_1 and Trial_A_2 at the 100% time. At

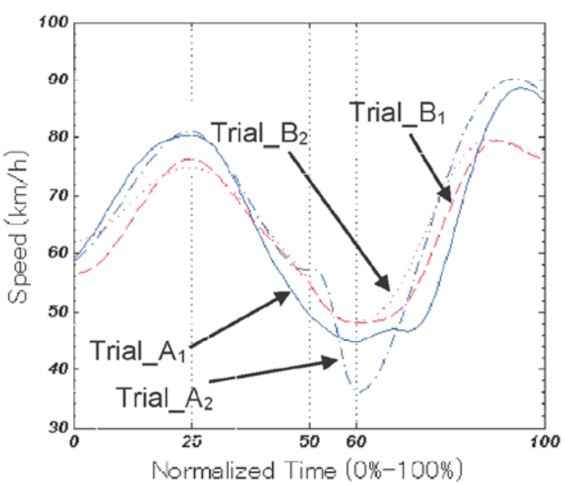

Figure 1 : Changes in the speed of skiing for Subject A and Subject B.

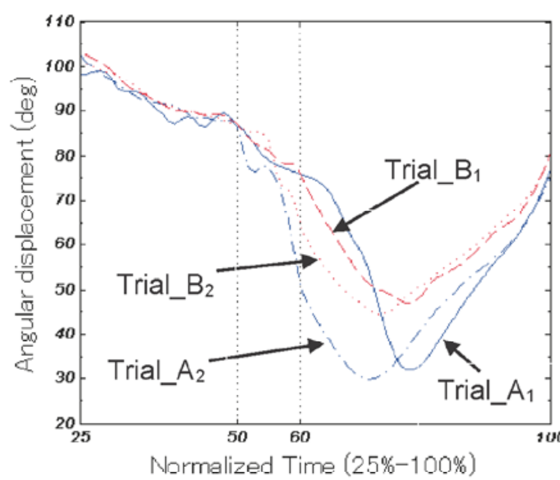

Figure 2 : Changes in the angular displacement of skiing for Subject A and Subject B.

the Turn phase, Trial_A_2 and Trial_B_2 were tended to be larger angular displacements than each other attempts during this phase. At the Final-cut phase, the timings of the smallest angle were recorded that Trial_A_2 and Trial_B_2 were earlier each other attempts.

DISCUSSION: The purpose of this study was to examine the differences in how a Japanese elite jumper and a university-level jumper executed the 3/4-cut jump technique in order to identify useful suggestions in instructing water ski jumpers. The main finding between Subject A (an elite jumper) and Subject B (a university-level jumper) was that deceleration in speed during the Turn phase was related to changes in the angular displacement during the Turn phase. This shows that skier needs enough decelerations to make sharper angles to the boat direction. Thus, it seems that jumpers need to focus on the Turn phase for long jump distance. The main finding between the good jumps (Trial_A_2 and Trial_B_2) and the bad jumps (Trial_A_1 and Trial_B_1) was the difference in the timing of the smallest angle at the Final-cut phase. This indicates that jumpers need to reach the smallest angle as possible as early phase. Thus, it seems that jumpers need to focus on the Final-cut phase techniques for good jumps.

CONCLUSION: This study showed the new attitudes in water skiing jump that were derived from the analysis between a Japanese elite jumper and a university-level jumper, and the analysis between good jumps and bad jumps. The results are summarized as follows;
(1) During the Turn phase, the difference in angular displacement was caused by the deceleration in speed.
(2) The timings of the smallest angle at the “Final-cut phase” were different between the good jumps and the bad jumps.

REFERENCES:

Grove, K.M. (1979). Biomechanics of take-off technique in water ski jumping. *Dissertation: Thesis (M.S.)--Springfield College, 1979.*

Watanabe, Y., Saito, T., Wada, T., Hayashi, S., Miyasaka, Y., Yano, H. & Onodera, S. (2014). Effects of gradient and skiing velocity on heart rate while cross-country skiing. *Kawasaki Medical Welfare Journal Vol.24, No.2, 2015 261 - 265.*

Yasuda, S., Ishii, Y., Funo, T., Eiraku, H., Nakamura, N. & Matsushita, M. (2013). Effectiveness of zigzag sailing for laser radial class boats in sailing: Evaluation by Japanese first-class single-handed sailors. *Japan Society of Sports Performance Research, 5, 189-201.*