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Snow sports injuries in Scotland: a case-control study

M Langran, S Selvaraj

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See end of article for authors' affiliations

Correspondence to: Dr Langran, Aviemore Medical Practice, Aviemore, Inverness-shire PH22 1SY, Scotland, UK; doc_mike@hotmail.com

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Objectives: To examine the incidence and patterns of snow sports injuries at the three largest commercial ski areas in Scotland and to identify factors associated with injury risk.
Methods: A prospective case-control study of all injured people at Cairngorm, Glenshee, and Nevis Range ski areas during the 1999–2000 winter season. Personal details, snow sports related variables, diagnosis, and treatment were recorded. Control data were collected at random from uninjured people at all three areas. Random counts were performed to analyse the composition of the on slope population.
Results: A total of 732 injuries were recorded in 674 people. Control data were collected from 336 people. The injury rate for the study was 3.7 injuries per 1000 skier days. Alpine skiers comprised 67% of the on slope population, snowboarders 26%, skiboarders 4%, and telemark skiers 2%. Lower limb injuries and sprains were the commonest injuries in alpine skiers and skiboarders. Snowboarders sustained more injuries to the upper limb and axial areas. Skiboarders and snowboarders had a higher incidence of fractures. After adjustment for other variables, three factors were all independently associated with injury: snowboarding (odds ratio (OR) 4.07, 95% confidence interval (CI) 1.65 to 10.08), alpine skiing (OR 3.82, CI 1.6 to 9.13), and age <16 years (OR 1.9, CI 1.14 to 3.17). More than five days of experience in the current season and at least one week of experience in total had a protective effect against injury.
Conclusions: Despite a change in the composition of the alpine population at Scottish ski areas, the overall rate and pattern of injury are similar to those reported previously in comparable studies. Several factors are associated with an increased risk of injury and should be targeted in future injury prevention campaigns.

Since injury reports were first published in the 1970s, there has been a decrease of nearly 50% in the overall injury rate for alpine skiing.[1] Recent studies based on ski patrol data report rates of 2–4 injuries per 1000 skier days.[2] This reduction has been associated with a change in injury patterns, largely as the result of improvements in equipment design.[3] The development of plastic ski boots, releasable bindings, and ski brakes has resulted in reductions in the number of lower limb fractures and lacerations in particular.[4]

The long held monopoly of alpine skiing at commercial ski areas has been broken by several sports. Snowboarding, which first appeared in the 1970s, has established itself as a separate activity and became an Olympic event in 1998.[5] Snowboarders now constitute about one third of all slope users.[6] Higher rates of fractures and upper limb injuries have been reported in this population than in skiers.[7 8] Telemark skiing, traditionally an off piste sport, has also become increasingly popular at ski areas.[9] The introduction of alpine-style boots and skis allows the telemark turn to be combined with the speed of alpine skiing.[10] The latest sport to emerge is skiboarding. Defined as skis of length 1 m or less, skiboards (also known as snowblades) allow more manoeuvrability than a ski. Skiboarders use standard ski boots attached to the blade with a non-release binding.[11]

Skiing has been a commercial sport in Scotland for over 30 years. The five ski areas are relatively small, have no skiing above 4500 feet, and are susceptible to variable snow and weather conditions. Two previous publications have reported on the patterns of injury seen at separate Scottish ski areas.[12 13] The results were comparable to those from other areas, but both had limitations in their study design, principally the lack of control data. Subsequently, there has been a perceived growth in the popularity of snowboarding and skiboarding in Scotland. We conducted a prospective case-control study of all injuries at the three largest ski areas in Scotland during the 1999–2000 winter season. The aims of the study were to examine the incidence and patterns of injuries and to identify factors associated with injury risk.

METHODS

All who attended the ski patrol services at Cairngorm, Glenshee, and Nevis Range ski areas after sustaining an injury on the slopes during the 1999/2000 winter season were included in the study. Non-traumatic episodes were excluded. Patients who presented directly to the Aviemore Medical Practice after sustaining an injury at the Cairngorm ski area were also included. Basic personal and various snow sports related details were recorded. Patients with an unclear final diagnosis were identified. Subsequent enquiries were then made by one of the authors (ML) to confirm the final diagnosis wherever possible.

