

Changes in Skiing and Snowboarding Injury Epidemiology and Attitudes to Safety in Big Sky, Montana, USA

A Comparison of 2 Cross-sectional Studies in 1996 and 2013

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Background: Despite a risk of harm, the past 20 years have seen dramatically increased participation in snow sports such as skiing, and particularly, snowboarding. This period has also seen revolutions in piste maintenance and paradigm developments in the use of safety equipment. Consequently, the numbers and characteristics of injury may be very different from those traditionally quoted.

Purpose: To compare and evaluate the injury patterns among skiers and snowboarders in a North American ski resort in 1996 and 2013.

Study Design: Cross-sectional study; Level of evidence, 3.

Methods: Questionnaire-based cross-sectional studies were carried out independently in a North American ski resort between the dates of March 6 and April 11 in both 1996 and 2013. Demographic data and information about incident circumstances were collected from injured patients who visited the local on-site clinic. Data were compared statistically to assess for significant changes in injury characteristics between the 2 time periods.

Results: The 1996 report consisted of 148 injured participants, and the 2013 study included 156 participants. Results from 2013 demonstrated significant increases in helmet use, the number of snowboarders injured, and shoulder injuries. Injury was also more likely in those aged 46 to 55 years, those never having had professional instruction, or those with rented equipment. Significant reductions were seen in those injured with other people close by and in the 36- to 45-year age group. Overall, the knee was the most commonly injured body part in both periods (1996: 31%, n = 38; 2013: 33%, n = 36), although upper limb injuries were predominant in snowboarders.

Conclusion: Snow sports injury characteristics of patients presenting to a ski resort medical clinic have changed between 1996 and 2013. These findings can be used to further inform safety recommendations and areas to target with further research.

Keywords: skiing injuries; snowboarding injuries; snow sports

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Skiing, snowboarding, and other snow sports activities are enjoyed by many worldwide, and with expansion of ski areas, faster ski lifts, and the use of snow machines, accessibility is increasing. In the United States alone, over 18 million people aged 5 years and older participated in Alpine skiing or snowboarding at least once during the 2011-2012 season, and approximately 12 million people older than 7 years participated twice or more in 2011.¹¹ Furthermore, many people who primarily snowboard also ski, and likewise, those who primarily ski may also snowboard.¹¹

Participation in such pursuits carries a risk of injury. The factors that influence this risk are varied and complex,

involving everything from the weather¹³ to personal attitudes and behaviors (including the use of drugs and alcohol).⁴

Some nonbehavioral factors have been shown to be modifiable. Ski boots, once made of soft leather, are now constructed from hard plastic, providing rigid support to the lower leg and ankle. This change was largely responsible for the huge reduction in ankle injuries sustained by skiers since the 1970s.⁷ However, the resultant shift in stress up to the knee joint may be the main reason for an increase in knee injuries, especially to the anterior cruciate ligament (ACL).⁶ In addition, changes in design of ski bindings to ones that release the skis when a set force is applied and growth in popularity of shaped skis, which make turning easier, may also have an impact on injury.

Much work in the past 20 years has gone into the development of safer skiing environments, such as pisting (use of specialized vehicles that smooth and flatten the main ski routes) and designated slower skiing areas, and also into improving protective clothing and equipment for skiers and snowboarders, but the real impact of such changes is unknown.

The use of a helmet to protect from head injury would seem largely intuitive and is widely advocated.⁵ However, helmet use is not yet compulsory on the mountain, and some opponents suggest their use encourages risk-taking behavior, which in turn could lead to more injuries.¹² Although such arguments have been discounted by others, there is little more than anecdotal evidence of benefit.⁵ Similarly, wrist guards are recommended for snowboarders, but the technology and research are still in the early stages of development and there is no consensus guidance on their use.

Therefore, the aim of this study was to compare and evaluate the injury patterns among skiers and snowboarders in a North American ski resort in 1996 and 2013.

METHODS

Study Location

Big Sky Ski Resort is located in Montana, USA. When combined with neighboring Moonlight Basin Ski Resort, it forms part of the largest ski area in North America, covering a total of 5532 skiable acres in 2013 (Table 1). The resort consists of 220 different slopes and over 110 miles on 3 separate mountains, including a variety of open slopes, gladed runs, and bowls. In addition, the nearby private ski area, Yellowstone Club, covers an additional 2200 skiable acres.¹⁷ For comparison, in 1996, the total skiing acreage accessible from the Big Sky Resort was estimated to be 3600.

