Is the Campbell Balancer an Effective Tool for Determining Ski Binding Position

conducted at Snowbird, UT April 2002
for Nordica

submitted to Gerhard Hammerle
on
June 27, 2002

by

Louis B. Rosenfeld
MSc. Mechanical Engineering

Steven Bagley
President, Superior Ski

Alan Schoenberger
President, Turning Point Ski Foundation

Contact information:

Louis B. Rosenfeld
info@lous.ca
(403) 288-8556

Introduction

It is known that the fore/aft position of bindings on skis affects the comfort level when performing turns for recreational skiers as well as the time of racers through gates (Nigg et al., 2000). Comfort level changes may be caused by balance differences and the relative ease of beginning, finishing and in general controlling turn shape.

It is also known that binding position affects the longitudinal position of the application point of force (Fig. 1) with a more rearward binding position throughout a turn having a more rearward (toward the tail) force application point on the ski.

For approximately 20 years manufacturers have been marking boots and skis to pinpoint the manufacturer stipulated binding mounting position. However, different manufacturers use different manufacturer stipulated binding positions for similarly marketed and designed skis. Some manufacturers have used identical binding placements through several redesigns and substantial ski construction changes of their own skis. Therefore, ski design according to popular manufacturer theory may have little to do with actual binding location. Also, it is implied manufacturers may think skier morphology has little affect on binding position, since men or women of substantially different morphology may utilize identical skis. Or more reasonably, it is not currently understood how to best use the binding/boot marking positioning system to optimize performance for all skiers. Researchers for this current experiment propose; there exists a method and tool (Campbell Ski Balancer) for determining individualized binding location, and that the method of positioning in their ski boots the skiers fore/aft balance point directly over the center of the ski running surface improves skier comfort and performance. Therefore, the purpose of this research was to determine skier preference for one of two binding locations (balanced position or manufacturer stipulated position) and to determine inter and intratester repeatability of the balancing tool.

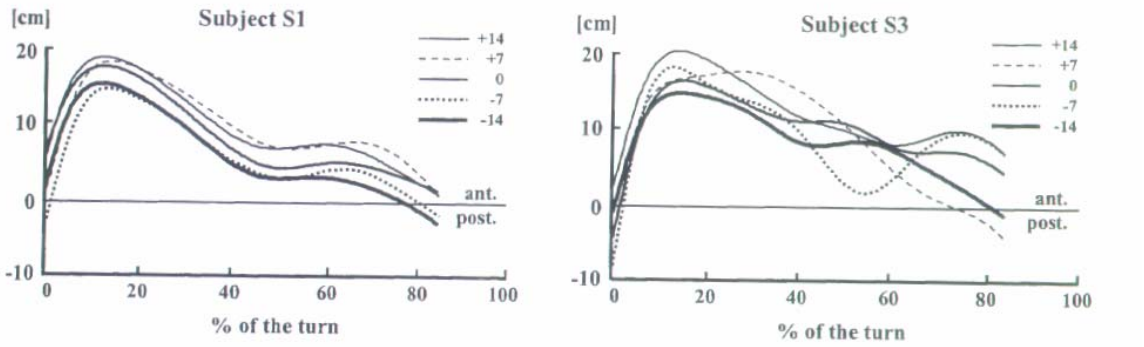

Fig. 1: Application point of the force in anterior-posterior direction over time concerning 5 different binding positions (subject S1 and S3). From Nigg et al. 2000. Data is time normalized. Subject S1 is former world cup racer while S3 is former Canadian junior racer. Zero point is manufacturer's stipulated position. Positive positions are towards the ski tip, measured in mm's.

Methods

10 subjects volunteered for the balancer repeatability research of which five subjects, three women and two men were also used for the ski portion. Both men were expert ski-

ers as was one woman. The other women were high-level intermediates. Test skis were Nordica Gel 70s in lengths 163 and 173 with factory-supplied risers and a pair of Blizzard Integrals, 160 cm. in length without factory risers. All skis were mounted with either Tyrolia or Rossignol rental bindings. The Nordica factory riser was moved forward approximately 2-3 cm. to ensure proper ski flexion with bindings in the Campbell balanced position. Function at the factory stipulated binding position was unaffected.