Control data were collected at all three areas by conducting face to face interviews with uninjured skiers, snowboarders, and skiboarders. These interviews were performed at a variety of times, on a variety of days, and in varied locations in order to reduce the likelihood of selection bias. A separate series of random manual counts were conducted to determine the percentage distribution of skiers, snowboarders, skiboarders, and telemarkers among the total piste population.

All three ski areas provided their skier day numbers for the season, calculated from total ticket sales and/or lift statistics. An overall injury rate was then calculated in terms of injuries per thousand skier days (IPTSD)—the accepted method for reporting ski injury rates in the literature[14]—where:

IPTSD = (Total number of injuries/total number of skier days) × 1000

Table 1 Details of injured and control populations

	Cases (%) (n=674)	Controls (%) (n=336)	p Value
Sex			
Female	41.1	36.9	0.199
Male	58.9	63.1	
Age group (years)			
<16	30.4	14.9	0.001
16–25	28.6	37.5	
26–40	26.7	31.8	
40+	13.8	15.8	
Unknown	0.5	–	
Equipment			
Alpine	65.3	54.2	0.001
Snowboard	29.5	30.1	
Skiboard	4.2	10.1	
Telemark	1.0	5.7	
Home address			
Local	8.9	16.0	0.000
Scotland	58.3	43.5	
UK	31.0	39.0	
Overseas	1.8	1.5	
Ski area			
Cairngorm	51.8	48.2	0.274
Glenshee	27.9	27.1	
Nevis Range	20.3	24.7	

Table 3 Factors associated with injury

	Odds ratio (95% confidence interval)
Age (years)	
⩽15	1.9 (1.14 to 3.17)
16–25	0.71 (0.44 to 1.14)
26–40	0.79 (0.51 to 1.24)
40+	–
Equipment	
Snowboard	4.07 (1.65 to 10.08)
Alpine	3.82 (1.6 to 9.13)
Skiboard	1.05 (0.37 to 2.94)
Telemark	–
Ski days this season	
0–5 days	–
6–10 days	0.5 (0.33 to 0.76)
11+ days	0.74 (0.46 to 1.18)
Total experience	
First day	–
First week	0.5 (0.3 to 0.83)
1–4 weeks	0.57 (0.34 to 0.94)
4–8 weeks	0.63 (0.37 to 1.08)
>8 weeks	0.43 (0.25 to 0.73)

The incidence of a specific injury (for example, a wrist fracture), however, is best expressed in terms of "mean days between injury" (MDBI),[15] where:

MDBI = Total number of skier days/total number of the specific injury seen

The skier days total for each sport was derived as follows:

Total skier days × percentage distribution*

(*for the sport in question)

Data were entered into a Microsoft Access database. Statistical analysis was performed using Stata 6.0. Factors associated with injury were first assessed by univariate analysis. Factors with a p value below 0.2 were included in a multiple logistic regression analysis. Statistical significance was accepted at $p<0.05$.

RESULTS

A total of 732 injuries were recorded in 674 people, and comparative data were collected from 336 uninjured controls from 12 December 1999 to 1 May 2000. No deaths were recorded. There were 197 033 skier days during the season, yielding an overall injury rate of 3.7 injuries per 1000 skier days. Only eight telemark ski injuries were recorded and were excluded from further statistical analysis. The on piste counts indicated that alpine skiers comprised 67% of the total population, snowboarders 26%, skiboarders 4%, and telemark skiers 2%. Table 1 shows characteristics of the cases and controls. There

