

Snowboarding Injuries

A Four-Year Study With Comparison With Alpine Ski Injuries

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Snowboarding is a rapidly growing winter sport. Its unorthodox maneuvers and young participants raise many safety concerns. We examined injury patterns in recreational snowboarders, comparing these patterns with those found in alpine skiers. Snowboarding and skiing injury patterns differed significantly ($P < .05$) for the following categories: 49% of injured snowboarders were beginners versus 18% of skiers. Snowboarders were more likely to suffer wrist (19% versus 2%) and ankle (16% versus 6%) injuries, but less likely to sustain knee (17% versus 39%) or thumb (2% versus 4%) injuries than skiers. For snowboarders, wrist injuries were most common in beginners (30%), knee injuries in low intermediates (28%), ankle injuries in intermediates (17%), and shoulder or clavicle injuries in advanced snowboarders (14%). Most snowboarders (90%) wore soft-shelled boots, 73% of lower extremity injuries occurred to the lead-foot side, and 73% of wrist injuries occurred during backward falls; 67% of knee injuries occurred during forward falls. Of all injuries, 8% occurred while loading onto or unloading from a ski lift. The sport of snowboarding brings with it a different set of injuries from those seen in alpine skiing. The data focus attention on improvements such as wrist guards or splints, releasable front-foot bindings, and better instruction for beginner snowboarders to improve the safety of this sport. Finally, the data confirm that snowboarders and skiers may be safely combined on the same slopes.

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Despite initial concerns over safety and liability, snowboarding has grown into a major winter sport. Now welcome at most North American ski resorts, snowboarders with their baggy pants and flannel shirts are predicted to have grown from an estimated 100,000 North American participants in the 1989-1990 season¹ to an estimated 20% to 30% of all lift-ticket holders by the 1999-2000 season, according to the publishers of *Transworld Snowboarding* (written communication, March 1994). Their skateboard- and surfboard-like maneuvers, both on snow and in the air, strike fear and dismay into the hearts of traditional alpine skiers and raise concerns over issues of safety to self and others (K. Hamilton, "Culture Clash on the Slopes," *Newsweek* 1993, 2:51).² This project was designed to characterize snowboarding injury patterns and to determine what factors influence these injuries and whether snowboarding and alpine skiing are compatible sports.

The first snowboards were called "snurfers" and were designed and developed by Sherwin Popper during the 1960s in Michigan (P. Shelton, "Riding a New Wave," *Skiing* 1988 Spring, 40:108-111, 127; P. Shelton, "I Surfed the Rockies," *Powder* 1987, 15:88-94; and E. Blankman, "Boards Ablaze," *Powder* 1987, 15:95-100, 120).¹ These first boards were made of wood with a skegg or fin on the bottom to help the board track in deep

powder. Snurfers lacked the steel edges necessary for turning control on packed snow.² In the late 1970s, these difficult-to-control boards gave way to the "winterstick" by Dimitrije Milovich and later to the modern snowboards designed by Jake Burton Carpenter and Tom Sims.^{1,3} Modern snowboards are constructed much like alpine skis, with fiberglass bodies, plastic bases, and steel edges, making them easier and safer to control on today's groomed ski slopes. Despite improvements in snowboard technology, many differences exist between ski and snowboard equipment.

Snowboarding boots can be divided into two types, hard and soft. Hard-shelled boots come in two varieties, the ski boot and the hybrid snowboard boot. Both hard-shelled boot varieties provide rigid ankle support, but the hybrid boot has a softer, more flexible upper for comfort and maneuverability.⁴ The soft-shelled boots are the most popular among recreational snowboarders and consist of "sorrel" or sorrel-type boots manufactured by snowboarding companies. They provide less ankle support, allowing increased range of motion at the ankle for greater comfort and snowboard maneuverability. Hard inserts can be placed in the soft-shelled boot for increased ankle support; newer soft-shelled boots are being designed with stiffer ankle support. To date, most

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snowboard bindings are nonreleasing, in contrast to the multidirectional releasable binding used in alpine skiing.⁵ The hard-shelled boot is fixed to the board by a metal plate or binding that is nonreleasable, whereas soft boots are held to the board by a soft, high-backed, buckle binding that is also nonreleasable. A final difference in equipment is that unlike skiers, snowboarders with their surferlike stance on the board do not use poles.

