KINETIC ANALYSIS OF THE V2 SKATING TECHNIQUE ON ROLLER SKIS

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INTRODUCTION

In the early 1980s, a new method of cross-country skiing commonly known as "freestyle" or "skating" revolutionized the international racing circuit. As the popularity of skating grew in the following years, modifications to the early marathon skating technique gave birth to new techniques such as the V1, open-field, and V2 techniques. Recent scientific investigation has sought to examine the various biomechanical parameters involved in the skating style of skiing. However, despite the wide spread usage of the V2, open-field, and marathon skating techniques, the majority of this inquiry has pertained to the V1 skating technique. The lack of knowledge surrounding the various other modes of skating warrants investigation into these techniques. The purpose of this investigation was to determine the kinetic poling patterns of one of these techniques, the V2. Through the controlled observation of cycle duration, cycle force, peak force, and impulse patterns, it is hoped that the key factors involved in increasing velocity may be determined

METHODS AND PROCEDURES

Informed consent for this investigation was obtained from five elite male biathletes prior to testing. All subjects were members of the United States Biathlon developmental program at the Olympic Education Center in Marquette, Michigan. To minimize variations between pairs of roller skis and binding systems, one pair of Jenex V2 750™ roller skis equipped with NNN® skating bindings were used for all subjects during testing. A piezoelectric load cell was incorporated within the shaft of each ski pole to measure the magnitude of axial forces applied during skiing.

Three target velocities were selected during pilot testing to represent sprint (6.7m/s), race (5.8m/s), and slow (4.7m/s) skiing paces. Subjects were paced by a cycle equipped with a digital speedometer as they skied a flat 200 meter course. Actual data collection began 100 meters from the start to allow the skiers to stabilize their skiing velocities. Data was subsequently processed and averaged over two consecutive poling cycles to determine cycle duration, average cycle force, average cycle impulse, and peak cycle force.

Statistical Analysis: Mean values from the poling variables examined were compared with a one-way repeated measures analysis of variance design using a $p<0.05$ alpha level. For significantly different parameters, a student Newman-

Kuels multiple comparison test was used to determine pairwise significance ($p<0.05$) among treatments.

RESULTS AND DISCUSSION

Cvcle Duration Mean cycle duration for the three observed velocities were significantly different ($p<0.05$) between all treatment velocities (see Table 1). For the sprint, race, and slow velocities, cycle duration increased from 1.93 to 2.13 and 2.44 seconds, respectively. In agreement with previous findings by Street (1988) and Smith (1989), results from this current study indicate a general trend by skiers to decrease cycle duration as velocity increases (see Figure 1). Cycle rate differed 0.11 Hz between mean sprint and slow skiing paces.

Average Force Production Average cycle force was calculated by dividing total cycle impulse by cycle duration. Mean cycle force values for sprint, race, and slow paces were 95.6 N, 94.6 N, and 83.5 N, respectfully. Although no significant differences were observed in average cycle force, skier's tended to apply larger mean cycle forces at the sprint and race paces. The similar magnitudes of force production at the faster velocities (94.6 ± 23.3 N vs. 95.6 ± 25.6 N) would indicate another mechanism(s), other than average cycle force, is responsible for the noted increases in velocity. A graphic presentation of average cycle forces is displayed in Figure 2.

Total Cvcle Impulse Total cycle impulse was calculated by dividing total resultant cycle force by cycle duration. The resulting mean cycle impulses are represented in graphic format in Figure 3. Among the threegroup means observed, no significant differences were found ($p = 0.745$). Total cycle impulse tended to increase as roller skiing velocity decreased from the sprint (190.5 N·s), race (204.7 N·s), and slow (206.1 N·s) paces.

Peak Cvcle Force Although peak poling forces for the slow skiing velocity (300.7 N) were much less than those for the sprint (359.2 N) and race (360.0 N) paces, no significant differences were determined among treatment velocities ($p = 0.533$). Peak cycle forces for each of the three velocities are depicted in Figure 4. As seen with average cycle forces, skier's tended to increase peak cycle force between the slow and sprint and slow and race paces (see Table 1), while only a small variance in peak force (mean difference = 0.8 N) was observed between sprint and race pace values.

