DEVELOPMENT OF CROSS-COUNTRY SKIING SKATING ABILITIES

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INTRODUCTION

The skating technique in cross country skiing was developed in marathon ski races in the beginning of the 80's. Since then the skating technique has been the topic of interest not only for skiers and coaches, but also for many scientists. For the researcher cross country skiing is a very challenging sport. There are a huge variety of techniques that an individual skier can adopt in a competition. Ski tracks and snow hardness differ from one place to another and the temperature range varies from several degrees above Celsius down to -20 degrees below Celsius. Cross country skiing is unique compared to other sports where conditions remain about the same from one race to another.

A common finding from research on both skiing styles (classical and skating) has been the relationship of the stride length to racing results (Waser 1976, Dillman 1979, Smith 1988). This has also been found in a study which controlled technique and speed (Leppavuori 1989). Waser (1976), Komi and Norman (1987) described the velocity and the path of the centre of gravity in racing situations with the diagonal stride.

The purpose of this study was to follow the skier's technical development by utilizing film analyses. Three goals were set for the project: first to develop the skating techniques of Finnish skiers through practise, second to find and evaluate suitable parameters for technical analysis, and third to evaluate the suitability of the film analysis methods.

Methods

Two camcorders were used with a frequency of 25 to 30 hz situated on the left and right front at approximately a 90 degree angle to each other, 20-30 metres from the filming spot. The calibrations used six calibration poles and a tachometer. The filmed data were processed with an APAS-motion analysis system on a 20 point model.

Over a period of two years five different 3-D film analyses were recorded on the V2-skating technique on various uphill sections with an inclination varying from 4 to 14". The skiers belonged to the elite group of the Finnish ski team.

The following parameters were calculated from the data: Contact phases of skis and poles, speed and height of the CG, velocity direction vectors, knee and hip angles. These parameters were selected for analyses according to the literature reviews. Weather conditions varied from -15°C to -2°C during the different recordings. Conditions remained the same during the same recording. Neither the hardness of the track nor the friction coefficient of the snow was evaluated.

Results
Intraindividual Changes

The velocity of the centre of gravity combined with the pole and ski contracts were selected for evaluation (figures 1,a,b,c). The figure I a represents the first analysis of one individual skier in November 1992. The maximum cycle speed was achieved during the beginning of the pole push (0.462 sec prior to the end of the strong leg contact). During the last half of the poling work the speed decreased up to the moment of final kick. After two months of technical training the respective phases were changed and the decrease in velocity of the CG during the pole push and strong leg kick was not present (figure I b). The maximum speed during the cycle was achieved 0.033 sec before the end of the strong leg kick. Ten months later (figure Ic), in the following December, the decrease of the velocity was present in the poling phase again. The maximum speed achieved was now 0.066 sec after the strong leg kick. The technical training before the measurements was focused on the leg work.

For another athlete the height of the path of the centre of gravity was lowered over the period of the 18 months measurements. The lowering of 8 cm with the minimum height of the CG and 10 cm with the maximum height of CG was observed during the period. The changes in the respective average values for the knee and hip angles were 18 degrees and 11 degrees.

Effect of Velocity

To find out if the changes in the velocity curve were due to speed, we recorded the skier at three different speeds on the same 8-degree uphill. Figure 2 indicates the changes due to speed. Maximum velocity was reached at the end of the pole push at the slow speed, 0.198 sec before the end of the strong leg kick and at the end of the strong kick at other speeds. The minimum height of the CG was 91 cm, 75 cm and 69 cm, and the maximum height of the CG was 104 cm and 83 cm's with slow, moderate and competition speeds respectively.

Changes Due to Fatigue

We also measured our athletes at the World championships in Falun 1993 racing the 50 km race on three different laps (12.4, 29.1 and 45.8 km) to evaluate the possible changes due to fatigue. The velocity of the CG was decreased from lap to lap. Figure 3 presents the changes in the cycle velocity in relation to the working cycle. In the first lap the maximum speed was achieved 0.033 sec prior to the end of the strong leg kick, in the second and third lap 0.198 sec and 0.132 sec respectively. Respective heights of the CG at the minimum and maximum values were 79 cm, 80 cm, 79 cm and 98 cm, 97 cm, and 95 cm.