Along with differences in boot, board, and binding, the biomechanics of snowboarding are different from those of skiing. Snowboarders stand sideways on their boards, much as skateboarders or surfers do, with the rear foot at 90 degrees to the long axis of the board and the front foot positioned between 45 and 90 degrees to the long axis.^{3,6} Turns are executed by shifting the body weight to the front foot and allowing the tail of the board to swing outward (Shelton, *Powder* 1987; N. A. Plate, "Snowboarding Only Looks Impossible," *Sunset* 1985 March, pp 78-82; and L. Han, "Snowboarding Basics," *Skiing* 1990, 43:204-212).²

Figure 1 shows two boarders executing the front and back turns typical of snowboarding. Without poles, the arms and hands are used more actively for maintaining balance and are often dragged along the snow surface for show or added stability. With the fixed bindings and sideways stance, the outstretched arms are often used to break a fall.¹ Snowboarders love to jump, as shown in Figure 2.

Although there is a substantial body of data characterizing alpine-skiing injuries, few data exist regarding snowboarding.^{1,3,4,7,9} Published studies suggest that mechanisms and patterns of injury differ from those of traditional alpine skiers. Upper limb and ankle injuries are reported to be more common, and knee injuries are less common than in alpine skiers. One author reports that impact rather than torsion is the most common injury mechanism. Finally, it has been suggested that boot type influences the type and location of lower limb snowboarding injuries.^{4,7} Missing from these studies has been a large-scale study that directly and statistically compares skiing and snowboarding injuries from the same ski area during the same seasons. Therefore, this study was designed to compare ski and snowboard injuries, characterizing differences in snowboard injury patterns and factors influencing these injury patterns. The second part of the study was designed to investigate the relationship of certain snowboard-specific factors such as boot type, activity, and lead foot with patterns and incidence of injuries.

Methods

This study was designed in two parts. The first part reviews all injuries recorded during the 1989-1990 through the 1992-1993 ski seasons at the Mammoth and June mountains ski resorts (eastern Sierras, California). The second part was designed to prospectively look at factors influencing snowboarding injury patterns and took place during the 1989-1990 winter season. The study was conducted at the Mammoth-June ski resorts in



Figure 1.—Two snowboard instructors demonstrate front and back side turns (photo courtesy of Brad Peatross, Mammoth Mountain Ski Area).

