SKI CHARACTERISTICS FROM DIFFERENT WIDTH SKIS WHILE POWDER SKIING

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Introduction

The geometry of Alpine skis used to be long, straight, and narrow. These shapes started to change in ski season 1958-59 when skis became shorter with the introduction and acceptance of the Graduated Length Method (GLM) (Taylor, 1978). By the 1980s the straight shape of alpine skis started to disappear when several ski companies first experimented with the deeper parabolic side-cut allowing greater carving (Masia, 2005). The last geometric alteration was introduced by Atomic in 1988, a wide ski, 115mm underfoot. This increased the ski surface area allowing increased floatation in powder snow.

Ski geometry evolved in response to skier demand. Shorter to facilitate learning, increased side-cut to enhance carving, and lastly, increased width, to augment the skier's powder experience. To our knowledge short skis have not been scientifically challenged. Shaped ski have been compared to conventional side-cut ski by Bachrach et al. (2002) and Sahashi & Ichino (2001) compared conventional skis. Only Zorko et al. (2015) and Seifert et al. (2018) and Seifert et al. (2019) have examined skis of differing widths.

While most of these geometric alterations have been advantageous to ski industry hard goods sales (SIA, 2017) in that they make skiing more "fun" (Freeskier, 2019), the width dimension is of concern to the ski racing community (Pišot et al., 2010; Supej & Holmberg, 2019). Ski width is dictated by the FIS (2018), although only the minimum width. This minimum width is regulated because ski racing involves steep ski edge angles on hard snow. To accomplish this, a narrow ski underfoot is the desired tool (Vaverka & Vodickova, 2010). Even with a narrow ski, many training hours over many years are involved with a young skier acquiring optimal ski racing technique. There may be concern that a wide ski may not offer the same learning stimulus as the narrow race type ski (Fajen et al., 2008; Supej & Holmberg, 2019).

Ski racers may have concerns about the difference in kinematics on wide skis versus the narrow race ski width. Seifert et al. (2018) found less muscle activity of the gluteus medius, rectus femoris, vastus medialis, and tibialis anterior with the wide ski (WS) while free skiing. While during race simulation, however, they found less muscle activity with the rectus femoris, vastus medialis, peroneus longus, and tibialis anterior with the narrow ski (NS). Also, the WS resulted in greater knee extension by 15% which was similar to the 14% found by Zorko et al. (2015). Additionally, Seifert et al. (2018) found an increase muscle activity of gluteus maximus and peroneus longus on the WS free skiing and in the race course compared to the NS. From a ski characteristic perspective, peak edge angles were greater on the NS compared to the WS while free skiing and race simulation.

Past research with wide skis has been performed on hard or compacted snow (Seifert et al., 2018; Zorko et al., 2010) which may explain the difference in muscle activity, knee kinematics, and ski edge angle. The purpose of this study was to study the NS and WS in groomed (GR) and powder (POW) conditions. Specifically turn time, peak edge angle, where that peak edge angle occurred in the turn, and the peak angular velocity of the ski around its longitudinal axis.

Methods

Following approval from the Montana State University Institutional Review Board, three élite level skiers provided written informed consent; two males, ages 35 and 36 years old with former FIS points of 18.24 and 10.38, and one female, age 52, former World Cup skier, 10 year U.S. Ski Team member skied their own narrow waisted (67-71 mm) race type ski (NS) and their own wide waisted ski (94-102 mm) (WS) under four testing conditions in a counterbalanced design. The four conditions were the two ski types (NS & WS) by two ski conditions, groomed (GR) and powder (POW). Turn speed and size were self-selected to coincide with verbal instructions to make similar turns in all four conditions.

All testing was performed on the same run at Bridger Bowl, Bozeman MT, USA. The run had an average pitch of 23°. The GR run was tilled the morning of testing, following an overnight snow fall. The POW portion was adjacent and had 33 cm of new snow with a density 45 kg/m^3 as reported by the ski area. Ambient temperature was -10°C. A 9-channel motion sensor was used to define turn durations (Electronics Realizations, Bozeman, MT, USA). The motion sensor was attached to the right ski boot above the heel binding. Sampling frequency was 100 Hz. A turn began and finished when the right ski was flat (0°) relative to the snow between turns (Supej et al., 2003). Data was collected from four turns once skiers reached a stable skiing speed. to make comments.

Results

Average turn time was less, peak edge angle was greater and occurred earlier, and peak angular velocity of the ski rotating around its longitudinal axis was higher in the NS and the GR condition. See Table 1.

Table 1 *Ski characteristics during skiing on groomed and powder conditions (mean (SD)).*

	Turn Time (sec)	Peak Edge Angle (º)	% of Turn	Peak Angular Velocity (º)
NS GR	1.11 (0.06)	72 (3)	50.0 (3.0)	273 (3)
WS GR	1.40 (0.33)	59 (2)	53.1 (6.3)	226 (60)
NS POW	0.93 (0.01)	68 (1)	56.0 (2.0)	246 (19)
WS POW	1.00 (0.06)	53 (6)	56.4 (5.0)	205 (45)

Results were similar to past research (Seifert et al., 2018; Zorko et al., 2010). Edge angles were less and were found at a later part of the turn (50-53.1% to 56.0-56.4%). Peak angular velocity was lower in the POW relative to the ski as Vaverka & Vodickova (2010) predicted and faster as explained by Brodie et al. (2009).

