AN ANALYSIS OF THE SPECIFICITY OF SKI STRIDING TO THE UPHILL DIAGONAL TECHNIQUE

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Given the absence of snow during the summer and early fall periods, Canadian cross country ski racers are forced to rely on a variety of dryland training methods to improve technique. You can't actually learn ski technique during the dryland season, but you can accustom specific muscles to perform the motions involved in skiing. The way to do this is through specific and technical workouts that replicate the skill (Endestad & Teaford, 1987). Empirical evidence suggests that specificity of training is critical to performance (Gervais & Wronko, 1988). However, the specificity of dryland training to the technique of elite Nordic ski racers has undergone only preliminary analysis.

Baumann (1982) examined the movement patterns and kinematics of skiers on roller skates, roller skis, and snow skis. The author found that the cycle time for roller skiing was longer than on snow and was attributed primarily to a longer glide phase. Dillman and Dufek (1983) filmed six US National team skiers performing roller and on-snow skiing each at four different skiing speeds. The authors found that there were no significant differences between the mean velocities for roller and on-snow conditions. However, differences in the stride patterns and leg actions were noted and were attributed to the movements of the kick phase. Gervais and Wronko (1988) investigated the marathon skate performed on roller skates, a newly designed 'Nordic Skate' roller ski, and snow skis. Although they found that both dryland &vices approximated the snow skiing pattern, there were some discrepancies in the actions of the propulsion phase. The specificity of ski walking (similar to a steep uphill diagonal stride without the glide) and/or ski striding (much more intensive and used principally on moderate uphills) to the uphill diagonal technique remains unclear. The purpose of this investigation was to compare the temporal and angular kinematics of ski striding, the predominant technique used to dryland train for uphill sections of Classical style races, to the uphill diagonal technique performed by Canada's elite skiers.

METHODOLOGY

Four female and 7 male Team '91' skiers were each videotaped at the Canmore Nordic Center while performing four trials of the ski striding technique on a 12 degree slope (12°), and four trials of the diagonal stride technique performed on a five degree uphill slope (5° S) on the Haig glacier. In addition, the male skiers were also videotaped while ski striding on a five degree slope (5°). A Panasonic SVHS video camera equipped with a high speed shutter was used to pan the performances of the skiers as they passed through the targeted zones. The camera was leveled at a height of one meter and was positioned so that the optical axis of the camera was at right angles to the track and at a distance of approximately 20 m. Nine markers were placed in a straight line behind the track at a distance of 1 m apart. Attached to each of the markers was a meter reference stick which was levelled in the horizontal plane and used to set up the conversion factors necessary for the subsequent analyses.

One complete cycle (two strides) for each skier was digitized using the PEAK Performance video analysis system at Lakehead University. The data extracted from the taped records included the x and y coordinates for an 18 segment model adapted to include poles. The data were smoothed using a fourth order Butterworth digital filter and processed to compute measures for the average stride lengths and rates of the skiers, segmental displacements and velocities, joint angular displacements, as well as the orientation and inclination of the poles. Stick figures were plotted to highlight similarities and differences between the actions, and sequence of actions, of the different techniques for each of the skiers.

RESULTS & DISCUSSION

Table 1 presents a summary of the average stride and temporal characteristics.

Table 1. Comparison of the Average Stride Phase **Times, Stride Lengths, Stride Rates and Velocities**

	Kick Time (Seconds)			Recovery Time (Seconds)			Total Time (Seconds)			Stride Length (Metres)			Stride Rate (Strides/Sec)			Stride Velocity (m/sec)		
	5°D	12°D	5°S	5°D	12°D	5°S	5°D	12°D	5°S	5°D	12°D	5°S	5°D	12°D	5°S	5°D	12°D	5°S
Female Skiers (N=4)	/	.19	.18	/	.35	.38	/	.42	.55	/	1.82	2.34	/	2.37	1.84	/	4.31	4.28
Male Skiers (N=7)	.18	.17	.17	.29	.28	.43	.44	.46	.60	2.44	1.78	3.13	2.28	2.18	1.64	5.85	3.92	5.19