Table 2 Details by equipment type

	Alpine		Snowboard		Skiboard	
	Cases (%)	Controls (%)	Cases (%)	Controls (%)	Cases (%)	Controls (%)
Sex	(n=440)	(n=183)	(n=198)	(n=101)	(n= 28)	(n= 33)
Male	51.8	56.3	73.2	73.3	67.9	57.6
Female	48.2	43.7	26.8	26.7	32.1	42.4
Age group (years)	(n=440)	(n=183)	(n=198)	(n=101)	(n=28)	(n=33)
<16	36.2	15.3	17.2	5.9	46.4	48.5
16-25	19.5	20.2	49	73.3	35.7	39.4
25-40	24.3	42.1	33.3	17.8	10.7	9.1
40+	20.1	22.4	0.5	3	7.1	3
Ski time this season	(n=406)	(n=183)	(n=192)	(n=101)	(n=28)	(n=33)
0–5 Days	81	66.7	71.9	51.5	82.1	72.7
6–10 Days	9.4	16.9	13.5	30.7	10.7	18.2
11+ Days	9.6	16.4	14.6	17.8	7.1	9.1
Total experience	(n=439)	(n=183)	(n=197)	(n=101)	(n=28)	(n=31)
1st Day	14.8	7.1	28.4	11.9	35.7	30.3
1st Week	22.1	16.9	13.7	14.9	25	30.3
1–4 Weeks	17.8	16.9	20.8	20.8	32.1	27.3
4–8 Weeks	23	17.5	13.2	21.8	3.6	9
8+ Weeks	22.3	41.5	23.9	30.7	3.6	3
Instruction history	(n=439)	(n=183)	(n=196)	(n=101)	(n=28)	(n=33)
No lessons	13.9	15.9	53.6	66.3	82.1	97
One season	42.6	34.4	25	25.8	14.3	3
Two seasons	16.2	22.4	13.8	5.9	3.6	0
>Two seasons	27.3	27.3	7.7	2	0	0

Table 4 Anatomical location and type of injury by equipment

	Alpine ski Skier days=132436		Snowboard Skier days=52804		Skiboard Skier days=7974	
	n (%)	MDBI	n (%)	MDBI	n (%)	MDBI
Anatomical location						
Upper limb	116 (24.2)	1142	98 (46)	539	4 (12.9)	1994
Lower limb	255 (53.1)	519	46 (21.6)	1148	23 (74.2)	347
Axial	109 (22.7)	1215	69 (32.4)	765	4 (12.9)	1994
All injuries	480 (100)	276	213 (100)	248	31 (100)	257
Type of injury						
Fracture	60 (12.5)	2207	53 (24.9)	996	9 (29)	886
Sprain	248 (51.7)	534	61 (28.6)	866	17 (54.8)	469
Laceration	46 (9.6)	2879	40 (18.8)	1320	2 (6)	3987
Joint dislocation/subluxation	13 (2.7)	10187	18 (8.5)	2934	–	–
Other	113 (23.5)	1172	41 (19.2)	1288	3 (10.2)	2658

MDBI, Mean days between injury.

was an excess of males in both groups. Younger subjects, alpine skiers, and subjects living in Scotland were over-represented among the cases. The distribution of cases and controls was similar at all three ski areas.

Table 2 gives a more detailed breakdown of case and control characteristics. Compared with alpine skiers, snowboarders and skiboarders were more often male and from younger age groups. However, there was no relation between sex and case-control status in any of the equipment types. Alpine skiers less than 16 years of age were more likely to be injured. Among snowboarders, injuries were more likely in the less than 16 years and 25–40 years age groups.

For alpine skiing and snowboarding, both lifetime skiing experience and current season's experience were related to injury risk. Skiers and snowboarders on their first day were over-represented in the injured group compared with controls, and there was an excess of injuries in those with less than five days of experience in the current season. In contrast with skiers, most snowboarders and skiboarders had taken no professional lessons.

Table 3 summarises the results of multivariate logistic regression analysis. After adjustment for other variables, skiing, snowboarding, and younger age were independently associated with injury. More than five days of experience in the current season and at least one week of experience in total had a protective effect against injury. Use of hired gear, snow and weather conditions at the time of injury, and level of instruction, although recorded, did not reach the level of significance required to be included in this multivariate analysis.