Discussion

Two levels of two independent variables were manipulated in this study. Skis; narrow and wide, and snow; groomed and powder. Previous studies have looked solely at the type of ski as the independent variable. These were conducted while keeping conditions consistent, by using groomed slopes (Seifert et al., 2018, 2019; Zorko et al., 2010). While WS can be used on groomed slopes they were initially designed for POW conditions. To increase ecological validity, this study was performed on GR and POW conditions to conform with the intent and design of each ski category; NS and WS.

The POW condition resulted in less edge angle in spite of the width of the ski. The WS also resulted in latter pressure in the turn and a peak angular velocity that was slower. These three items, edge angle, pressure location, and peak angular velocity are critical to the learning of the young ski racer. The modern ski racer desires high edge angles and pressure in the fall-line (Kipp et al., 2010), along with a quick edge change.

Skiing on the WS is seemingly similar to the technique seen of the NS. Although it is the small differences such as edging movements, pressure modulation, and speed of edge switching that this study points out. These traits make skiing on the WS suspect when used for training by young ski racers that believe they are accumulating training volume.

This may even be endorsed by many ski race coaches who view the WS as a form of variable practice. While variable practice through contextual interference (Lin et al., 2009) is recommended for motor learning (Schmidt, 1975), and specifically ski learning (Pišot et al., 2010), the belief that the WS contributes to variable practice may be out of context.

Variability is altered when the environment challenges the performer's motor control by altering the calibration and recalibration of their motor response (Davids et al., 2012). This motor response needs to have intention toward the goals of the action (Bernstein, 1967; Cañal-Bruland & van der Kamp, 2009), such as increased edge angle, pressure in the fall-line, and a rapid edge change. According to ecological dynamics theory, when implements that temporally alter a performers effective body dimensions are introduced the muscle synergies and resultant movements may be confused resulting in diluted motor learning (Fajen et al., 2008). With respect achieving desirable motor outcomes to ski race training, the NS on GR is the benchmark. The results of the NS in POW are closer to the desirable outcomes compared to the WS on GR (Figure 1). This supports Fajen et al. (2008) in that the tool should not be altered only the environment for optimal training.

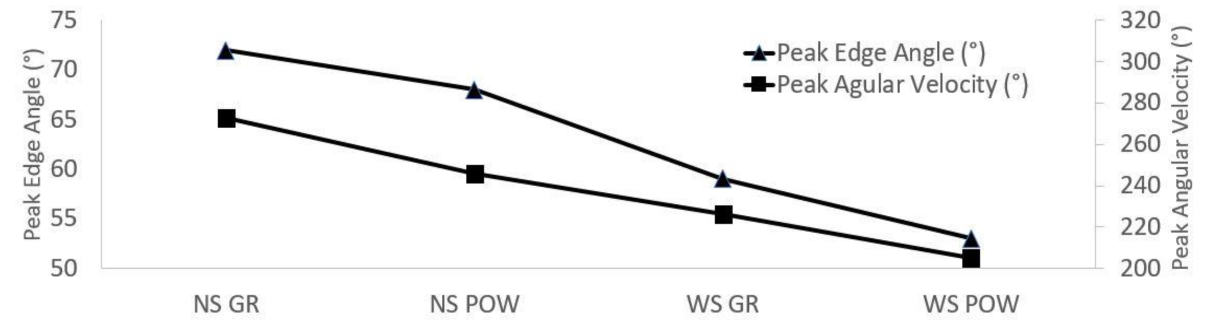

Figure 1 Peak Angular Velocity and Peak Edge Angle.

Conclusion

This study was novel in that it examined two ski types (NS & WS) in groomed and powder snow. To our knowledge this series of research (see also Seifert et al. 2019) is the first to exam ski width in the environment it was intended for. Each ski was designed to excel in a specific condition. NS in GR and WS in POW. As a result, edging movements, pressure modulation in the turn, and speed of edge switching were dimensions that favored the design of a NS on GR. Since there are no objective measures for the WS, only subjective inference, it may be assumed the WS does meet criteria for POW skiing. Meanwhile the NS did still meet NS criteria while in POW conditions, albeit to a lesser degree compared to GR.

Bernstein (1967) proposes that the performer adapts to their environment by learning to engage additional degrees-of-freedom as mastery is acquired. If we assume that the ski, wide or narrow, is part of the performer, and the connection to the ski contains its own degrees-of-freedom then it would be advantageous to a young ski racer to ski on the tool (NS) that they are trying to master. Then to enhance learning through variability of practice (Pišot et al., 2010; Schmidt, 1975) altering the environment. In the case of this research, using the NS in the POW condition.

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