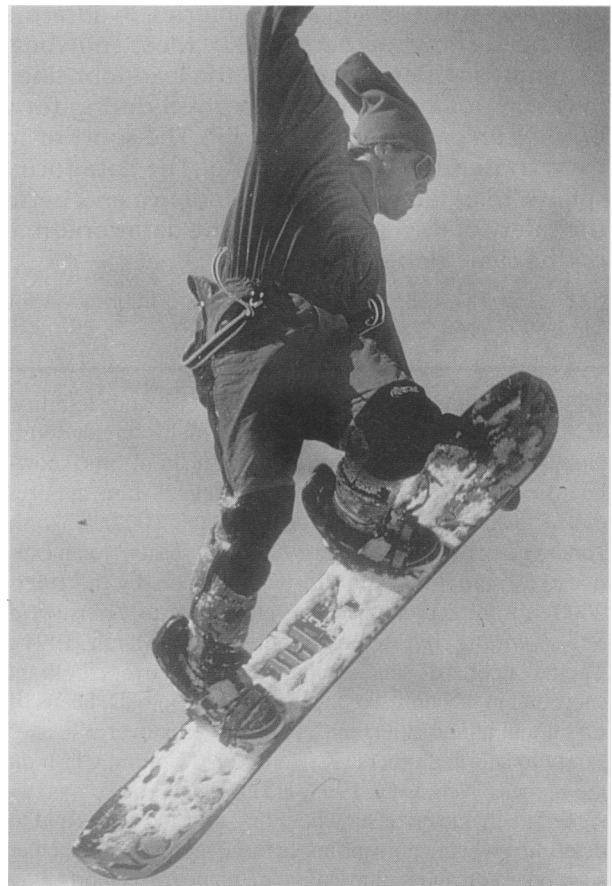


Figure 2.—Snowboarder jumping is shown. This is a frequent snowboard activity (photo courtesy of Brad Peatross, Mammoth Mountain Ski Area).

California where the senior author (T.M.D.) has been a member of the ski patrol since 1963. During the four seasons of this study, the Mammoth-June ski area estimated that the number of snowboarders increased annually to an estimated 5% of all lift-ticket sales (written communication, December 1992).

The data for this project are taken from the incident-injury reports of the Mammoth-June Ski Patrol. All

diagnoses are made by winter emergency care-certified full-time professional ski patrollers. Patients self-triage to innumerable medical facilities, and physicians' diagnoses are simply not available. Fractures and sprains are distinguished by injury zone and patrol assessment; therefore, knee injuries, unless there is dislocation, are diagnosed as sprain, whereas a midshift lower leg injury is diagnosed as a fracture. The Mammoth-June Ski Patrol is responsible for completing incident reports on any injured person tended to by patrol or first-aid room staff at both Mammoth and June mountains. Completed incident reports are then entered into a computer accident file, including type of injury, body zone of injury, date and time of day, ability level, sex, age, snow and weather conditions, location of the accident, and whether the injured person was on a snowboard or skis. Snowboarders were first invited to the Mammoth ski area in the 1989-1990 season. The data reported here include the first four years' experience.

Data for the prospective snowboard study were collected during the 1989-1990 season in which ski patrol members completed a supplementary incident form on all snowboard incidents, including information on snowboard boot type; binding; snowboard length; snowboarder activity such as jumping, "riding the half-pipe," and getting on or off lifts; and lead foot and direction of fall such as toe side, heel side, and backward or forward over the board.

Proportional data were compared among groups using the *z* test with Yates' correction.¹⁰ Mean ages were compared using the unpaired Student's *t* test.¹⁰ Statistical significance was accepted at *P* values of .05 or below.

Results

Part 1

Demographics. The total number of snowboarder injuries reported by the Mammoth-June Ski Patrol during the 1989 through 1993 seasons was 931. This compares with a total of 8,255 alpine skier injuries during the same time period. Total ticket sales for this period were 2,694,640. The percentage of these sold to snowboarders was not recorded. The average age of injured snowboarders was significantly lower than that of injured skiers (20.9 years versus 29.4 years, respectively) (Table 1). Of the 931 snowboarders injured, 72% were male, but only 48% of injured skiers were male. Injured snowboarders and skiers differed in their self-assessed ability level, with beginners comprising 49% of injured snowboarders versus 18% of skiers.

Cause of injury. Human error was the most common self-reported cause of injury in both snowboarders and skiers (60% and 58%, respectively). Equipment failures (0.54% and 1.46%) and speed (4.4% and 6.3%) were slightly more common among skiers (*P* < .05). Snowboarders were injured three times more frequently jumping than were skiers (15% versus 5%, *P* < .001). Collisions with objects, skiers, or snowboarders were the cause of injury more often in skiers than in snowboarders

TABLE 1.—Demographics of All Snowboarders and Skiers Injured During the 1989-1990 Through 1992-1993 Ski Seasons

Characteristic	Snowboarders	Skiers
Total injuries, No.	931	8,255
Mean age (SD), years	20.9 (8.2)	29.5 (14.4)*
Sex		
Male, %	72	48*
Female, %	28	52*
Ability		
Beginner, %	49	18*
Low intermediate, %	7	14*
Intermediate, %	23	39
Advanced, %	15	18
Expert, %	5	4
Racer, %	1	2
Unknown, %	1	6

SD = standard deviation
**P* < .001.