Tables 4 and 5 illustrate anatomical location and type of injury by equipment type. Patterns of injuries differed by equipment type. Lower limb injuries and sprains were the commonest injuries in alpine skiers and skiboarders. In contrast, snowboarders were more likely to sustain an upper limb or axial injury. Skiboarders and snowboarders had a higher incidence of fractures. Table 6 shows the four commonest individual injuries seen in each snow sport (expressed as a percentage of total injuries seen and MDBI).

Table 5 Anatomical location of injury by equipment

	Alpine ski n (%)	Snowboard n (%)	Skiboard n (%)
Upper limb	116 (24.2)	98 (46)	4 (12.9)
Shoulder	33 (6.9)	19 (8.9)	1 (3.2)
Humerus	5 (1)	3 (1.4)	–
Elbow	7 (1.5)	11 (5.2)	–
Forearm	–	2 (0.9)	–
Wrist	15 (3.1)	47 (22.1)	2 (6.5)
Thumb	34 (7.1)	8 (3.8)	1 (3.2)
Hand/digit	22 (4.6)	8 (3.8)	–
Lower limb	255 (53.1)	46 (21.6)	23 (74.2)
Thigh/femur	16 (3.3)	–	–
Knee	176 (36.7)	26 (12.2)	15 (48.4)
Tibia/fibula	23 (4.8)	1 (0.5)	3 (9.7)
Ankle/calf	39 (8.1)	15 (7)	5 (16.1)
Foot	1 (0.2)	4 (1.9)	–
Axial	109 (22.7)	69 (32.4)	4 (12.9)
Head/face	68 (14.2)	42 (19.7)	1 (3.2)
Chest	9 (1.9)	7 (3.3)	1 (3.2)
Neck	7 (1.5)	5 (2.4)	–
Back	14 (2.9)	7 (3.3)	2 (6.5)
Pelvis	5 (1)	3 (1.4)	–
Abdomen	6 (1.3)	2 (0.9)	–
Other	–	3 (1.4)	–
Total	480 (100)	213 (100)	31 (100)

DISCUSSION

The overall injury rate of 3.7 IPTSD in this study compares favourably with those reported from other ski areas world wide using similar ski patrol data.[2 16] Our results confirm the perception of many that the constitution of the on piste population at Scottish ski areas has changed dramatically. Snowboarders now account for 26% and 29% of the total and injured populations respectively. In 1994, snowboarders accounted for only 4% of the injured population at Cairngorm.[12] Although we registered relatively few on piste telemark ski injuries, many participants ski away from designated ski areas, and the injury rate in this population in Scotland remains unknown.

Table 6 Four commonest injuries by equipment type

	n (%)	MDBI
Alpine ski	480 (100)	276
Grade 1–2 knee sprain	158 (32.9)	838
Head/face laceration	33 (6.9)	4013
Tibia/fibula fracture	26 (5.4)	5094
Grade 1–2 thumb sprain	24 (5)	5518
Snowboard	213 (100)	248
Wrist fracture	31 (14.6)	1703
Head/face laceration	27 (12.7)	1956
Grade 1–2 knee sprain	19 (8.9)	2779
Shoulder dislocation	10 (4.7)	5280
Skiboard	31 (100)	257
Grade 1–2 knee sprain	13 (41.9)	613
Tibia/fibula fracture	5 (16.1)	1595
Ankle sprain	3 (9.7)	2658
Wrist fracture	2 (6.5)	3987

MDBI, Mean days between injury.

Males comprised the majority of all our injured groups, but we found no difference between the sex constituencies of any injured and control group. In other words, more males are injured simply because there are more males on the slopes in all equipment groups. Injured snowboarders and skiboarders were younger than injured skiers, as has been previously noted.[16 17] Our control data would indicate once again that this is merely a reflection of the distribution of the on slope population as a whole. Those aged 16 years or less were, however, over-represented in both the injured ski and snowboard groups compared with controls, indicating a true increased risk of injury. Previous concerns have been expressed about the level of injuries sustained by children.[18] Inexperience, problems with ski binding settings for children, and the use of handed down and outdated ski equipment have all been suggested as possible contributing factors.[18 19] Goulet[20] found that children aged 12 years or less were over-represented among injured skiers in Quebec compared with a control population by a factor of 1.86. In our own study, this factor was 2.37 for skiing and 2.92 for snowboarding for those aged less than 16 years.

