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## Translation of International Snow-Sports Equipment Standards into Injury-Prevention Practice

### Reference

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### ABSTRACT

International industry standards set out requirements to mount ski bindings, test equipment functionality, provide guidelines on how to maintain the ski-binding-boot interface, and calculate correct release values. The standards call for the use of a torque testing device to assess functionality of the ski-binding with release values based on parameters of age, weight, height, boot-sole length, and skier type. To determine whether these standards were being applied in New Zealand a cross-sectional study was completed with a national survey of ski technicians and structured interviews with senior ski industry personnel. In setting up ski bindings, only 10 % of ski technicians used a torque-testing device, and substantial proportions did not take into account appropriate skier characteristics or check the boot-binding interface. Interviews of senior personnel indicated that there was good intent about quality of rental service;

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however, there were inconsistencies between operating procedures and international standards. The interviews also highlighted a need for better standardized questioning techniques for ski technicians to accurately determine skier type, and increased education for both ski technicians and skiers on correct setup to prevent injury related to non-release or inadvertent release. In conclusion, Ski-Binding-Boot (SBB) system inspection, routine torque testing to ensure safe functional ski-bindings, and consistent application of the international standards for correct setup of ski-binding-boot systems continues to be elusive in New Zealand. Assessment of the implementation of the international standards in other countries is also needed.

### Keywords

alpine skiing, equipment, standards, ski-binding-boot system, torque, injury

## Introduction

International standards provide the ski industry and snow sports participants with the framework for ensuring supply of snow sports equipment of good quality, increased interoperability of products, service quality, and equipment-related safety practices [1–6]. There is presently no mandatory requirement for members of the Ski Areas Association of New Zealand (SAANZ) or the New Zealand Snow Industries Federation to comply with the international standards. Standards New Zealand is a member of the International Standards Organisation (ISO), but has no representation on the Sport & Recreational Equipment Committee T83 or the sports equipment subcommittees for ski bindings (S3) or skiing and snowboarding (S4). New Zealand does not have technical membership with the American Society for Testing and Materials International (ASTM) either. SAANZ members have worked together over decades on projects to enhance skiing safety; momentum has changed dependant on the work of enthusiastic individuals or the commercial challenges of the winter season. The steady increase in United States ski rental facilities complying with ASTM F1064-03 [3] was an important part of the decline in the lower leg injuries between 1972 and 1989 [7]. In 2006, concern was raised by Ettlinger et al. [7] that the ski industry began to look at the newly established standards “as a ceiling for their efforts and not the floor, resulting in a gradual decline in service.” This study explored whether New Zealand ski rental shop practices for setup of ski equipment benchmarked to international standards.

## Methods

Electronic searches of Pubmed, Medline, SportDiscus, and Standards Organisation databases were performed for standards related to alpine skiing. Standards that were not current were excluded from the study. Standards with content related to alpine skiing, ski binding construction, ski binding testing methods, ski boot construction checks, and ski binding boot system (S-B-B) setup informed the development of questions for the survey and interviews. Ethics approval for the survey and interviews was gained from the AUT Univ. Ethics Committee (number 07/158).

New Zealand Snow Sports Council supplied the list of member organisations in Ski Areas Association New Zealand (SAANZ) and the New Zealand Snow Industries Federation. Anonymised numbered questionnaires for ski technicians were delivered personally to all major ski areas and large off-hill rental facilities in 2007 and by post in 2009. The term ski technician broadly described the rental shop workforce (it is noted that in some settings this term is reserved for those that have comprehensive roles of setup that include mounting ski bindings, maintaining edges and bases, torque testing, and repairing the S-B-B systems). Recorded interviews were undertaken with key personnel based on 14 set questions. Key personnel were senior staff that were either directly involved in ski-binding-boot setup or management of service quality. Rental shop managers and operations managers or general managers at all major ski areas were interviewed. Thematic analysis of interview data was subsequently completed.

## Results

Of the 424 surveys circulated to all commercial ski areas in New Zealand and large off-hill rental facilities, 227 surveys were completed and returned (an overall response rate of 54 %). The demographics of the rental shop workforce were 50 % had more than three seasons' experience in S-B-B setup, 22 % one to three seasons experience, and 28 % were new that season. Interviews were completed with 23 key industry personnel. Interviews generally took 45 min.