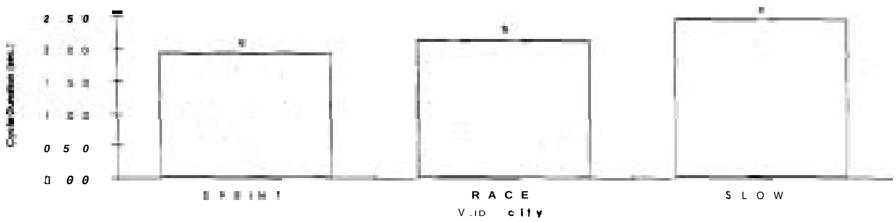

Figure 1. Average cycle duration for sprint, race, and slow velocities.

[a] significantly different from b and c ($p<0.05$)
[b] significantly different from a and c ($p<0.05$)
[c] significantly different from a and b ($p<0.05$)

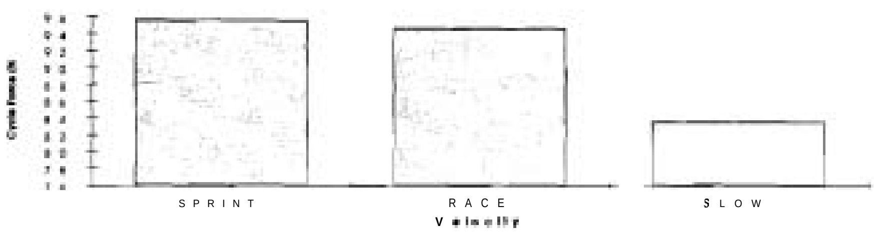

Figure 2. Average cycle force for sprint, race, and slow velocities.

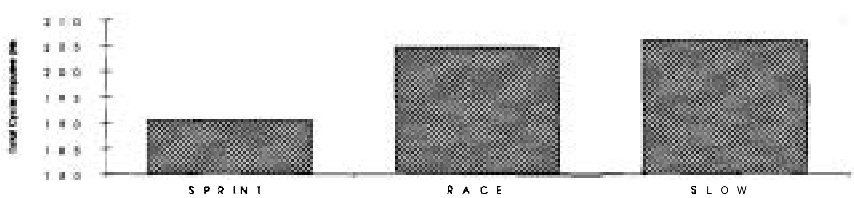

Figure 3. Average cycle impulse for sprint, race, and slow velocities.

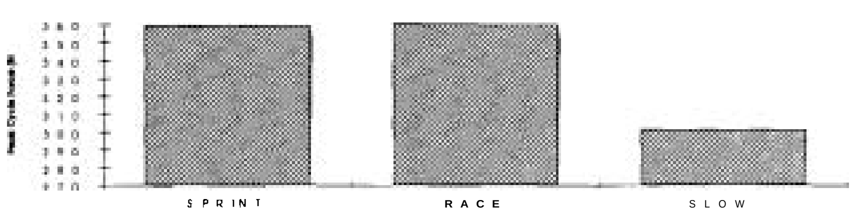

Figure 4. Average peak cycle force for sprint, race, and slow velocities.

Table 1. Summary of mean values for cycle duration, average cycle force, cycle impulse, and peak cycle force.

		VELOCITY	
	Slow (4.7 m/s)	Race (5.8 m/s)	Sprint (6.7 m/s)
CYCLE DURATION (sec.)	2.44 ± 0.20*	2.13 ± 0.20*	1.93 ± 0.34*
AVG. CYCLE FORCE (N)	83.5 ± 19.4	94.6 ± 23.3	95.6 ± 25.6
CYCLE IMPULSE (N·s)	206.1 ± 61.9	204.7 ± 65.7	190.5 ± 87.0
PEAK CYCLE FORCE (N)	300.7 ± 44.8	360.0 ± 71.6	359.2k141.4

*** = Significantly different ($p< 0.05$) from other two cycle duration values.**

Conclusions Based upon the results of this study, it appears that the primary means by which a skier controls velocity is through manipulation of cycle rate (i.e., increasing or decreasing cycle duration) with little or no change in average cycle force or peak force at the faster paces. Practical application of these results would suggest that skiers wishing to maximize velocity should place an emphasis on increasing cycle rate as opposed to applying a greater amount of force with the upper torso.

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