(14% versus 10%, *P* < .002), and only 1% of injuries to skiers were caused by collisions with snowboarders versus 7% of injuries to skiers being caused by collisions with other skiers (*P* < .001).

Injury zone. Compared with skiers, snowboarders sustained a higher percentage of upper extremity injuries (40% versus 17%), with fewer lower extremity injuries (38% versus 54%, *P* < .05) and axial or trunk injuries (17% versus 20%) (Table 2). The wrist was the most common site of injury to snowboarders, accounting for 19% of injuries. Other common snowboard injury sites included the knee (17%), ankle (16%), and clavicle or shoulder (10%). Compared with alpine skiers, snowboarders had significantly more injuries to their wrists (19% versus 2%, *P* < .001), arms (5% versus 2%, *P* < .001), elbows (2% versus 0.4%, *P* < .001), and ankles (16% versus 6%, *P* < .001). Snowboarders sustained significantly fewer injuries to their thumbs (2% versus 4%, *P* < .002), legs (5% versus 9%, *P* < .001), or knees (17% versus 39%, *P* < .001).

Injury type. The type of injury was evaluated and recorded by ski patrol and first-aid room staff without the aid of radiographic studies. Therefore, only first-aid impressions are reported. Snowboarders were twice as likely to sustain a fracture (27% versus 13%, *P* < .001). Snowboarders were less likely overall to sustain soft tissue or sprain or strain injuries than skiers. The rate of dislocations was identical in the two groups (5%), as was that of concussions (3%). There were no cases of hypothermia or death among the snowboarders and two cases of hypothermia and one death among skiers during the four seasons reported.

Most frequent injuries. Wrist injuries were the most common snowboarding injury at 19% versus 2% in alpine skiers. Knee injuries were the next most common injury reported in snowboarders (17% versus 39%). Ankle injuries were the next most reported snowboarding injury at 16% versus 6% in skiers. Thumb injuries

TABLE 2.—Comparison of Most Common Injury Zones in Snowboarders and Skiers

Injury Zone	Snowboarders, No. (%) n = 929	Alpine Skiers, No. (%) n = 8,046	P Value
Upper extremity			
Shoulder.....	70 (8)	577 (7)	
Arm.....	45 (5)	194 (2)	<.001
Elbow.....	17 (2)	36 (0)	<.001
Wrist.....	176 (19)	182 (2)	<.001
Hand.....	18 (2)	94 (1)	
Thumb.....	21 (2)	361 (4)	<.002
Total.....	347 (37)	1,444 (18)	<.001
Lower extremity			
Thigh.....	1 (0)	32 (0)	
Knee.....	160 (17)	3,122 (39)	<.001
Leg.....	44 (5)	709 (9)	<.001
Ankle.....	148 (16)	458 (6)	<.001
Foot.....	4 (0)	9 (0)	<.05
Total.....	357 (38)	4,330 (54)	<.001
Axial skeleton			
Head and face.....	95 (10)	1,103 (14)	<.005
Neck or throat.....	9 (1)	89 (1)	
Chest or rib.....	16 (2)	120 (1)	
Back.....	24 (3)	249 (3)	
Clavicle.....	19 (2)	68 (1)	<.001
Hip or pelvis.....	9 (1)	119 (1)	
Total.....	172 (19)	1,748 (22)	<.05
Other.....	53 (6)	524 (7)	

were nearly half as common in snowboarders as in skiers (2% versus 4%). Shoulder or clavicle injuries are also common in snowboarders (8% and 7%).