The on-site clinic is located near the base area at the bottom of the mountain and is the closest medical facility for all 3 ski areas. The clinic is open 7 days a week during the winter season and shares the building with ski patrol headquarters, making it the first point of call for any injured patients transported from all 3 ski resorts.

TABLE 1
Ski Area Information and Study Participants^a

	Year	
	1996	2013
Visits to Big Sky, March 6–April 11 (not including Moonlight Basin or Yellowstone Club), n	NA	103,103
Skiing acreage (Big Sky and Moonlight Basin) (approximate)	3600	5532
Eligible patients, n	203	225
Study participants, n (%)	148 (73)	156 (69)
Big Sky Ski Patrol rescues (not including Moonlight Basin or Yellowstone Club), n	NA	177

^aNA, not available.

Study Design

This was a cross-sectional study. As no externally validated tools existed for such a study, and the questionnaire template from a 1996 study was unavailable at time of designing the 2013 investigation, a new questionnaire was designed. This was based largely on results of the previous study, although with additions and modifications made in light of current thinking and after a search of the literature.

The questionnaire was short (2 sides of size A4 paper) and designed to be easily and promptly completed at interview, with mostly tick box–style questions (see the Appendix). The data collected in 2013 were then compared with that from 1996. To avoid any seasonal differences, the study was conducted in the same time period: March 6 to April 11 inclusive. Participants were eligible for inclusion if they presented to the clinic with a snow sport–related injury and were able to give consent.

Data Collection

Questionnaire data were collected between March 6 and April 11, 2013. Patients who attended the clinic as a result of a snow sports–related injury were invited to complete the questionnaire after treatment had been received. Informed consent was obtained from the individual in all cases and additional parental consent for younger participants (those younger than 12 years). The questionnaire was designed for self-report; however, those unable to write on account of their injury were assisted by clinical staff.

Not every section of the questionnaire was completed by participants, and therefore, the denominator varies in the responses.

Variables Included for Comparison of 1996 and 2013 Data

A copy of questionnaire data from March 6 and April 11, 1996, which formed part of a previous study, was obtained² subsequent to the completion of the 2013 tool. Only

questions present on both questionnaires that were identical or had very similar response options were included for comparative analysis. Questions were excluded from comparative analysis if they were not present in both 1996 and 2013.

Ethical Considerations

Approach for formal ethical approval was made through recognized channels, but this was deemed to be a service evaluation. Informed consent was obtained in each case, questionnaire sheets were stored securely, and no record was made of any identifiable information.

Statistical Analysis

To compare data from 1996 and 2013, a chi-square analysis was used to analyze for differences in grouped variables and independent *t* tests for continuous variables. A *P* value of <.05 was considered significant. All statistical analyses were carried out using SPSS (v 20; IBM Corp).

RESULTS

The overall proportions of patients eligible to complete the questionnaire were similar for the 2 time periods (148/196 [73%] in 1996 and 156/225 [69%] in 2013) (Table 1). From March 6 to April 11, 2013, there were 103,103 visits to the ski lifts, and during this time, ski patrol transported 177 people off the mountain (Table 1).

Of the injured participants in 1996, 124 (84%) were skiers and 24 (16%) were snowboarders. In 2013, 112 (73%) were skiers and 41 (27%) were snowboarders (Table 2).

The mean age in both 1996 and 2013 was 34 years, but the age distribution varied. When analyzed in 10-year groups, 2013 revealed a reduction in the proportion of injuries in the 36- to 45-year age group (29% to 13%) while injuries in the 46- to 55-year bracket were more likely (12% to 21%) (Table 2). When age was considered for skiers and snowboarders in isolation, these differences were only significantly apparent in skiers (*P* = .016).