In a subsequent study, Goulet *et al*[21] found that low skill level, use of rental equipment, and incorrect binding adjustment were all associated with an increased risk of injury in those aged 12 years and younger. It is also possible that injuries to children are more likely to be reported immediately, thereby increasing the apparent injury rate in this age group. Although it has been estimated that up to 40% of all snow sport injuries go unreported to local medical services,[22] no analysis has yet been carried out on the injury reporting rates in different age groups.

Experience has been shown in previous studies to have an influence on injury risk. Beginner skiers[1] and snowboarders[7] have been shown to have an injury risk 2–4 times higher than that of more experienced peers. However, there is no uniform definition of "beginner", "intermediate" and "advanced"—subjective terms often used in other injury studies. We decided to categorise experience more objectively in terms of total amount of time spent on the slopes participating in that particular sport. For example, a life long alpine skier trying snowboarding for the first time would have had his or her total experience level registered as "first day" (snowboard experience) rather than "8+ weeks" (alpine ski experience) in our study.

In all equipment groups, those on their first day were over-represented among the injured population by a factor ranging from 1.18 to 2.39. More than one week of experience was an independent protective factor against injury risk. Those experiencing a particular snow sport for the very first time are clearly a subgroup who require more attention in order to try to reduce their risk of injury.

Skiing, snowboarding, or skiboarding for more than six days in the current season had a protective effect against sustaining an injury. This is consistent with the results of other investigators, who found that injured skiers had skied fewer days per season than a matched control population.[23]

Most snowboarders and skiboarders had taken no professional instruction, although this was not associated with an increased risk of injury. Previous studies have shown that instruction is only related to reducing injury risk when combined with the accumulation of significant experience.[24] Our observation was that many snowboarders picked up the sport by trial and error, supplemented by casual instruction from friends. The same could be said of skiboarding, although established skiers trying skiboarding may have believed that the resemblance of skiboards to skis obviated any need for separate instruction. Proficiency in one snow sport does not automatically guarantee ability in another.

The anatomical pattern of injuries varied between the three snow sports, reflecting the inherent differences in user technique and equipment design. The lower limb, the knee joint in particular, remains the commonest injury site among alpine skiers.[4 13–15] In the event of a fall, the legs can twist independently of one another creating the potential for rotational injury if excess force is applied. Since their introduction, releasable ski bindings have dramatically reduced the incidence of lower leg fractures among alpine skiers.[1] Nevertheless, a lower leg fracture was still the third most common injury seen among alpine skiers in our study. Unfortunately, the worldwide incidence of knee injuries has at best remained static in spite of release bindings, and the search for a boot/binding interface that can offer increased protection against all knee injuries continues.[25]

With both feet fixed by non-release bindings to the same board, reducing the potential for rotational injury, snowboarders sustain fewer lower limb injuries than alpine skiers.[8] Injuries to this area occurred either when one foot was not secured to the board—that is, when using a lift—or from direct trauma.

The high rate of lower limb injuries seen in skiboarders is consistent with previous injury reports concentrating on this sport.[11 17] The combination of non-release bindings and the younger age of participants has been cited as an associated factor. Although studies to date are limited, the emerging injury pattern associated with this sport is a cause for concern and attention should be directed towards developing a lightweight, low cost release binding for skiboards.

Since its inception, snowboarding has consistently been associated with a higher incidence of upper limb injuries than alpine skiing, with the wrist being the single commonest site of injury.[7 8] In the event of a fall, the natural tendency for a snowboarder is to stretch out (and land on) the hand. Less than 10% of snowboarders currently wear wrist guards,[22] although there is now both epidemiological and laboratory evidence to support their use.[22 26 27] More emphasis must be placed on increasing the injury awareness of snowboarders and the promotion of wrist guards as a specific injury preventive measure. Supply of suitable guards is still a major problem, especially in the United Kingdom. We implore snowboard shops and hire departments to consider and include wrist guards as standard snowboard equipment.

