ANALYSIS OF SELECTED MECHANICS OF THE BACKWARD C-CUT ICE SKATING STRIDE

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INTRODUCTION

Traditionally there are two techniques used in backward skating in the game of ice hockey. Both are commonly employed under various game conditions and as a matter of personal preference by players. These methods are the cross-over and the C-cut. In the cross-over considerable lateral deviation occurs due to the crossing over of one leg in front of the other. In fact, normally several cross-overs occur in the same direction before a direction change occurs. The cross-over also involves alternating periods of single and double support. The C-cut technique is a backward skating method involving continuous double support and in which alternating periods of thrust and glide (support) occur. Unlike more traditional forms of locomotion such as walking and running, the direction of thrust is lateral rather than forward and backward. As the skates are in continuous double support the legs are alternately extended perpendicular to the direction of motion and the angle of the skate blade relative to the ice ensures a backward reaction force which propels the skater in the backward direction. Although various authors (Patterson et al., 1986; Stamm, 1989) have described the basic movements of backward skating, at present, no evidence exists of research focusing on the backward C-cut skating pattern. The intent of this study, therefore, was to undertake a basic study of the movement pattern to look for relationships between selected movement characteristics and backward skating velocity. Also, a preliminary attempt was made to investigate the bilateral symmetry of the backward skating pattern. Specifically, the purpose of the study was to evaluate the contribution of structural and performance variables to the skating velocity of ice hockey players performing the backward C-cut skating technique.

METHODOLOGY

Ten skilled ice hockey players ranging in age from 18 to 22 years of age volunteered to participate as subjects. Each was required to skate backward at maximum velocity through a predetermined filming area using the C-cut technique. Each trial was filmed from overhead using a 16 mm Locam camera operating at 100 Hz. The film was analyzed using a Vanguard projector, Altek AC30 digitizer and microcomputer system. The software was self generated for use in this study.

As the study was designed to look at relationships, there was no independent variable. Film analysis and direct measurement were used to measure 17 dependent variables including backward skating velocity, several technique factors, height, weight, and three characteristics of the forward skating mechanics of the same sample of subjects. The statistical analysis took two forms. Pearson product-moment correlation analyses were used to look at the relationships between backward velocity and the technique variables measured. The same measure was used to look at the relationship between forward and backward skating velocity. In cases where left and right side movement characteristics were measured, a one-way Analysis of Variance with repeated

measures was used to evaluate bilateral differences. Statistical significance in both relationships and differences was accepted at $p<0.05$.

RESULTS

The basic cycle characteristics of the backward C-cut skating technique are listed in Table 1. The skating cycle was defined as a combination of two skating strides and, therefore, involves both a lateral thrust to the right and a lateral thrust to the left during one complete cycle.

Table 1. Basic cycle characteristics of backward C-cut skating (n = 10).

Cycle Time (s)	0.86
Cycle Rate (cycles/s)	1.16
Cycle Length (m)	5.65
Backward Velocity (m/s)	6.57
Forward Velocity (m/s)	8.03

On average, the subjects skated with a backward velocity of 6.57 m/s. This was comprised of a cycle rate of 1.16 cycles/s and a mean cycle length of 5.65 m. In comparison, the mean forward skating velocity of the same sample of subjects was 8.03 m/s. It is apparent, therefore, that the backward skating velocity was approximately 80% of the maximum forward velocity.

As the purpose of the study was to determine which factors were related to backward skating velocity, a correlation matrix was developed to look at relationships between velocity and all other variables measured. Those found to be significantly related to backward velocity are listed in Table 2. It was immediately apparent that a longer distance covered during each cycle was associated with higher velocities. At the same time, the relationship between cycle rate and velocity was negative, indicating that a lower cycle rate accompanies higher velocities. In addition, wider cycles were associated with higher velocities. In combination, these relationships can be interpreted to mean that skaters who are able to create the largest thrust forces create both more lateral as well as backward displacement during a given cycle time. Even if the cycle rate is lower, these skaters achieve higher velocity in the intended backward direction. It is interesting to note that there is 71% common variance between backward velocity and the length of the skating cycle. Many other statistically significant relationships were found in this study. Those considered to be of particular interest are listed in Table 3.

Table 2. Variables significantly related to backward skating velocity (n = 10).

Variable	R	R^2
Cycle Width	0.80 *	0.64
Time of Cycle	0.68 *	0.46
Cycle Rate	-0.70 *	0.49
Cycle Length	0.84 *	0.71

* Statistically significant relationship at $p<0.05$

It was apparent that a strong positive relationship exists between the distances covered during the right and left strides in each cycle. Also, a strong negative relation-

ship exists between cycle rate and length. This indicates that those subjects who cover the most distance during each skating cycle take the longest time to complete the cycle. This finding was expected in view of the relationships between length and velocity and rate and velocity.

Table 3. Selected other significant relationships (n = 10).

Variables	R
Left Stride Width vs. Right Stride Width	0.78 *
Left Stride Length vs. Right Stride Length	0.84 *
Cycle Rate vs. Cycle Length	-0.91 *
Backward Velocity vs. Forward Velocity	0.81

* Statistically significant relationship at $p<0.05$

A second focus of the study was the bilateral nature of the skating cycle and specifically the question of left-right symmetry. Several variables were measured to investigate the possible differences between left and right strides. The results of this aspect of the study are listed in Table 4. It is evident that the left-right nature of the backward skating cycle is symmetrical, at least for the population of skilled skaters. This may not be true for beginners or those less accomplished in backward skating. In any event, when comparisons were made of left versus right stride times, rates, lengths, and widths no statistically significant differences were found.

Table 4. Basic stride characteristics of backward C-cut skating (n = 10).

Variable	Right Stride	Left Stride
Stride Time (s)	0.42	0.44
Stride Rate (st/s)	2.38	2.22
Stride Length (m)	2.88	2.77
Stride Width (m)	0.33	0.35

No statistically significant differences between left and right strides.

DISCUSSION

It has been shown that the backward C-cut skating technique consists of symmetrical left and right strides which produce similar lateral and backward deviations. It appears that those skaters able to create the longest strides and therefore the longest movement cycles are able to skate the fastest in the backward direction. Since both stride length and width are associated with velocity it seems that the critical factor in backward skating is the impulsiveness of the lateral thrust against a skate which is angled to produce both a lateral and a backward reaction force. In comparison to their maximum forward skating velocity, skilled skaters reach a maximum backward velocity in the 80% range.

CONCLUSIONS

Ten skilled skaters performed the backward C-cut skating technique. Several backward skating variables were measured along with forward skating velocity which was determined from separate forward skating trials. Based on the results of the study and

with the limitations in mind, the following conclusions are warranted:
1. There is a strong positive relationship between forward skating velocity and backward C-cut skating velocity.
2. Maximum backward skating velocity of skilled subjects is approximately 80% of forward skating velocity.
3. For skilled subjects, backward skating is a symmetrical movement pattern with no significant differences between left and right strides.
4. Faster backward skaters have lower cycle rates, longer cycle lengths, and wider cycles than slower backward skaters.

REFERENCES

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