Ability versus common injury zones. Among skiers, the knee was the most commonly injured area regardless of ability level. Among snowboarders, the most commonly injured area varied significantly among ability levels (Table 3). Beginning snowboarders were most likely to injure the wrists (30%), low intermediates their knees (28%), intermediates their ankles (17%), and advanced and expert snowboarders injured their shoulder or clavicle most commonly (14%).

Part 2

Demographics. Information for part 2 of the study was gathered on a prospective basis during the 1989-1990 season. Of the 210 snowboarders injured during the season, only 78 (37%) had correctly completed supplemental survey forms that could be used in the study. Many of the supplementary forms had to be excluded because of an inability to match the supplemental form with an incident reported in the accident database. There is no reason to think that these exclusions are not random, nor should they affect the outcome of this study. Demographics for this group did not vary significantly from all snowboarders for age, sex, or ability level.

Boot type. Of the 78 snowboarders, 70 wore the soft (sorrel or snowboard-specific) type boots. Only 1 of the 78 was reported wearing a snowboard-specific hybrid hard boot. Boot type was not reported for seven persons.

Among the soft-boot wearers, there was no significant difference in injury patterns when comparing sorrel with snowboard brand-specific boots for any upper or lower extremity injury zones ($P > .15$). The one snowboarder wearing the hard hybrid boot sustained an injury to the ankle.

Lead foot. Of the 78 snowboarders, 41 (52%) rode with the left foot in the lead or forward position, whereas 36 (46%) snowboarded with the right foot forward. When we examined the correlation of injured side and lead foot, we found that upper extremity injuries had no predilection for lead or rear foot side (Table 4). Of the lower extremity injuries, however, 72% occurred to the lead foot extremity versus 28% to the rear foot extremity ($P < .001$). This difference was most noted for knee and ankle injuries but only significant for knee injuries (80% lead foot versus 20% rear foot, $P < .001$).

Activity. The most commonly reported activity leading to injury was "regular snowboarding," which included all facets of basic snowboarding maneuvers such as stopping, cruising, and standing. Turning was the next most frequent cause (21%). Together, turning and regular snowboarding maneuvers accounted for 53% of injuries, with reported mechanisms including simple falls to the slope as well as more complex falls with twisting and cartwheeling motions. Jumping accounted for 11 of the injuries among all snowboarders (14%) and was an especially common injury to the intermediate snowboarders (29%). Six injuries (8%) occurred during

TABLE 3.—Comparison of Most Common Injury Zones by Ability Level for Snowboarders and Skiers*

Ability	Injury Zone %					
	Wrist	Arm	Shoulder	Knee	Leg	Ankle
Snowboarders						
Beginner.....	30	4	5	21	3	17
Low intermediate.....	11	6	6	28	5	20
Intermediate.....	11	8	7	13	7	17
Advanced or expert.....	6	4	14	9	6	10
Skiers						
Beginner.....	2	2	5	49	10	9
Low intermediate.....	1	2	5	50	10	6
Intermediate.....	2	3	8	41	9	5
Advanced or expert.....	3	3	10	30	9	4

*Bold numbers represent most common injury zone for each ability level.

lift loading or unloading, whereas speed (5 [6%]) and collisions (4 [5%]) accounted for relatively few injuries.

Direction of fall. Falls in the forward direction and during front-side turns were most common (42 [54%]), and falls backward and during heel-side turns were less common (26 [33%]). Table 5 shows that, when examining the direction of fall in relation to the three most common injury zones, knee and ankle injuries occur significantly more often during forward front-side-turn falls. Just the opposite is found for wrist injuries, with backward heel-side-turn falls being the direction of fall in 73% of wrist injuries reported.