The number of respondents wearing a helmet significantly increased from 1996 to 2013 (6% to 84%) (Table 2). Overall, the most common site of injury was the knee in both time periods (about 28% in both 1996 and 2013), particularly in skiers. The proportion of shoulder/arm injuries increased significantly between 1996 and 2013 both for skiers and snowboarders alike. The most common injuries among snowboarders in 1996 were shoulder/arm (21%, *n* = 5) and wrist (21%, *n* = 5), and in 2013, shoulder/arm injuries (33%, *n* = 13) predominated. However, this did not represent a statistically significant change.

In both years, the majority of patients had never previously sustained a snow sports injury (Table 2), and injuries were more likely in the afternoon (1996, 54%; 2013, 61%) than the morning, although this was not statistically significant (Table 2).

TABLE 2
Comparison of Data From 1996 and 2013^a

	Year		<i>P</i> Value ^b
	1996	2013	
Sport			
Skiing	124 (83.8)	112 (73.2)	
Snowboarding	24 (16.2)	41 (26.8)	.026
Helmet use			
Yes	8 (5.8)	129 (83.8)	
No	131 (94.2)	25 (16.2)	<.000
Area injured			
Head	18 (12.2)	12 (8.0)	
Neck	0 (0.0)	3 (2.0)	
Shoulder/arm	20 (13.6)	41 (27.3)	.024
Wrist/hand	35 (23.8)	27 (18)	
Knee	41 (27.9)	42 (28)	
Foot/ankle	21 (14.3)	18 (12)	
Spine/back	7 (4.8)	7 (4.7)	
Hip/pelvis	1 (0.7)	0 (0.0)	
Chest	4 (2.7)	0 (0.0)	
Age group, y			
≤10	8 (5.4)	15 (9.6)	
11-17	21 (14.2)	22 (14.1)	
18-25	17 (11.5)	20 (12.8)	
26-35	29 (19.6)	26 (16.7)	
36-45	43 (29.1)	20 (12.8)	.08
46-55	17 (11.5)	33 (21.2)	.08
>55	13 (8.8)	20 (12.8)	
Time			
0900-1200	60 (46.5)	57 (39.3)	
1200-1700	69 (53.5)	88 (60.7)	
Previous injury			
Yes	33 (23.6)	38 (25.9)	
No	107 (76.4)	109 (74.1)	
Prior instruction			
Yes	102 (81.0)	103 (70.1)	
No	24 (19.0)	44 (29.9)	.038
Speed			
Slow	41 (29.7)	43 (30.3)	
Moderate	70 (50.7)	66 (46.5)	
Fast	27 (19.6)	33 (23.2)	
Crowding			
Clear	27 (24.1)	127 (84.7)	
Other skiers nearby	85 (75.9)	23 (15.3)	<.000
Transport			
Unaided	86 (59.3)	80 (53.3)	
Ski patrol	57 (39.3)	70 (46.7)	
Equipment			
Rented	29 (26.6)	57 (38.5)	.046
Owned	80 (73.4)	91 (61.5)	

^aValues are reported as n (%).

^bOnly significant *P* values are provided.

In 1996, there were 19% (*n* = 24) of injured patients who had never received professional instruction in skiing/snowboarding, compared with 30% (*n* = 44) in 2013 (*P* < .038). The number of injuries sustained with rented equipment increased from 27% (*n* = 29) in 1996 to 39% (*n* = 57) in 2013 (*P* = .046).

Most patients in both periods came to clinic without the aid of ski patrol (Table 2).

DISCUSSION

This study demonstrates some significant changes in snow sports injury characteristics in the patients presenting to Big Sky Medical Clinic in 2013 compared with 1996. Overall, clinic attendances were up in 2013, likely due to the increases in ski area and number of participants, although it was not possible to delineate this with certainty.

Some have suggested that the rise in proportion of snowboard-related injuries, in this study from 16% in 1996 to 27% in 2013, is representative of increased participant risk-taking behavior.^{10,12} However, it seems more likely that the difference is largely due to the increasing popularity of snowboarding in the past 20 years.¹⁴

There was also a shift in the age of those injured in 2013, with injuries occurring more often in an older population (46-55 years vs 36-45 years in 1996), but when considered for each sport, this finding was only true for skiers. Reasons for this are unclear.

One of the most striking observations was the difference in helmet use among those attending the clinic, from 6% in 1996 to 84% in 2013—higher than other reports.^{3,11} Interestingly, all 16 people who sustained a head injury in 1996 had no helmet protection, but in 2013, 10 of 12 people who sustained a head injury were wearing a helmet. However, no inference on the impact of headgear on head injuries can be made from this study design.