A high percentage of survey participants reported that ISO release selection tables were used to determine release values, but when asked separately about each parameter, required to check during the setup of S-B-B systems: age, height, weight, and boot sole length was not always checked (see **Table 1**). Only 10 % of ski technicians surveyed used a torque testing machine. These ski technicians worked at an off-hill rental shop in Queenstown. No commercial ski areas or other off-hill rental outlets used torque testing machines or torque wrenches in pre-season testing, in-season testing, or during setup.

In interviews, it was established that all ski areas had standard operating manuals for the rental shop; however, only one off-hill rental shop of the seven had an operating manual. Training for staff was mostly on-job coaching, and <50 % received formal pre-season training. All respondents expressed a desire to have more education from ski manufacturers, with the majority commenting that ski manufacturers appeared to have abandoned educational input on ski maintenance, testing, and correct setup. Equipment service and ongoing maintenance schedules for rental equipment were largely based on constant vigilance, with gear checked on- return for damage. One respondent noted that "ski equipment is better manufactured than 10 years ago. In the eruptions (on Mt Ruapehu in 1995–1996) we replaced all the bindings, and now, with no rope tows, Cats (groomers) not dropping oil, and snow-making, there is less dirt and debris that can get into the binding—this could still be an issue on some fields." Some binding systems had replaceable anti-friction plates, toe-pieces, and heel-pieces, which were routinely

**TABLE 1** Responses of ski technicians to questions about ski set-up (%).

	Yes	Sometimes	No
<b>General</b>			
Use of release value selection table	85	13	2
Change of set-up practices in rush hour	4	42	54
Snow conditions taken into account	24	—	76
<b>Skier characteristics taken into account</b>			
Age	81	15	4
Gender	16	—	84
Physical condition (fitness)	47	31	22
Height	55	13	32
Weight	48	12	40
Beginner of 7 days skiing or less	37	—	63
<b>Checking of equipment</b>			
Ski-boot size	68	11	21
Ski-boot wear and tear	68	22	10
Ski-binding-boot compatibility	79	10	11
Ski-binding elastic travel in twist	79	—	21
Ski-binding elastic travel in forward lean	75	—	25

Note: Data are proportions of those who responded to the item; missing values were <3%.

inspected and replaced. Equipment was generally retired from the rental fleet after three or four years.

Approximately one-third of respondents thought that a national stance was needed on determining skier type. Suggestions included using "conservative" rather than "beginner" as a description, and providing a greater range of descriptors for type II skiers. Last time skiing and average number of days also needed to be factored into determining skier type. Beginner, intermediate, and advanced were the most common terms used on rental documentation, not international standard skier type I to III classifications. Posters on skier type or general public information on correct setup were not commonly displayed. Some ski technicians made additional adjustments for some at-risk groups. The decisions by ski-technicians to lower the release settings for at-risk groups were not based on guidelines in Standard Operating Manuals.

Manufacturer workshops were requested by two-thirds of the respondents, and educational input from ski patrollers on injury patterns was suggested by approximately one-third. Up to three respondents requested development of each of the following: user-friendly release-value selection tables without confusing arrows, guidelines on lower release settings for at-risk groups (gender/female, light-weight males, beginners of less than 7 days skiing and those in poor physical condition), direction on additional adjustments for wet heavy snow conditions, specific education on S-B-B setup for children, boot-fitting education, and injury prevention education.

Suggestions for education packages for skiers were diverse and mostly singular; however, approximately one-third of respondents thought Information technology was under-utilised, and that unsafe vintage ski equipment should be removed from sale (predominantly sold in ski-swaps' and on-line sales). There appeared to be two viewpoints on where skier education should start: in rental shops, as this was the first-place that those who are new to snow sports congregate, versus in other mountain facilities, where it was not so busy. One respondent noted that customers often did not understand why they needed to divulge private information like weight, and thought that simple messages needed to be displayed in rental shops on the importance of accurate information on skier characteristics to ensure correct setup.