Discussion

The results of this study show that snowboarders and skiers have substantially different injury patterns. Injured snowboarders were significantly younger and more likely to be male compared with skiers. This agrees with previous work showing a lower mean age (range, 19.6 to 21 years) and a higher percentage of men (range, 74% to 90%) in snowboarders compared with alpine skiers.^{1,3,4,7,8} Beginners were the largest fraction of injured snowboarders both in this and previous reports.^{1,4,7,8} Without controls, we cannot determine if any of the factors of young age, male sex, or beginner ability level are true risk factors for snowboard injuries. It has been noted that the overall population of snowboarders is relatively younger with more male participants than the skiing population (Hamilton, *Newsweek* 1993; Shelton, *Skiing* 1988; and Shelton, *Powder* 1987).⁸ Although this new and growing sport should have a generous proportion of beginners, studies of alpine skiing injuries show beginners to have as much as a sixfold increase in risk of injury versus skiers of other ability levels.^{11,12} Therefore, although it is less likely that age or sex are risk factors in snowboarding injuries, lower ability level may be an important risk factor for snowboarders. Because a breakdown of lift-ticket sales to snowboarders and skiers was not available, the overall incidence for snowboarding injuries could not be calculated. Other studies have estimated this rate to be between 2.0 and 4.2 injuries per

1,000 snowboarder days,^{1,4,7} with one author estimating a higher rate at 8 to 16 injuries per 1,000 snowboarder days.⁸ These estimates compare with recent calculations of an overall incidence of injury in alpine skiers of 3 to 6 injuries per 1,000 skier days.^{5,12} In this study, it was noted that snowboarding accounted for about 10% of all injuries. During this same time period, the Mammoth-June ski resort management estimated that snowboarders accounted for 5% of all lift-ticket sales at the resort (written communication, December 1992). If these estimations are correct, then the overall injury rate in snowboarders at Mammoth-June ski resort may be twice that in skiers. As noted previously, the rapid growth of the sport has placed many beginner snowboarders on the slopes, some without formal instruction, and it would not be surprising if a somewhat higher overall incidence is noted and persists as the sport grows.

In this and another study, a low collision rate between snowboarders and skiers was demonstrated.⁷ In fact, we found the collision rate between snowboarders and skiers to be lower than that for skiers colliding with skiers. Thus, any increased risk of injury to alpine skiers or snowboarders caused by sharing the same slopes has yet to be shown.

Another important finding in this study is the increased rate of upper extremity injuries when compared with skiers, a conclusion shared by other workers.^{1,4,7} Wrist, arm, and elbow injury rates were all increased compared with those in skiers, and snowboarders were almost ten times as likely to injure the wrist as were their alpine skier counterparts. In fact, the wrist was the most common injury zone in the total population of injured snowboarders and accounted for a third of all injuries in beginning snowboarders. Differences in how a snowboarder falls may be responsible for the increased proportion of upper extremity injuries. As discussed, snowboards do not have releasable bindings, and poles are not used. During a fall, the feet remain fixed to the board, and the main force of impact with the snow is often placed on the outstretched arms. Figure 3 shows a snowboarder turning. Any slip

TABLE 4.—Comparison of Injuries to Front Foot Side Versus Rear Foot Side Based on Injury Zone*

Injury Zone	Injured Side		P Value
	Lead Foot, No. (%)	Rear Foot, No. (%)	
Upper extremity*	13 (52)	12 (48)	1.00
Lower extremity	23 (72)	9 (28)	<.001
Knee	12 (80)	3 (20)	<.001
Ankle	11 (65)	6 (35)	<.05

*Thumb, hand, wrist, elbow, arm, and shoulder injuries.

TABLE 5.—Influence of Direction of Fall on Common Injury Zones

Injury Zone	Direction of Fall*		P Value
	Toe Side, No. (%)	Heel Side, No. (%)	
Knee	10 (67)	3 (20)	<.05
Ankle	11 (65)	6 (35)	<.05
Wrist	4 (27)	11 (73)	<.05

*Falls forward or to the toe side of the board were classified as toe-side falls, and falls backward or to the heel side of the board were classified as heel-side falls.

could easily involve the upper extremities. Beginner snowboarders seem particularly at risk for wrist injuries, possibly reflecting a lack of knowledge of falling techniques that diminish the impact to the upper extremity or perhaps reflecting the increased number of falls suffered by beginning snowboarders.¹⁴ In this study, injuries to the wrist were significantly more common during falls to the heel side of the snowboard, suggesting a greater force of impact to the upper extremity when falling backward.