Skiers were balanced six times, three times by each of two testers. Skiers were blind to balancing results and testers were blind to inter-tester results. Skiers performed on-snow exercises and free-skied in each of two binding positions, A and B for three runs on moderate groomed. A final run on expert groomed terrain was offered in a binding position of the skier's choice.

The tool used to determine skier balance point was the Campbell Balancer ™. The balancer consisted of two independently adjustable platforms with a centrally located ball type pivot underneath each, which allowed motion in all anatomic planes. Platforms were adjustable to the individual subject width of stance. Subjects using ski poles for extra support were positioned in their ski boots on the balancer platforms over the pivots. Subjects practiced flexing and counterflexing their ankles to fully pivot (approximately 20^{o}) the platforms clockwise and counterclockwise (fore and aft) in the sagittal plane. Subjects were continuously repositioned forward and rearward with relation to the pivot until balanced on the platforms. The balanced position was defined as the position when the subjects determined the effort to pivot fully clockwise and counterclockwise was equal. The distance, at the balanced position, from the pivot center to the end of the ski boot toe was recorded. Subjects were then balanced an additional five times, six times total, with a rest off the platforms between each individual trial. Data for each trial was measured and recorded by an assistant.

For the skiing portion of the research the mean distance for each subject of all six trials from the pivot center to the ski boot toe was used as the balanced binding position (position A). Therefore, in position A ski bindings were adjusted such that the mean of the distance from the center of the pivot to the end of the boot toe equaled the distance from the center of the ski running surface to the end of the boot toe. Position B was the factory stipulated position that used the boot sole center mark aligned over the factory ski mark.

During on snow testing, subjects skied 3 controlled runs on moderate groomed terrain and a final free run on expert groomed terrain. A single controlled run consisted of a stepping exercise while making both left and right turns and a free-ski section. The stepping exercise portion consisted of two halves in which a subject skied a different binding position in each half. The free ski portion of each run was completed in the binding position used in the second half of the step turn run (Table 1).

Run	Binding position 1st half of step turn run	Binding position 2nd half of step turn run	Binding position for free ski portion of run
1	A	B	B
2	B	A	A
3	A	B	B

Table 1: Binding position for each ski run. Position A is the balanced position while B is the factory position.

Subjects were individually questioned on their preference for binding position A or B immediately following completion of the 2nd half of the step turn runs and after runs 2 and 3 for free ski information.

Finally at the end of controlled testing, subjects were offered their choice of position A or B for unlimited free skiing anywhere on the mountain.

Data Analysis

Range and means of the three balance trials of each subject were individually calculated for each tester. Additionally the means of the intersubject range was calculated for each tester. Subject preferences for each binding position were analyzed.

Results

Table 2 lists the distances from the factory point to the Campbell balanced position. Subjects balanced position on average was 2.7 cm. forward (toward the ski tip) of the factory stipulated position. The greatest was 3.4 cm. and least was 2.0 cm. The greatest distance was for a male subject while least was for a female.

Subject	Distance
8	3.4
9	3.0
10	2.5
13	2.5
14	2.0

Table 2: Distance from factory position to Campbell balanced position in cm. for each subject. All Campbell positions are forward (towards the ski tip) of the factory stipulated position.

Table 3 shows that for each tester, the mode of the three trial balancing ranges across all subjects was 0.5 cm. The intratester mean of the range was 0.63 for tester 1 and 0.50 for tester 2. The greatest range for tester 1 was 2.5 cm. and for tester 2 was 1.25 cm. The mean intertester difference in Campbell position was 0.73 cm.