The knee was the most commonly injured body part among skiers both in 1996 and 2013—a finding echoed in other studies.^{14,16} Knee injuries appear difficult to prevent due to the relatively low twisting forces that can result in significant ligament and cartilage injury. Although work to develop bindings that are more protective to the knee has been undertaken, as yet, no successful products are available commercially.¹⁵ A significant increase in shoulder/arm injuries was observed in skiers between 1996 and 2013, and further research is needed to assess whether this trend is found in other resorts.

Injuries to the wrist and shoulder/arm were the most common in snowboarders in both 1996 and 2013—a finding supported by previous studies.⁸ Research is currently ongoing into wrist guards, and it is hoped that these may provide a good level of protection to snowboarders, who are vulnerable to falling onto their hands, especially as beginners.⁹

A higher proportion of people in both time periods were injured in the afternoon. Again, this is in line with other reports and may be due to a wide range of factors, including tiredness, business, heavy lunches, or alcohol intake, which may impair ability,¹ as well as changes in snow conditions.

This study also demonstrated increases in the number of injured patients who had no prior professional instruction (19% to 30%) and who were using rented equipment (27% to 39%) in 2013. The high number of first-time injuries presenting to clinic in both time periods may be due to injuries in relatively inexperienced participants, but this was not clear from our data.

Injuries occurring with no other skiers or snowboarders nearby rose significantly from 24% to 85% in 2013. The increase in skiing acreage from 3600 to 5532 may partly

explain this, but it remains unclear whether less crowding is a risk for injury, for example, due to faster speeds or a more care free approach.

Limitations

Although no one approached refused consent to take part in the study in both 1996 and 2013, at times of increased workload at the clinic, some eligible patients were missed. Furthermore, some patients with severe injuries rescued by ski patrol went directly to a hospital, and some with minor injuries brought to the clinic left before being seen by medical staff. Comparative data regarding the injury profile and destination of patients transferred by ski patrol were not available. In addition, the lack of true denominators (such as total number of skiers/runs, etc) inhibits injury rates being calculated and subsequent inferences being drawn. Future research assessing these factors would be valuable, as would the integration of follow-up reports confirming diagnoses.

Although the questionnaire forms for 1996 and 2013 were similar, they were not identical, and this may have had an impact on how participants responded to certain questions. Data were collected prospectively in both time periods.

This study involved only a single center, but the clinic is the only facility in the entire resort and therefore captures injuries from all ski areas.

Questionnaires were completed in real time; however, recall bias cannot be ruled out. Confounding factors including differences in seasonal snow conditions, crowding, ski racing/sports, and amount of trail grooming also reduces the ability to draw inferences that will affect the practice of sports medicine.

CONCLUSION

Significant changes in snow sports injury characteristics between 1996 and 2013 are apparent. These findings along with other studies can be used to help guide safety recommendations and areas to target with further research.

REFERENCES

1. Barnas C, Miller CH, Sperner G, et al. The effects of alcohol and benzodiazepines on the severity of ski accidents. *Acta Psychiatr Scand*. 1992;86:296-300.
2. Coury T, Napoli AM, Wilson M, Daniels J, Murray R, Milzman D. Injury patterns in recreational alpine skiing and snowboarding at a mountainside clinic. *Wilderness Environ Med*. 2013;24:417-421.
3. Fenerty L, Thibault-Halman G, Bruce BS, et al. Helmets for skiing and snowboarding: who is using them and why. *J Trauma Acute Care Surg*. 2013;74:895-900.
4. Gaudio RM, Barbieri S, Feltracco P, et al. Impact of alcohol consumption on winter sports-related injuries. *Med Sci Law*. 2010;50:122-125.
5. Haider AH, Saleem T, Bilaniuk JW, Barraco RD; Eastern Association for the Surgery of Trauma Injury Control Violence Prevention Committee. An evidence-based review: efficacy of safety helmets in the reduction of head injuries in recreational skiers and snowboarders. *J Trauma Acute Care Surg*. 2012;73:1340-1347.
6. Hunter RE. Skiing injuries. *Am J Sports Med*. 1999;27:381-389.
7. Johnson RJ, Ettlinger CF, Shealy JE. Skier injury trends 1972 to 1994. In: Johnson RJ, Mote CD Jr, Ekland A. *Skiing Trauma and Safety*.