Thumb injuries were significantly less prevalent than in alpine skiers in this and other studies.^{3,4,8} Injuries to the thumb among skiers represent the most common upper extremity injury, with rupture of the ulnar collateral ligament, “skier’s thumb,” being the most common thumb injury.^{13,14} The mechanism of injury described involves the ski-pole handle acting as a lever as the thumb collides with the snow during a fall, causing stretching or rupture of the ulnar collateral ligament.¹³⁻¹⁶ Without poles, snowboarders seem to be at much less risk for thumb injuries.

Patterns in lower extremity injuries also differed among snowboarders and skiers, with knee injuries being twice as common in skiers and ankle injuries almost three times as common in snowboarders. Similar results have been reported in other studies, with speculation that the soft-shelled boot and the absence of release binding are the major contributing factors.^{1,3,4,7,8} In this study, 70 snowboarders (90%) were found to be using the soft-shelled snowboarding boots, which provide less ankle stabilization, supporting our finding of an increased prevalence of ankle injuries. Other studies have shown that hard-shelled boots and soft boots with rigid ankle-support inserts substantially reduce the risk of ankle injuries, but increase the rate of knee injuries.^{4,7} This pattern of injury in snowboarders is similar to that found in



Figure 3.—An extreme front-side turn is shown. The upper extremity is at obvious risk if the snowboarder falls (photo courtesy of Brad Peatross, Mammoth Mountain Ski Area).

the early years of skiing, when it was noted that the ankle was the most common injury zone in the lower extremity.¹² This pattern was attributed to the low-topped ski boots that provided little ankle support. As the boot became more rigid with a higher top to provide increasing ankle support, the rate of ankle injuries declined dramatically.¹² The dilemma is to better protect the ankle without adding increased risk to the knee. We conclude, as have others, that soft-shelled boots with rigid ankle inserts or supports, particularly in beginner snowboarders who have the highest incidence of ankle injuries, may be beneficial.^{4,7} Further work needs to be done examining the effects of rigid inserts and soft boots with more rigid ankle support on the knee and ankle injury rates before more definitive recommendations can be made.

It was somewhat surprising to find that 72% of all lower extremity and 80% of knee injuries occurred to the leg in the front, or lead foot, position. Other workers have reported similar trends,^{3,4,8} but this study is the first to show actual statistical significance. The reasons for this finding are unclear. It was initially thought that having both feet fixed to the snowboard would offer some protection from torsional injuries, particularly to the knees.³ Although this study shows that snowboarders have fewer knee injuries than do skiers, the finding that most knee and lower extremity injuries are concentrated in the front foot suggests that different forces are acting on the front leg than on the rear leg. This may be due to the fact that the lead foot is usually placed at an angle of 30 to 45 degrees to the long axis of the board and not parallel to the rear foot. In a fall with the snowboard edge fixed in the snow and acting as a lever, the angle of the front foot may translate into different and possibly more damaging torsional forces acting on the lead leg. In addition, most of a rider’s weight is concentrated on the lead foot when initiating a turn, thus placing greater forces on the front foot. Future attention needs to focus on the factors contributing to the preponderance of front-foot lower extremity injuries and perhaps the development of a release-binding system to protect the front foot.

Last, six of the snowboarder injuries (8%) occurred during loading and unloading from chairlifts. Chairlifts

have developed for the forward-facing two-skied alpine skier and may not be appropriate for the sideways-facing, one-foot-on-the-board snowboarder.

