Strategies for Improving Japanese Elite Male Cross-country Skiers' Double Poling Skills to an Internationally Competitive Level

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1 OBJECTIVES

The strategies of raising the cycle rate of the pole ground contact phase and of overcoming the trade-off between cycle rate and cycle length have been noted as important for improving a cross-country skier's double poling skills (Yoshimoto and Suzuki, 2013).

The present study investigates the problem of improving the double poling skills of Japanese elite male cross-country skiers to an internationally competitive level by analyzing the trade-off or absence thereof and the timing skills seen in their gliding motion.

2 METHODS

2.1 Experimental Participants

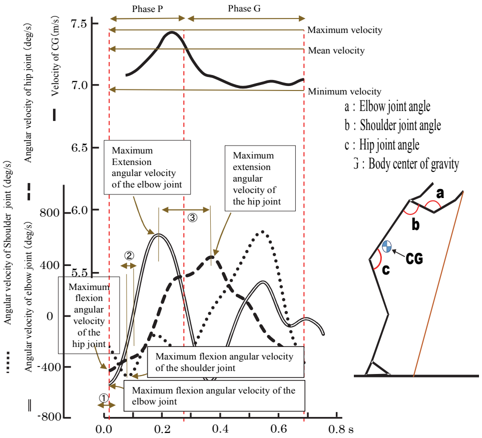
Fourteen elite male Japanese skiers participated in this experiment. They were classified into a high-rank group of six skiers whose gliding velocity in a set measurement zone was faster than the mean of all of the skiers, and a low-rank group of eight skiers whose gliding velocity was slower than the mean. Male skier A with the fastest gliding velocity was extracted, and the high-rank group, low-rank group, and male A were compared with each other.

2.2 Experimental Task

This was full-power gliding in double poling on a straight, 8-m ascending (5% incline) course. Two high-speed cameras (300 f/s) were set up in front of and beside the subjects, and recorded their double poling gliding motions.

2.3 Measurement Items

Motion analysis software (Frame-DIAS IV, made by DKH) was used to find three-dimensional coordinate values of different parts of the body by direct linear transformation (DLT) from the resulting video. Part of one cycle of their gliding motion, from the ground contact of the poles to take-off from the ground, was understood to be the poling phase (Phase P), and the part from take-off from the ground to the next ground contact was understood to be the gliding phase (Phase G) (see fig. 1 for measurement items and definitions of angles).



①: Time points for maximum flexion angular velocity of the elbow joint to time point maximum flexion angular velocity of hip joint
②: Time points for extension start point of the elbow joint to time point maximum flexion angular velocity of shoulder joint
③: Time points for maximum extension angular velocity of the elbow joint to time points to maximum extension angular velocity of hip joint

Figure 1: Different measurement items, and definitions of angles.

2.4 Analytical Methods

We ran a correlation analysis on the relationships between cycle rate and cycle length in the Phase P and Phase G of the high-rank group and the low-rank group. Means of each of the measurement items for the two groups were tested by unpaired t-test. The significance level was set to less than 10%.

Gliding in the Phase P of all skiers was the subject of a hierarchical cluster analysis by the nearest-neighbour method, with speed, cycle rate, and cycle length as variables.

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3 RESULTS

The mean gliding speed was 6.69 m/s for the high-rank group and 6.20 m/s for the low-rank group. The difference between the highest speed of gliding seen in the Phase P and the lowest speed of gliding seen in the Phase G did not show a significant difference between the high-rank group and the low-rank group. Of the experimental participants, male A had the highest gliding speed (one stroke: 7.12 m/s; Phase P: 7.29 m/s; Phase G: 7.01 m/s).

3.1 Relationship between Cycle Length and Cycle Rate

Table 1: Correlation between cycle length and cycle rate in the high-rank group and low-rank group. (Pearson correlation coefficient).

		Cycle rate	
		Phase P	Phase G
Cycle length	High rank group	-.784	-.907*
	Low rank group	-.979**	-.989**
		**:p<.01	*:p<.05

A significant negative correlation was observed in the relationship between cycle length and cycle rate, excluding the Phase P of the high-rank group.

Of all the skiers, male A had the fastest Phase P cycle rate as well as the longest stride. Results from the cluster analysis allowed us to aggregate and classify the other skiers' relationships between cycle rate and cycle length in the Phase P. There seems to be a tendency for male A to overcome the trade-off of cycle length and cycle rate. Other high-rank-group skiers overcame the Phase G trade-off, and low-rank-group skiers overcame the Phase P and Phase G trade-offs, a fact which is regarded as a challenge for improving their double poling skills to an internationally competitive level.

3.2 Angular Velocity Changes of the Upper Limb Joints, and the Time Relationship between Elbow Joint Extension and Shoulder Joint Flexion

Maximum flexion angular velocity of the shoulder joint relative to the elbow joint extension start point was high in the high-rank group, but low in the low-rank group, and the difference between the two groups showed a significant (p=.069). Both time points coincided for male A (fig. 2 ①).

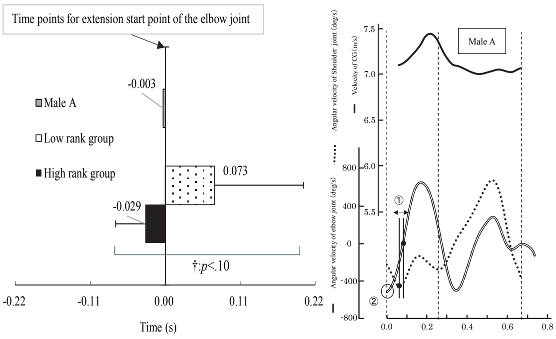

Figure 2: In phase P time relationship of elbow joint and shoulder joint motion and male A's angular velocity changes.