For each of the skiers the stride lengths were greatest on the five degree slope on snow. For the male skiers the average stride lengths on the five degree dryland technique were slightly greater (a difference between the means of 0.66 m) than those recorded for the 12 degree dryland technique (see Figure 1). The average stride rates for the women's performances were consistently greater for the 12 degree dryland technique versus the on snow technique. For the men the stride rates were greatest on the five degree dryland, followed by the 12 degree dryland, and finally the 5 degree on-snow slopes. All but two of the male skiers achieved the greatest velocities on the five degree dryland slope whereas three of the female skiers were fastest on the 12 dryland slope. In general the fastest ski striders and the fastest diagonal striders also had the greatest stride lengths.

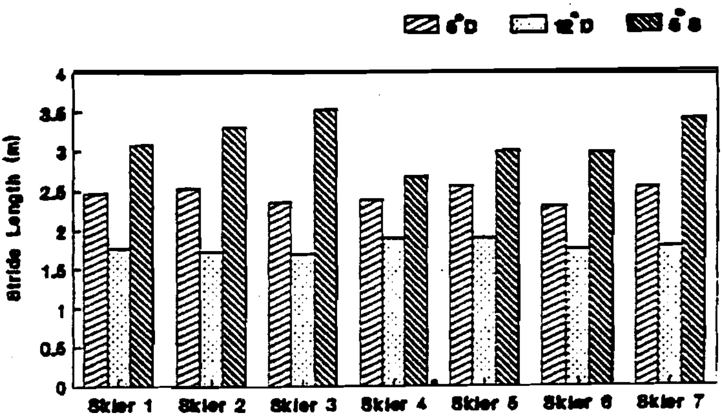

Figure 1. Stride Length Comparisons Across Stride Technique for Male Skiers

A temporal analysis of the time spent by each of the skiers during the kick and recovery phases of the different techniques was completed. The time taken to complete the kick phase for both dryland striding and the diagonal smde were remarkably similar with an average difference of only 0.01 s. Time spent completing the recovery phase, however, differed markedly between the on-snow and dryland techniques by an average of 0.18 s and was attributed to the on-snow glide phase.

The analysis of the plotted stick figures helped to provide insight into the specificity of the critical movements. The comparison between the females' dryland and on-snow performances indicated a *great* similarity between the degree of initial knee flexion, the position of the trunk throughout the skill, and the timing of the kick phase movements. The greatest differences observed were in the degree of arm extension at the end of the kick phase, and in the speed of the recovery phase movements. Comparison between the males' performances on the two dryland slopes (5°D, 12°D) and on the on-snow slope (5°S) indicated that the movements of the drive leg during the kick phase on the 12 dryland slope much more closely simulated the on-snow kick phase movements. Furthermore a number of the skiers demonstrated a more obvious vertical leaping action during the dryland flight phase on the five degree slope then on the 12 degree slope. The exaggerated vertical flight phase was associated with poor positioning of the lead foot placement, and of the trunk relative to the foot. The driving of the lead foot forward prior to foot placement is key to the optimization of the skier's stride length.

There was, however, a slightly greater range of motion of the arms during the pole push on the five degree slope versus the 12 degree dryland slope.

CONCLUSIONS

1. The dryland training ski striding technique involves movement patterns that very closely simulate the critical features of the uphill diagonal stride technique.

2. The stride length, rate, and velocity achieved during ski striding varies with the degree of uphill slope. The stride lengths recorded for the five degree dryland slope were closer to the values that were recorded on the five degree on-snow slope than were the 12 degree dryland values. Stride rates recorded during the ski striding performances on the 12 degree slope more closely matched the five degree on-snow performance than did values recorded for the five degree dryland slope.

3. Coaches who are interested in training their athletes to simulate the kicking actions of the diagonal stride on a moderate slope should select a much steeper dryland slope for training.

4. The action of the arms during the diagonal stride pole push may be best simulated on a dryland slope that approximates the degree of on-snow slope.

The analysis of the plots combined with the quantitative information resulted in an individual analysis and comparison of the techniques for each of the National Team skiers. Specific recommendations on how to improve the dryland techniques were made.

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