The incidence of head and face injuries in our study population mirrors that of other studies.[4 8] The majority were relatively minor in nature, many resulting from being hit by a swinging T bar as it recoiled on disembarkation. None were of the severity reported elsewhere.[28] Other workers have reported an increasing incidence of head injuries among children,[18] and it has been advocated that this age group in particular should be encouraged to wear a suitable protective helmet.[29] The absolute risk of a head injury (especially one of a serious degree) though remains very low, and to date there is no epidemiological evidence that helmets reduce the incidence of fatalities in snow sports.[30]

Although they are relatively rare, injuries to the spine and spinal cord are potentially extremely serious, accounting for 4–10% of fatal ski injuries.[31 32] The commonest factors associated with spinal injury are a backwards fall on to the occiput with consequent forced flexion of the neck in skiers[33] and the application of compressive axial forces up the spine as the result of a bad landing from a jump in snowboarders.[34]

Methodological considerations

Calculating snow sport injury rates accurately is problematic. At any ski area, an unquantifiable number of injured people do not seek medical attention locally and either receive no treatment, treat themselves, or wait to receive treatment when they return home. In Scotland, all ski patrol, ambulance, and medical services are provided free of charge to citizens of the United Kingdom and European Community. This removes a potential major barrier to seeking attention in an unfamiliar setting. We decided to use ski patrol data in this study because it is standard policy at ski areas in Scotland for all injuries to be reported

Take home message

- The incidence of injury while skiing, snowboarding, or skiboarding is relatively low
- People at increased risk of injury include those aged less than 16 years and those experiencing a particular snow sport for the very first time
- Wrist guards are underutilised in the snowboarding population and their use should be encouraged

to the ski patrol in order to comply with current United Kingdom health and safety legislation. Most injured people are therefore likely to be assessed, treated, and evacuated from the ski area through the patrol and thus be included in this study.

We also included those attending the Aviemore Health Centre who had not seen the ski patrol because of its unique nature, convenient location close to the Cairngorm Ski Area, and its well known historical role as a treatment centre for injured skiers for the last 30 years. Although we accept that some injured people may still have bypassed our study, this phenomenon is a problem for all ski injury investigators and we believe that, if anything, it is less likely to have had an effect on our study than others for the reasons highlighted above.

It is possible that our control data are not representative of the whole Scottish snow sports population. Unfortunately, practical considerations limited the amount of data that could be collected. As far as possible, collection of control data was organised in order to sample a random portion of the population at risk—for example, by interviewing every fifth person in a ski lift queue. We accept though that a larger control data population would have reduced the risk of inadvertent data bias. In some cases, complete data collection was not practical and it was not possible to make subsequent contact with the injured person to rectify this. Such data were therefore recorded as missing and not included in the analysis, although such occurrences were relatively rare. The comparatively small number of skiboarders registered in the study dictates that any statistical significance afforded to this group must be interpreted with some caution.

Conclusion

Although the constitution of the on slope population at the three largest Scottish ski areas has changed dramatically in the last five years, the absolute risk of injury is comparable to that seen in other ski areas world wide. Broadly speaking, the injury patterns seen in Scotland are also similar to those reported elsewhere. Our findings indicate that the following factors were associated with an increased risk of injury: age <16 years, inexperience (particularly those skiing, snowboarding, or skiboarding for the very first time), and less than six days of experience on the slopes in the current season. Several additional areas highlighted in this and other studies offer the potential to reduce injury risk further, in particular, encouraging snowboarders to use protective wrist guards and the development of an efficient release binding system for skiboards. The incidence of knee injuries in alpine skiers continues to cause concern, and continuing efforts to address this are to be supported.

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Authors' affiliations

M Langran, Aviemore Medical Practice, Aviemore, Scotland, UK
S Selvaraj , Highlands and Islands Health Research Institute, University of Aberdeen, Scotland, UK

Conflict of interest: ML has received honoraria from Smith Kline Beecham for participating in evening meetings on the subject of snow sport injuries and financial assistance from Novartis to attend a conference on ski injuries.

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