## Discussion

The main finding in this study is that most rental shops did not test S-B-B systems with a torque device even though the international standards require torque testing. Three- to four-year rental-fleet replacement cycles were in place to ensure the supply of safe functional ski-bindings. However, without torque testing there is no guarantee that the equipment replacement cycles are supplying functional equipment. In the standards, S-B-B systems are withdrawn from service when the torque S-B-B is less than or greater than 45 % from the reference point (Class III deviation) [3,6]. Manual checks in twist and forward lean test elastic travel and confirm that the ski-binding will return to centre. Ski technicians checked elastic travel most of the time; however, these checks do not replace torque testing.

The ISO release value selection tables were used by ski technicians across New Zealand. Inconsistency in acquisition of the skier characteristics for correct setup was a key finding. The parameter of weight was not acquired over a third of the time: weight is an essential characteristic in determining release values. The ISO tables do not provide direction on lowering release settings for at-risk groups, yet, additional adjustments were frequently made for skiers in poor physical condition, sometimes for beginners, and occasionally for females. The French national standards organisation, AFNOR, have lowered release values 5 %–15 % for groups that have a greater risk of lower limb injury: women, light-weight men (less than 57 kg), beginners with less than seven days skiing, and skiers in poor physical condition [8]. Some other countries have adopted the French recommendations on adjustment release values, creating unanswered questions for other skiing nations; it would be of value to all be on the same standards page. Release values were changed by nearly a quarter of respondents in wet heavy snow conditions. Guidelines on additional S-B-B adjustments in wet heavy snow conditions would also be useful.

Skier type I, skier type II, and skier type III selection criteria were not commonly displayed in rental shops or described on rental documentation. Some ski areas procedures had technicians ask the skier if they were a beginner, intermediate, or advanced skier without defining these subjective terms; this practice creates the potential for incorrect categorisation of skier type by the skier, and setup of an inappropriate release setting.



Omissions when checking equipment were also reported by some ski technicians. Proper release from ski-bindings depends on the dimensions and design of the ski-boot sole and the ski-boot heel [9]. Omitting wear and tear checks may lead to incompatible S-B-B systems. Snow cover in New Zealand ski areas in the Southern Alps and volcanic plateau of the North Island is affected by the maritime climate. It is not uncommon for skiers to walk over rocky surfaces in ski-boots to get to the snowline, leading to accelerated wear. A boot sole when worn will not interface correctly with the ski-binding, creating the potential for premature release. Respondents reported that replacement toe-pieces and heel-pieces were not always supplied by manufacturers with new ski-boots and that importing these parts separately was expensive. Any delays in replacing toe-pieces or heel-pieces could lead to incompatibility of the ski-boot to the ski-binding. An additional problem is a dirty ski-boot sole; dirt could render the anti-friction device ineffective and compromise release. The S-B-B interface could also be negatively affected if defective anti-friction devices are not replaced promptly.

One of the many challenges for skiers is to have the correct size of boot. Survey results indicated that some ski technicians did check boot size, and interview respondents noted that more education on boot-fitting was needed. For large rental operations, ensuring a comfortable fit may be a level of service that is marginalised by the pressures to get numbers through the rental facility and out on to the slopes.

## Conclusion

There is room for improvement in rental shop practices across New Zealand. International standards should be the base-line for good service [3,6]. Direct involvement by New Zealand representatives in writing standards could lead to greater buy-in and translation of these standards to everyday practice. New Zealand rental shops need to be properly equipped with torque testing machines or wrenches. Torque testing should be mandatory to ensure functional ski-binding spring and lever systems that work at the correct torque in twist at the toe-piece and in forward-lean at the heel-piece. Consistent acquisition of all parameters for determining the correct release selection is paramount [5]. Understanding why all setup steps need to be followed correctly is an important educational bottom-line for both the ski technician and the skier. More discussion at international standards bodies is warranted on the classification of skier type using contemporary, unambiguous language. The different viewpoints on lowering release values for skiers that are at-risk of lower limb injury have the potential to confuse ski technician decision-making. Concurrence is needed on ski-binding release values for women, light-weight men, beginners with less than seven days skiing, and skiers in poor physical condition [1,8]. Given that ski technicians are also making ski-binding adjustments in different snow conditions, guidelines are needed to inform these decisions. Translation of the international standards into skier education is vital for torque testing and correct setup, all of which is demanded by the customer.