Conclusion

This study shows that the fast-growing sport of snowboarding has a notably different injury pattern from that seen in alpine skiing, with an overall incidence rate that is comparable to or higher than that for alpine skiers. Important differences from alpine-skiing injury patterns include higher rates of ankle and wrist injuries, a lower but still common knee injury rate, and a lower prevalence of thumb injury. We agree with the conclusions of others that nonrelease bindings and soft boots have contributed to the higher incidence of ankle injuries,^{1,3,6-8} but we remain cautious in recommending hard-shelled boots with or without releasable bindings because they may simply shift the incidence of lower extremity injuries from the ankles to the knees, as has been observed in the evolution of alpine skiing. To reduce the incidence of wrist fractures and sprains, the use of wrist guards has been recommended in the sports of skateboarding, roller skating, and in-line skating.¹⁷⁻¹⁹ Gloves with similar wrist support are now available for snowboarders and may prove beneficial in reducing wrist injuries, particularly in beginners. As with many sports, it is recommended that beginners seek professional instruction to learn proper techniques and safety precautions that may reduce their risk of injury. Chairlift loading and unloading practices must be reexamined.

REFERENCES

1. Shealy JE, Sundman PD: Snowboarding injuries on alpine slopes. *In* Johnson RJ, Mote CD Jr, Binet MH (Eds): *Skiing Trauma and Safety: Seventh International Symposium*. Philadelphia, Pa, American Society for Testing and Materials, 1989, pp 75-81
2. Aitkens M: Have snowboard, will soar. *Physician Sports Med* 1990; 18:114-120
3. Pino EC, Colville MR: Snowboard injuries. *Am J Sports Med* 1989; 17:778-781
4. Bladin C, Giddings P, Robinson M: Australian snowboard injury database study: A four-year prospective study. *Am J Sports Med* 1993; 21:701-704
5. Johnson RJ, Ettlinger CF, Campbell RJ, Pope MH: Trends in skiing injuries—Analysis of a 6-year study (1972-1978). *Am J Sports Med* 1980; 8:106-113
6. Johnson RJ: Skiing and snowboarding injuries: When schussing is a pain. *Postgrad Med* 1990; 83:36-38
7. Ganong RB, Heneveld EH, Beranek SR, et al: Snowboarding injuries: A report on 415 patients. *Physician Sports Med* 1992; 20:114-122
8. Abu-Laban RB: Snowboarding injuries: An analysis and comparison with alpine skiing injuries. *Can Med Assoc J* 1991; 145:1097-1103
9. Fujioka K, Panes P: Snowboarding injuries. *Sports Med Dig* 1989; 11:1-2
10. Glantz SA: *Primer of Biostatistics*, 3rd edition. New York, NY, McGraw-Hill, 1992
11. Ekland A, Holtmoen A, Lystad H: Lower extremity equipment-related injuries in alpine recreational skiers. *Am J Sports Med* 1993; 21:201-205
12. Johnson RJ, Ettlinger CF: Alpine ski injuries: Changes through the years. *Clin Sports Med* 1982; 1:181-197
13. Newland CC: Gamekeeper's thumb. *Orthop Clin North Am* 1992; 23:41-48
14. Morgan JV, Davis PH: Upper extremity injuries in skiing. *Clin Sports Med* 1982; 1:295-308
15. Primiano GA: Skiers' thumb injuries associated with flared ski pole handles. *Am J Sports Med* 1985; 13:425-427
16. Van Dommelen BA, Zvirbulis RA: Upper extremity injuries in snow skiers. *Am J Sports Med* 1989; 17:751-753
17. Callé SC, Eaton RG: Wheels-in-line roller skating injuries. *J Trauma* 1993; 35:946-951
18. Banas MP, Dalldorf PG, Marquardt JD: Skateboard and in-line skate fractures: A report of one summer's experience. *J Orthop Trauma* 1992; 6:301-305
19. Lohmann M, Petersen AO, Pedersen OD: [Skateboard and rollerskate accidents]. *Ugeskr Laeger* 1990; 152:1591-1593 [Engl Abstr]