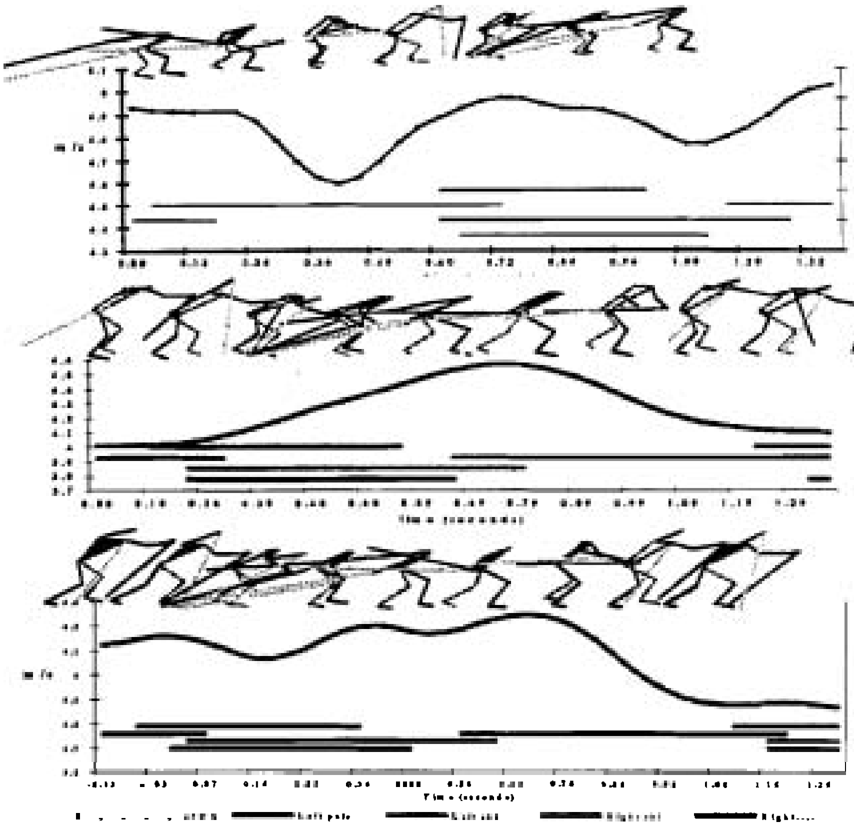

Figure 1 (a, b, c). Stick figure above shows the phases of the skier. Curve shows the speed of CG during the measured cycles. The straight lines under the curve represents respective contact phases of left pole, left ski, right pole and right ski. a) Initial measurement Nov. 1992, b) Measurement in Jan. 1993 and c) Measurement in Dec. 1993.

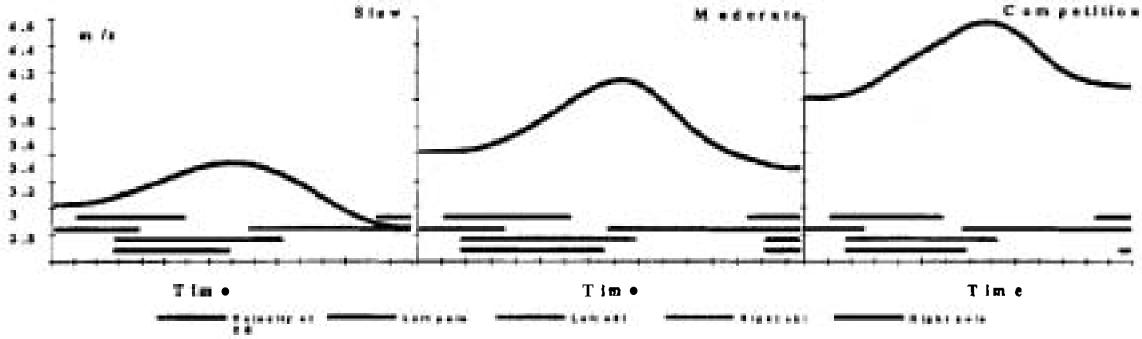

Figure 2 (a, b, c). The curve indicates the path of the CG during the different speeds (for explanation see fig.1.). a) Slow, b) Moderate and, c) Competition speed on the same 8 degree uphill for the V2-technique

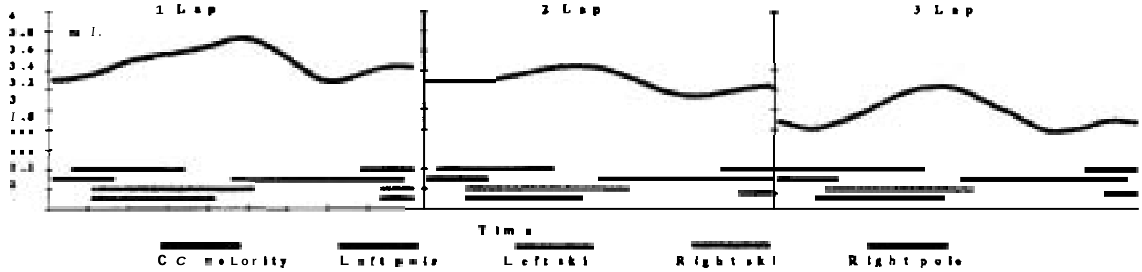

Figure 3 (a, b, c). The changes in the velocity curve in a 50-km race in Falun WC in 1993. a) 1. lap (12.4 km), b) 2. lap (29.1 km) and c) 3. lap (45.8 km).

Discussion

Basically the skier is supposed to accelerate his speed during pole and ski contacts and then during the glide phase the speed of the skier is supposed to decelerate. This path of velocity seems to be very individual, obviously depending on the physical characteristics and technical skill of the athlete.

Methods based on the evaluation of the instantaneous cycle velocity combined with the contact phases is possibly a useful way to evaluate the development of the technical characteristics of the skier both in the short and in the long term.

The technical model appeared to present a rather strong pattern, at least on the basis of recordings from the 50 km race. Our skier maintained the same technical pattern in terms of the height of the CG during the whole race. This leads to the conclusion, that the adopted technical pattern is strong enough to be unchanged, even in cases of extreme fatigue. In cross country races the effect of the fatigue is observed in a shorter glide, increased cycle frequency, and in the timing of the different movements. On the other hand, the position of the skier was changed due to increases in the velocity. This finding can be important for athletes and coaches during the technique training sessions.

Changing the technical pattern of the athlete takes time and depends on the motor skills of the athlete. The time needed for changes vary from a single training session to months of technical training.

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