CENTER OF MASS VELOCITY AND THE TURN CYCLE IN SLALOM

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Introduction

There is a diversity of opinion among coaches as to where in a turn cycle skiers gain and lose speed. Knowing more about in which phases of the turn cycle a skier accelerates could lead to different technical and tactical approaches. The purpose of this study was to describe the time course of center of mass velocity (V_{COM}) through a turn cycle.

Methods

In April 2006, the performances' of 6 male members of the Norwegian Europa Cup team were analyzed through 2 turns during a race simulation in slalom. Skier 3-D positions were determined from 4 panning cameras and calibration control points distributed near the course [1]. The instantaneous center of mass turn radius (R_{COM}) was calculated as the radius of the arc passing through the 3 previous points, the current point, and the 3 following points. V_{COM} was calculated using first central differences. The turn cycle was divided into two phases based on R_{COM}: The turn phase (TP) and the straight phase (SP). TP start and end points were defined as the time points when R_{COM} decreased below 15 m and increased above 15 m, respectively.

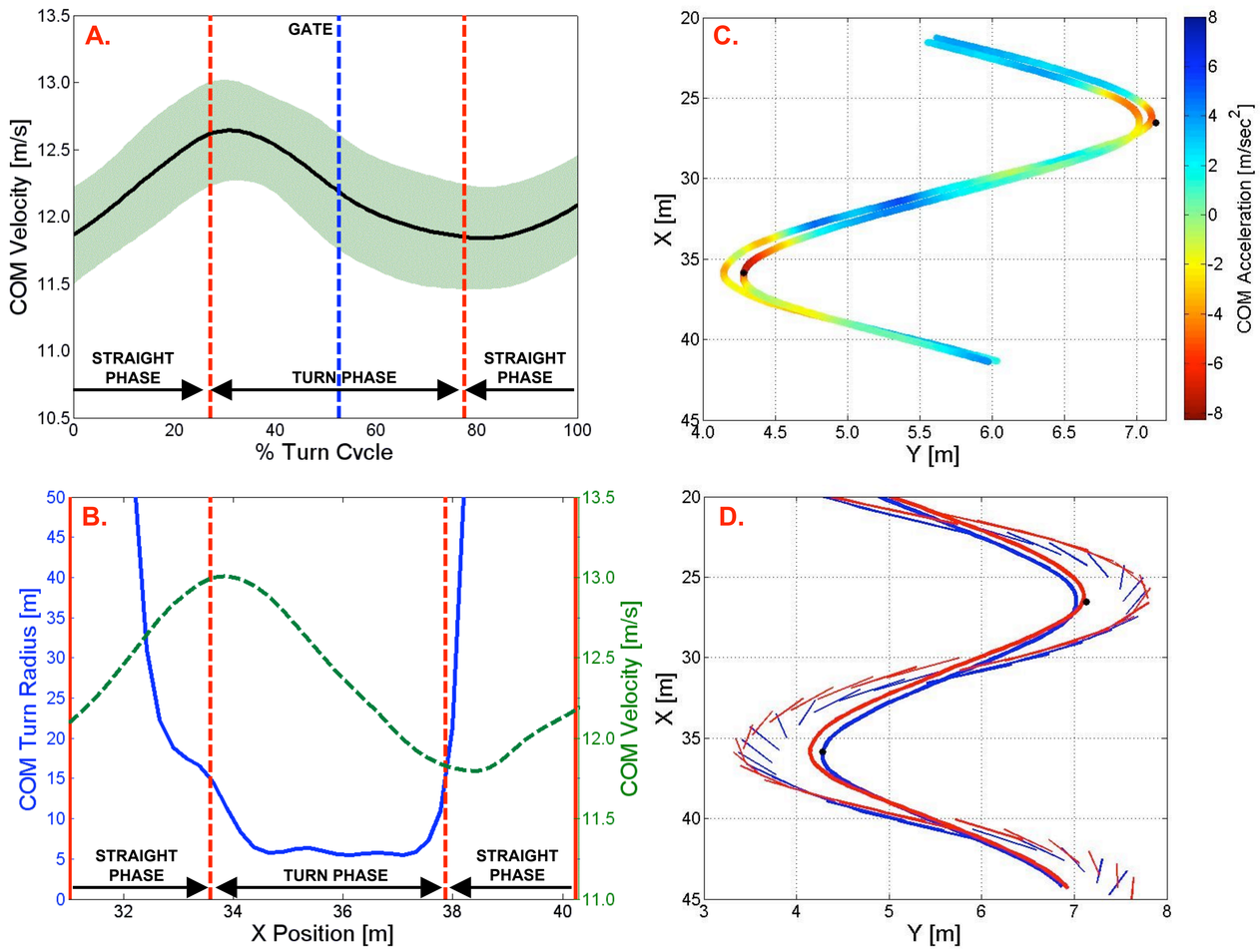

Figure 2. A. The ensemble average center of mass velocity (± SD) over the course of a turn cycle for the 12 analyzed turns. The average straight phase (SP) and turn phase (TP) of the turn cycle, as well as the gate passage, are indicated.
B. One example turn cycle showing the center of mass velocity and turn radius.
C. Two athletes' center of mass trajectories. Center of mass acceleration is indicated by color. The black points indicate gate positions.
D. The same two athletes' center of mass trajectories and outside ski orientations. The black points indicate gate positions. Note that the skidding of the ski appears exaggerated due to unequal scaling of the graph X- and Y-axes.

Figure 1. Experimental set-up showing control points, and gate positions.

Results & Discussion

In examining the ensemble average V_{COM} for the 12 analyzed turns (Figure 1), a cyclic pattern of positive and negative acceleration is readily apparent. The mean accelerations (± SD) in the SP and TP were 2.33 m/s^2 (± 0.20) and -1.86 m/s^2 (±0.54), respectively.

The results show a surprisingly strong relationship between the time course of V_{COM} and the turn cycle. Based on this knowledge, two approaches might be taken to improve performance.

In the first approach, skiers reduce braking forces in the TP by skiing a longer, more carved turn (Figure 2D, red line). In the second approach, skiers may try to shorten the trajectory length and maximize the benefits of acceleration in the SP by skiing a direct line (Figure 2D, blue line). The latter approach seems to be popular among coaches and racers today, particularly when the slope is moderate to steep and the snow conditions are hard. Recent changes in equipment regulations may also favor such an approach.

Conclusions

The results of this study indicate that the straight phase is where skiers increase speed while the turning phase is where speed is decreased. To what extent the same pattern will occur for turns with differing radii, or in turns on slopes of different inclinations, is yet to be determined.

References

[1] Nachbauer W *et al* (1996) J Appl Biomech, 12, 104-115.

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