Kinematical Aspects Gliding Technique in 500-m Speed Skaters: From Start to Seven Strokes

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INTRODUCTION

The goal of speed skating is to traverse a specific distance in the shortest possible time span. To achieve this goal, speed skaters must be able to essentially distribute their energy accordingly throughout the 400 m track (Muehlbauer, Schindler & Panzer, 2010). In mid- and long-distance speed skating races, pacing strategy throughout the 400 m track plays a larger role in performance than quick start (Hettinga, De Koning, Schmidt, Wind, MacIntosh & Foster, 2011). On the other hand, explosive power, speed, quick start, and completing the race with full force are more important in the 500 m sprint race (Lee & Back, 2005; Park & Lee, 2007; Muehlbauer et al., 2010).

Studies by De Boer and Nilsen in 1989 stated that the most important technical variables in speed skating are skating posture, push-off angle, stroke frequency, and distance. The skating posture is especially important since it provides balance between minimal track frictional loss and creation of full-force expressions. In addition, the push-off angle is reportedly a crucial variable that determines the amount of work per stroke, while stroke frequency regulates speed. In curves, stroke frequencies are constrained by speed, stroke performance, and radius of the curve. However, stroke frequencies can be freely regulated by speed skaters on a straight track.

Among speed skating postures, push-off angle, stroke frequency, and cycle rate are identified as the most crucial performance-affecting variables to speed expression in speed skating gliding technique. From a kinematic viewpoint, posture-based performance improvement is caused by the initial stance on straight and curved tracks. In particular, acceleration from the initial stance is very important to shortening completion time (Shin & Back, 1996; Back, Kwak & Chung, 2004). The initial speed skating stance is similar to the standing start stance of track and field athletes. However, speed skating incorporates a combined running-like and push-off techniques at the start signal. This motion is evident for the first 10 steps from the start line and is followed by a regular gliding and push-off technique. Therefore, speed skaters must transition to maximum speed in these first 10 steps as naturally as possible. A study by De Koning, Thomas, Berger, Groot, and Ingen Schenau in 1995...
reported that when a speed skater pushes forward by fixing the push-off leg on a specific point on the track as long as possible, the push-off leg exhibits compound speed, which is composed of the toe's extension in the y-direction, and rotation, which is identical to the y-directional (horizontal) speed from the center of body mass. Once the speed skater starts relying more on the gliding technique, these two speeds start to show differences and diverge from each other. This change is observed when the average speed is $6.7 \pm 0.3$ m/s, which is generally reached after six step push-offs.

According to Olson (2007), skating speed is induced by the vertical force on the skate blade. Since sprint skaters start from a standing position with the skate blades on hold, push-off is performed with the skate rotated to almost $90^\circ$. Since there are no slides in the initial motions, stride length and frequency are crucial to acceleration. This motion is called impulse push, and it allows the skater to accelerate faster with faster pushes. Therefore, sprint stroke must be related to stride length and stroke frequency, and the skater must perform skate gliding at a particular point of the stroke to gain speed. In other words, skater must be able to increase the pressure of the skate while gliding for a certain amount of time and maximize pressure on the track. The increase in pressure on the track ultimately results in increased acceleration. However, the impulse push in sprint skating cannot induce faster acceleration as the speed increases. Therefore, sprint skaters need to master prolonged application of force on the track during stroke to increase speed and acceleration in a short time span.

Single leg skating, in which acceleration is induced by bearing weight on one leg at the start of sprint skating, could be the most effective technique that increases speed by producing large motions in a short time span (Olson, 2007). To transition from the initial stance to gliding, an effective combination of stride frequency and stride length are necessary to achieve the maximum speed in a short time span. Therefore, skating speed and distance gain, which are produced by a combination of stride frequency and stride length, are important technical information for speed skaters and should be studied since they directly affect performance.

The aim of this study is to investigate the consistency of right and left single-leg gliding and push-off posture between the start of the race and 14 steps (seven strokes). The following questions were developed for the study. First, is there a difference between the right and the left legs in terms of cycle rate and step rate of the push-off leg and the stroke trajectory? Second, at what point is the difference between the compound speed of the push-off leg and horizontal speed of the center of body observed?

**METHODS**

1. **Participants**

Investigation was performed using the speed skating participants from the 49th National College Speed Skating Competition for Men and Women in 2016, hosted by the presidential committee of Korean Speed Skating Union. All participants were holding current records of 37.39 sec or less in the 500 m category, and 9.97 sec or less in the 100 m category. Total of five were selected, including three regular speed skaters and two college students. The participants had an average height of $1.80 \pm 0.02$ m, average weight of $76.8 \pm 3.96$ kg, and average record of $35.83 \pm 0.30$ sec.

2. **Measurements**

This study was conducted from the start line up to the 40-m mark of the straight portion of the track, in which a total of seven strokes were performed, and the data were analyzed. Five JVC cameras (GR-HD1KR) were installed in the audience area and the recording speed and the shutter speed were set to 60 fields/sec and $1/500$ sec, respectively. As shown in (Figure 1), ten 2 m range poles were installed as spatial coordinates on two parallel tracks, one pole every 10 m on each 50-m long track. The poles were removed after recording and two reference marks were installed parallel to the x-axis on the start line to calculate the camera orientation angle. The reconstruction error of the digitized 28 markers was calculated as 0.02 m. Two of the five cameras were installed parallel to the skaters’ direction of motion and an anchor point was set on the overlapping screens to determine the spatial coordinate of the recordings, which were overlapped to appear as a single recording. This recording method allows clearer visualization of the subject. To calculate the three-dimensional (3D) coordinates, right and left were defined as the x-axis, the direction of motion was defined as the y-axis, and vertical direction was defined as the z-axis in the world.

![Figure 1. Overview of the experimental set-up.](image-url)