	Tester 1					Tester 2					
Subject	Trial 1	Trial 2	Trial 3	Mean	Rng.	Trial 1	Trial 2	Trial 3	Mean	Rng.	Inter-tester difference
1	10.50	11.00	11.25	10.92	0.75	10.00	11.25	10.00	10.42	1.25	0.50
2	10.75	11.00	10.75	10.83	0.25	10.50	11.25	11.00	10.92	0.75	0.08
3	10.50	11.00	8.50	10.00	2.50	8.50	8.00	8.50	8.33	0.50	1.67
5	9.50	9.50	10.50	9.83	1.00	12.00	12.00	12.00	12.00	0.00	2.17
7	9.75	9.75	9.50	9.67	0.25	9.00	9.50	9.00	9.17	0.50	0.50
8	10.00	10.00	9.50	9.83	0.50	9.50	9.00	9.50	9.33	0.50	0.50
9	9.50	9.00	9.00	9.17	0.50	8.50	8.00	8.50	8.33	0.50	0.83
10	8.50	9.00	9.00	8.83	0.50	9.00	9.00	9.50	9.17	0.50	0.33
13	9.00	9.00	9.00	9.00	0.00	9.50	9.00	9.00	9.17	0.50	0.17
14	11.00	11.00	11.00	11.00	0.00	11.50	11.50	11.50	11.50	0.00	0.50
Mean Range					0.63					0.50	0.73

Table 3: Results in cm. of distance from balancer pivot center to boot toe for each subject and tester.

	Subject No.				
Run No.	8	9	10	13	14
1 Step Exercise	B	A	A	A	A
2 Step Exercise	*	B	A	A	A
2 Free Ski		A	A	B	A
3 Step Exercise	A	B	A	A	A
3 Free Ski		A	A	A	A
4 Free Ski	A	A	A	A	A

Table 4: Shows the preferred binding position of each skier following questioning at the end of each complete run.

Discussion

Results of this study indicate the Campbell Balancer yields a repeatable position that is preferred to the Nordica or Blizzard stipulated position. The greatest range of Campbell balanced positions was 2.5 cm. for subject 3 of tester 1. However, the average range for this tester was only 0.63 cm. For both testers the mode of the range was only 0.5 cm. The mean difference between the factory and Campbell position was 2.7 cm. However, it should be noted the figure is artificially low due to Subject 14's use of Blizzard test skis and the resulting 2.0 cm difference between factory and Campbell position. Calculations with her Campbell number and boot size indicate an actual difference of 4.5 cm. on Nordica test skis. The correction would result in a mean difference of 3.2 cm.

On the step turn portion of testing two skiers at times preferred the factory setting. However, neither preferred the factory setting for free skiing. Subject 13 preferred the factory position for free skiing for one of the four runs. When eventually given a position option for the final free run the balanced position was chosen. It should be noted this subject is

an all-mountain expert skier. His personal skis are 195 cm. mid fats. It is felt that initially he may not have been adapted to the responsiveness of a balanced carving ski.

Certainly to prove the repeatability of the balancer a larger subject population must be tested. However, current results are very favorable. It remains to be seen whether all ski types respond as positively to a balanced position as the all-mountain carving skis used in this test. Specifically short slalom skis should be independently studied.

Conclusion

It was determined that for free skiing, the balanced ski binding position was preferred when compared to the factory stipulated position by 100% of the subjects. The inter and intra tester repeatability of the Campbell Balancer is good and is several centimeters less than the difference between the on-ski balanced and factory stipulated binding positions.

Additional work remains. Ultimately, all ski types should be independently tested using skiing techniques designed for their respective categories. Snow conditions, and terrain changes should be considered. These researchers believe there is a correlation between the Campbell balanced number (distance from balancer pivot center to boot toe) and the location of the ball-of-foot in the ski boot. Therefore, the relationship between the Campbell number and ball-of-foot/center-of-running surface should be examined. Results could provide impetus to change the current boot/ski positioning system. A larger database of balanced positions and on-snow testing should be built. However, from this initial study it is clear the balancer is a valuable reliable tool to improve skier performance and that Nordica W70s utilize a mounting position that is to rearward.

References

Nigg B.M., Schwameder H., Stefanyshyn D. (2000). The effect of ski binding position on performance and comfort in skiing. 2nd International Congress on Skiing and Science, January 2000, St. Christoph, Austria, Book of Abstracts.