DOCUMENT RESUME

ED 098 149 SP 008 506

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TITLE A Comparative Analysis of Selected Mechanical Aspects of the Ice Skating Stride.
PUB DATE 74
NOTE 6p.; Paper presented at the Annual Convention of the American Alliance for Health, Physical Education, and Recreation (Anaheim, California, March 1974)

EDRS PRICE MF-$0.75 HC-$1.50 PLUS POSTAGE
DESCRIPTORS *Ability; *Athletes; *Athletics; *Motion; *Performance Factors; Physical Activities
IDENTIFIERS *Ice Skating

ABSTRACT

This study quantitatively analyzes selected aspects of the skating strides of above-average and below-average ability skaters. Subproblems were to determine how stride length and stride rate are affected by changes in skating velocity, to ascertain whether the basic assumption that stride length accurately approximates horizontal movement of the center of gravity during each stride is valid, and to identify some of the fundamental differences in skating stride between above- and below-average performers. Groups of five skaters performing at three different velocities were filmed. Each subject performed three trials at each of a maximum and two submaximal speeds. Graphic and statistical analyses were used to determine performance trends and the statistical significance of differences in performance parameters. Analysis of the data revealed that stride rate increased as a function of horizontal velocity for both levels of performers. No apparent trends were found for stride length in relation to velocity. Above-average skaters exhibited higher stride rates, longer stride lengths, and longer glide phases than did skaters of below-average ability. Also, above-average performers displayed less flexion of the lower leg, and, consequently, vertical displacement of the foot was less during the recovery phase of the ice skating stride. (Author)

ED 096145

A COMPARATIVE ANALYSIS OF SELECTED MECHANICAL ASPECTS OF THE ICE SKATING STRIDE

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1974

A COMPARATIVE ANALYSIS OF SELECTED MECHANICAL ASPECTS OF THE ICE SKATING STRIDE

The major focus of the study was power skating, as opposed to speed skating or figure skating, although all three embody several common facets, particularily in maximum speed forward striding. Power skating is generally considered as the skating style employed in hockey.

A myriad of hockey books and coaches manuals stress that skating is the most important prerequisite of top calibre performance in ice hockey. Very few authors, however, devote more than a few paragraphs to the explanation and description of skating technique. This is possibly due to the fact that, unlike running, walking, and other forms of locomotion, skating has seldom been studied quantitatively from a biomechanical point of view, and thus pertinent information from other than qualitative analysis may simply be unavailable.

This study was intended as an initial attempt to quantify mechanical parameters of power skating in order to develop a foundation upon which to base further research. Since speed is one of the main criteria of power skating, it was felt that an initial study had to deal with the fundamental question of how maximum speed was attained. Also, from a practical point of view, it is important to know how differing performance groups vary mechanically in their movement patterns when skating at maximum velocity.

The purpose of the study was to quantitatively analyze selected aspects of the skating strides of above and below average ability skaters. More specifically, the problems were: 1) To determine how stride rate and stride length are affected by changes in skating velocity; 2) To ascertain the validity of the basic assumption that stride length accurately approximates absolute movement of the total body as represented by horizontal movement of the center of gravity; and 3) To identify some of the fundamental differences in skating stride between above and below average performers.

Methodology

Ten skaters were selected as subjects. These subjects were appraised by three instructors as the five best and five poorest skaters from an undergraduate hockey class of thirty-five students. Therefore, while the sample N's are not large, the subjects represent both ends of the performance continuum.

A Locam 16 mm. camera operated at one hundred frames per second was used to film each of the two groups of skaters, performing at three different velocities. Each subject performed three trials at each of a maximal and two sub-maximal speeds.

Measurements of stride rate, stride length, duration of glide phase, and degree of lower leg flexion about the thigh, were made through the use of a Vanguard Motion Analyzer.

Statistical procedures included a linear regression analysis to determine the relationship between horizontal velocity and stride length and stride rate. A dependent samples t-test was used to study the differences between horizontal movement of the center of gravity and stride length during each stride. Finally, independent samples t-tests were used to study differences in performance parameters between the two groups of skaters.

Results

A fundamental theorm of locomotion via running states that Horizontal Velocity = Stride Rate X Stride Length. Logically, this equation should also hold for ice skating, and from a performance stand point, it is important to know whether changes in horizontal velocity are accompanied by changes in stride rate, stride length, or both.