## Appendix: Ski Binding Adjustment Survey

### A. PRESENT POSITION

Please tick the one response that best applies to you.

#### 1. Which of the following best describes your ski industry employment?

Full-time ski rental worker	[ ]
Part-time ski rental worker	[ ]
Full-time ski retail & rental worker	[ ]
Part-time ski retail & rental worker	[ ]
Only retail new skis	[ ]
Ski mechanic	[ ]

### B. WHAT BACKGROUND DO YOU HAVE IN ADJUSTING SKI BINDINGS

#### 2. Which of the following best describes your background in adjusting skis as a part of your employment?

New this season	[ ]
1 – 3 seasons	[ ]
Over 3 seasons	[ ]

#### 3. What orientation did you receive specific to adjusting ski bindings in 2007?

None	[ ]
Relied on my own experience	[ ]
Informal demo from other staff	[ ]
In a workshop run by my employer	[ ]
In a workshop run by my employer with additional input from ski industry reps	[ ]
Completed NZQA unit standard education. Specify NQF number(s)	[ ]

Overseas experience had <u>no</u> recent training update	[ ]
Overseas experience had recent training update	[ ]

### C. WHAT TESTING DEVICE DO YOU USE?

4.	Yes	[ ]
Mechanical	No	[ ]
	Partly	[ ]
Manual	Only	[ ]

### D. ADJUSTING SKI BINDINGS

#### DIN (Deutsche Industrial Norm)

#### 5. Do you use a ski binding DIN chart?

Never	[ ]
Sometimes	[ ]
Always	[ ]

#### 6. What type of ski binding DIN chart do you use?

ISO	[ ]
AFNOR	[ ]
ASTM (height, weight, sex, age)	[ ]
German (tibial diameter, age, sex)	[ ]
Manufacturer	[ ]
Specify Manufacturer	[ ]

#### 7. Do adjustment practices change during rush hours?

Yes	[ ]
No	[ ]
Sometimes	[ ]

#### 8. Do clients accurately indicate their alpine skiing ability?

Never	[ ]
Sometimes	[ ]
Always	[ ]

#### If sometimes, what do clients say about their alpine skiing ability?

Understate	[ ]
Overstate	[ ]
Unsure - ask for a wider range of parameters to more accurately define their ability	[ ]

#### 9. Do you factor in snow conditions when setting bindings?

Yes	[ ]
No	[ ]

If yes, describe

#### 10. Do you factor in age when setting bindings?

Yes	[ ]
No	[ ]
Sometimes	[ ]

#### 11. Do you factor in physical condition (fitness level) when setting bindings?

Yes	[ ]
No	[ ]
Sometimes	[ ]

#### 12. Do you use lower settings (additional adjustments)?

For young people under 14 yrs	[ ]
For females	[ ]
For beginners of 7 days skiing or less	[ ]





## CRITICAL REVIEW OF SKI BINDING ADJUSTMENT STANDARDS AND RELATED RESEARCH

### Interview Questions

1. Do you think that in general workers that adjust ski bindings understand their role in the prevention of injury?
2. Do you think that in general workers that adjust ski bindings understand the mechanics of injury to the lower leg and knee?
3. Do you think that in general workers that adjust ski bindings know what is required for safe functioning ski binding release?
4. Does your place of work have a ski binding adjustment policy?
5. Do you have an operations manual?
6. What input do you receive from commercial binding manufacturers?
7. What training is provided to workers that adjust ski bindings to ensure best practice standards are understood and being applied?
8. What advice is given to customers purchasing new bindings?
9. What is your place of work service and ongoing maintenance schedule for rental equipment?
10. When is rental equipment retired from rental service?
11. Do you have any suggestions for improvements in current service?
12. Do you have any suggestions for education packages for staff?
13. Do you have any suggestions for education packages for skiers?
14. Are there any other comments you wish to make in regards to this research?

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