In the time from the Nagano Olympics (1998) to the Turin Olympics (2006), skiers at an internationally competitive level have had coinciding time points for maximum flexion angular velocity of the shoulder joint and elbow joint (Suzuki et al., 2002). However, currently the time point for the maximum flexion angular velocity of the elbow joint has moved forward relative to the maximum flexion angular velocity of the shoulder joint, appearing at about the same time as ground contact of the poles, as is the case with male A (fig. 2 ②). This means that the timing skill where by the elbow joint flexes at the greatest speed is now earlier than before.

3.3 Each Joint Flexion Angular Velocity Changes, and Time Relationship between Elbow Joint Flexion and Hip Joint Flexion

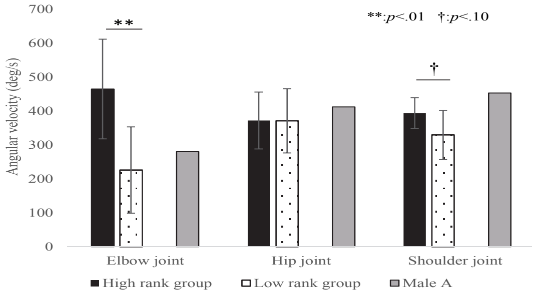

Figure 3: In phase P elbow/hip/shoulder joint maximum flexion angular velocity.

The maximum flexion angular velocity of the elbow was significantly higher in the high-rank group than the low-rank group (p=.007). Male A's angular velocity was substantially the same as the mean of the low-rank group. The high-rank group had a slightly higher maximum flexion angular velocity of the shoulder than the low-rank group, and a significant was noted (*p*=.080). Male A was higher than the mean of the high-rank group.

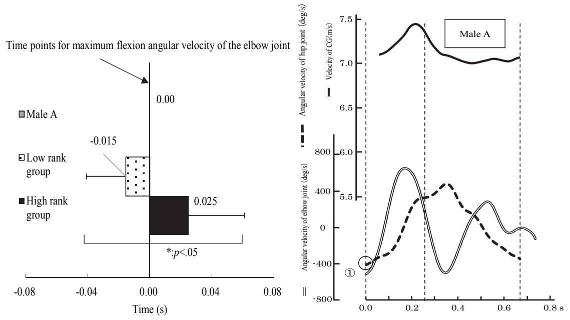

Figure 4: In phase P time relationship between elbow joint and hip joint motion and male A's angular velocity changes.

The time point of maximum flexion angular velocity of the hip, relative to the time point of maximum flexion angular velocity of the elbow, appeared late in the high-rank group but came earlier in the low-rank group, and a significant difference was observed between the means of the two groups (*p*=.029). Both time points coincided for male A, and were simultaneous with ground contact of the poles (fig. 4 ①).

3.4 Joint Extension Angular Velocity, and Time Relationship between Elbow Joint Extension and Hip Joint Extension

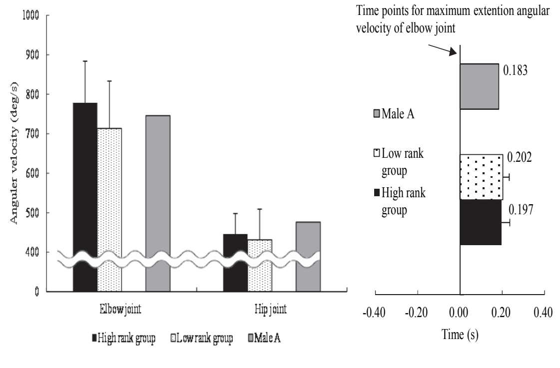

Figure 5: In phase G elbow/hip maximum extension angular velocity and time relationship between elbow joint and hip joint motion.

The maximum extension angular velocity of the elbow and hip joints and the time from maximum extension angular velocity of the elbow to maximum extension angular velocity of the hip showed no difference among the three classifications.

4 DISCUSSION

Male A, whose gliding speed in a one-stroke interval was the highest of the high-rank group, exhibited the following characteristics.

Male A's high gliding speed is believed to have been supported not only by the high muscle power (maximum angular velocity) exerted in elbow and hip flexion and extension, but also by the timing skills observed in elbow and hip flexion and in shoulder flexion and elbow extension in the Phase P.

Shoulder flexion is reflective of muscle power for pushing the poles to the rear, and it is the final phase of the kinetic chain for which each part of the body is responsible in double poling. The timing skills involved in this kinetic chain are believed to contribute to an increase in the muscle power for continuing to push the poles to the rear in double poling.

These results suggest that improving the Phase P timing skills to be similar to male A could enable skiers with particularly high muscle power to improve their Phase P cycle rate, overcome the trade-off between cycle length and cycle rate, and raise their gliding speed.

However, the present study failed to yield clues as to overcoming the trade-off between cycle length and cycle rate in the Phase G. In the future, investigation will need to include data on skiers of a high internationally competitive level, as indicators.

REFERENCES

Suzuki, T., et al. 2002. Feedback from a Video Motion Analysis of Cross-country Skier's Movement. *Bulletin of Education and Research Nihon University School of Dentistry at Matsudo 2002,* Japan.

Yoshimoto, D., and Suzuki, T., Strategy to Increase The Double-Poling Skill of Women Cross Country Skiers to an International Level. *6th International Congress on Science and Skiing 2013 Book of Abstracts*, 125. St. Christoph a.