Linear regression analysis showed that there was a significant positive relationship between stride rate and horizontal velocity for both performance groups over the three skating velocities. For the above average group the linear relationship between velocity and stride rate was described by the equation: $Y_i = .1101 X_i - .0050$. The correlation coefficient for velocity versus rate was .686, and the F-ratio for mean square regression over mean square deviation from regression was 35.42 which is significant at less than the .01 confidence level. For the below average performers the linear relationship was $Y_i = .0993 X_i + .2669$. The correlation coefficient was .813, and the F-ratio was again a highly significant 84.01.

The relationship between horizontal velocity and stride length was found to be statistically non-significant for both groups. For the above average performers, the linear equation was $Y_i = -.0178 X_i + 10.0837$. This line was found to be not statistically significantly different from a line with a slope of zero going through the Y intercept. The correlation between stride length and velocity for the above average group was $-.0369$. For the below average performers, the linear relationship was $Y_i = .1137 X_i + 6.855$. Again, this relationship was found to be non-significant statistically, and the correlation coefficient for length versus velocity was .355.

Qualitative analysis of skating strides at different velocities may show why stride rate increases as velocity increases, but that stride length does not. At slower velocities, the movement pattern involves a relatively long, leisurely glide phase, during which no forward propulsion is taking place. Since the resistance between skate blade and ice is very low, one propulsive thrust is sufficient to propell the skater a relatively great distance. As a skater desires to increase velocity, he must stride with more forceful and more numerous propulsive thrusts. Therefore, although the stride length may not change significantly, the relative duration of the gliding and propulsive phases of the movement change. At maximum velocity, the propulsive phase of the subsequent stride begins shortly after the striding leg establishes contact with the ice, while at slower velocities, a longer, non-propulsive glide phase may intervene.

Stride lengths were compared to horizontal movement of the center of gravity for twenty randomly selected maximum velocity strides. Center of gravity was determined from the film through the use of Dempster's data and the segmentation method. A dependent samples t-test produced a t-ratio of 1.74 which is non significant at the .95 confidence level.

As a comparison of selected fundamental differences between performance levels, differences in stride rate and stride length during maximal trials, and differences in amount of lower leg flexion about the knee joint during the recovery phase of the stride were analyzed.

At maximal velocity, the mean stride rates were 3.117 strides per second for above average and 2.44 strides per second for below average performers. The mean stride lengths for both groups respectively were 9.127 and 8.438 feet. In each case, independent t-tests showed the means for the above average group to be significantly greater than the means of the below average group at the .95 significance level.

Flexion of the knee during the recovery phase of a stride gives an indication of whether or not a skater is opening up at the hips and stroking properly with power coming from the inside edges of the skate blades. Although there must be some flexion at the knee, the skate should be kept close to the ice and put back down quickly to facillitate a quick initiation of the thrust phase of the subsequent stride. The mean degree of flexion at the knee as indicated by the minimum angle between the thigh and the lower leg was 95.96 degrees for above average and 84.73 degrees for below average performers. This difference was found to be statistically significant at the .95 level, and indicates that the better performers tend to keep their skates closer to the ice during recovery than do poorer performance level skaters. Unlike sprinting, in which it is important to flex the knee to minimize the moment of inertia about the hip and bring the recovery leg through as quickly as possible, the important factor in skating seems to be getting the skate back on the ice, under the center of gravity, as quickly as possible because this facilitates a quicker initiation of the subsequent stride. The significantly greater flexion of the lower leg and consequently greater vertical displacement of the skate off of the ice, by the poorer performers, indicates a tendency towards running on the skates rather than using the proper hip action and stroking form.

Conclusions

As a result of the film analysis and statistical findings of the study, it is felt that the following conclusions are warranted.

1) As the horizontal velocity of power skating increases, stride rate also increases.

2) Increases in skating velocity may not be accompanied by increases in stride length.

3) Stride length of the skating movement provides a close approximation of the linear movement of the center of gravity during each stride.

4) At maximal velocities, above average skaters exhibit both higher stride rates and longer stride lengths than do below average performers.

5) Poorer performers have a greater tendency to run on their skates than above average performers do.