Volume 11. West Conshohocken, PA: American Society for Testing and Materials; 1997:37-48.

8. Kim S, Endres NK, Johnson RJ, Ettlinger CF, Shealy JE. Snowboarding injuries: trends over time and comparisons with alpine skiing injuries. *Am J Sports Med.* 2012;40:770-776.
9. Kim S, Lee SK. Snowboard wrist guards—use, efficacy, and design. A systematic review. *Bull NYU Hosp Joint Dis.* 2011;69:149-157.
10. Koehle MS, Lloyd-Smith R, Taunton JE. Alpine ski injuries and their prevention. *Sports Med.* 2002;32:785-793.
11. National Ski Areas Association. 1) 2011 Snowboarding Participation. 2) 2011 Downhill Skiing Participation. 3) Facts/Skiing and Snowboarding Safety. <http://www.nsa.org/>. Accessed June 25, 2014.
12. Ruedl G, Kopp M, Burtscher M. Does risk compensation undo the protection of ski helmet use? *Epidemiology.* 2012;23:936-937.
13. Ruedl G, Fink C, Schranz A, Sommersacher R, Nachbauer W, Burtscher M. Impact of environmental factors on knee injuries in male and female recreational skiers. *Scand J Med Sci Sports.* 2012;22:185-189.
14. Rust DA, Gilmore CJ, Treme G. Injury patterns at a large Western United States ski resort with and without snowboarders: the Taos experience. *Am J Sports Med.* 2013;41:652-656.
15. St-Onge N, Chevalier Y, Hagemester N, Van De Putte M, De Guise J. Effect of ski binding parameters on knee biomechanics: a three-dimensional computational study. *Med Sci Sports Exerc.* 2004;36:1218-1225.
16. Warme WJ, Feagin JA Jr, King P, Lambert KL, Cunningham RR. Ski injury statistics, 1982 to 1993, Jackson Hole Ski Resort. *Am J Sports Med.* 1995;23:597-600.
17. Yellowstone Club. <http://www.yellowstoneclub.com/>. Yellowstone Mountain. Accessed June 25, 2014.

APPENDIX
Incident Questionnaire

This questionnaire is ANONYMOUS, please do not write your name on it.

Please check boxes where appropriate

Age:

Sex: Male Female

Where's home?

Weight (in pounds):

Height (in feet):

Are you a: Skier Snowboarder Other

Skill Level: Beginner Intermediate Advanced

Have you ever attended ski/snowboard school? Yes No

Have you ever had private lessons? Yes No

Time of incident?

What type of incident?

Fall Collision with another person Collision with an object

Ski lift incident Non ski/snowboard related

If you fell, did you fall: Forwards Backwards Sideways

Is your equipment: Rented Own equipment

Were you wearing a helmet? Yes No

Were you wearing other protective equipment? Yes No

If yes please state what?

Where did the incident occur? (please give slope name)

Slope difficulty?

How crowded? Clear Busy (5-10 people close by)

Very busy (10+ people close by)

Visibility conditions: Clear Up to 150 ft Less than 50 ft

Snow conditions: Powder/Soft Good/groomed Icy

What speed were you travelling? Stationary Slow Moderate Fast

Were you the only person injured? Yes No

Was your equipment was at fault? Yes No

If yes please state fault:

How did you arrive here? Unaided Ski Patrol By Friends By the Hotel

Where is your injury (please check all areas injured)?

Head Neck Shoulder/Arm Wrist/hand Knee Foot/Ankle

Spine/Back Hip/pelvis

Any alcohol intake within 4 hours before the incident? Yes No

Any illegal drugs/substances taken up to 24 hours before the incident? Yes No

If yes please state substance

Do you suffer from any of the following:

Asthma Type 1 Diabetes Type 2 Diabetes High blood pressure

Any other medical conditions? please state:

Have you had any previous snowsports accidents that have required medical attention? Yes No

Finally, were there any measures that you think could have prevented your injury/incident?

Thank you for taking the time to complete this!