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## Evaluation of skiing and snowboarding injuries sustained in terrain parks versus traditional slopes

M Alison Brooks<sup>1</sup>, Michael D Evans<sup>2</sup>, and Frederick P Rivara<sup>3</sup>

<sup>1</sup>Department of Orthopaedics and Pediatrics, University of Wisconsin–Madison, Madison, Wisconsin, USA

<sup>2</sup>Department of Biostatistics, University of Wisconsin-Madison, Madison, Wisconsin, USA

<sup>3</sup>Department of Pediatrics, University of Washington, Seattle, Washington, USA

### Abstract

This study compares skiing and snowboarding injuries in terrain parks versus slopes at two ski areas, 2000–05. A total of 3953 (26.7%) injuries occurred in terrain parks, predominantly among young male snowboarders. Terrain park injuries were more likely to be severe, involving head (RR 1.31, 95% CI 1.16 to 1.48) or back (RR 1.96, 95% CI 1.67 to 2.29).

### INTRODUCTION

Snowboarding injuries, particularly head and spine injuries, are increasing.<sup>1</sup> This increase may be due to jumping in terrain parks.<sup>1–3</sup> Terrain parks are outdoor areas containing man-made features (half-pipes, jumps, and metal features such as rails and boxes) that allow aerial manoeuvres and other tricks. The objective was to compare skiing and snowboarding injuries sustained in terrain parks to those sustained on traditional slopes.

### METHODS

This cross-sectional study was conducted with the approval of the University of Washington. Primary data collection was performed for a ski helmet effectiveness study.<sup>4</sup> Each ski resort provided number of skier days based on ticket sales for each season. De-identified data was obtained from all ski patrol reports during the study period at two ski resorts (one large destination, one small local) in two western states. Only injury reports from falls or collisions with people or objects while skiing or snowboarding were included. Non-skiing or snowboard related injuries (eg, fall from ski lift) were excluded because these have no relationship to skiing terrain. The terrain parks and traditional slopes were similar at the two resorts, and neither had a helmet policy. Subjects were persons who suffered injuries to any anatomic area during a fall or collision while skiing or snowboarding and subsequently received medical care from the Ski Patrol. Individuals could have injuries to multiple anatomic areas.

The outcomes of interest were characteristics of injury sustained (type, anatomic location, disposition). Severe injuries were defined as fractures of any type or location, injuries to

**Correspondence to** Dr M Alison Brooks, 621 Science Drive, Madison, WI 53711-1047, USA; brooks@ortho.wisc.edu.

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head or spine, or injuries requiring hospital transportation by ambulance or air. Characteristics of injuries occurring in terrain parks were compared to those on ski slopes using log-binomial relative risk regression models.<sup>5</sup> To adjust for potential confounding factors, multivariate models included covariates for age, sex, self-rated ability, ski season, ski resort, equipment type, equipment ownership, helmet use, ski or snowboard school participation when injured, wind and visibility.<sup>4</sup> Similar multivariate relative risk regression models were fit to compare terrain parks to slopes among skiers and among snowboarders, and to compare skiers to snowboarders at terrain parks.

## RESULTS

A total of 6 331 425 skier days were recorded at two ski areas for five seasons, 2000–01 to 2004–05. In total, 16 945 injured people were reported (injury rate 2.68 per 1000 skier days). Location of injury event in either terrain park or slope was missing for 1856 people. A total of 308 people on telemark or cross-country skis were excluded. Among the remaining 14 781 people, 10 828 (73.3%) were injured on slopes, and 3953 (26.7%) in terrain parks. Individuals sustaining terrain park injuries were more likely to be snowboarders, male, aged 13–24, self-rated as expert, own their equipment, and wear a helmet compared to those injured on slopes (table 1). Subjects injured in terrain parks were younger (terrain park versus slopes, mean 20.5 versus 27.2 years,  $p < 0.0001$ ).

Injuries in terrain parks were more likely to be fractures or concussions, involve injury to head, face and back, and require hospital transport compared to injuries sustained on slopes (table 2). Injuries in terrain parks were less likely to involve the lower and upper extremities compared to injuries sustained on slopes.

When comparing injuries in terrain parks to slopes separately among snowboarders and among skiers, there was higher likelihood for both snowboarding and skiing injuries in terrain parks to be fracture or concussion, involve injury to head and back, and require hospital transport compared to snowboarding and skiing injuries sustained on slopes (table 3). This suggests that injury characteristics are related to injury event location in terrain parks and types of manoeuvres performed there rather than type of activity (skiing or snowboarding).

When comparing snowboarding injuries to skiing injuries in terrain parks only, snowboarding injuries were more likely to involve injury to chest/abdomen and upper extremity/shoulder and less likely to involve injury to face and lower extremity/hip as compared to skiing injuries (table 4).

## DISCUSSION

Most terrain park injuries resulted from high falls among non-beginner male snowboarders aged 13–24 years, and were more likely to involve severe injury requiring hospital transport compared to injuries on slopes. Snowboarding injuries are common among young men.<sup>6–9</sup> There were more injuries among self-rated intermediates and experts than beginners.<sup>6,10</sup> Beginners may appropriately assess their low skill level and not attempt manoeuvres beyond their ability. Injured intermediates/experts may overestimate their true ability and be misclassified beginners.

Hagel hypothesised that beginner child snowboarders from the 1990s may now be experienced adolescent snowboarders attempting difficult tricks in terrain parks.<sup>6</sup> Advanced skill implies faster speeds and attempts at higher, more difficult jumps. If aerial manoeuvres attempted are not in proportion to ability level, more severe injuries may occur. The sport of snowboarding and terrain park design allow for extreme tricks and high risk-taking

attitudes.<sup>11</sup> Some terrain park features are not designed for aerial manoeuvres, and traditional slopes may include terrain-like cliffs or moguls for aerial manoeuvres.

Helmet use is more prevalent among experts, children and snowboarders<sup>12–14</sup>; a higher proportion of those injured in terrain parks were wearing helmets, perhaps reflecting a younger, expert, snowboarder population. Terrain park injuries were more likely to be concussion or involve the head; however the majority of those injured in terrain parks were not wearing a helmet. There is convincing evidence that ski helmets reduce risk of head injury.<sup>415–17</sup> Traumatic brain injury remains the leading cause of death and morbidity for both skiers and snowboarders.<sup>718–20</sup> At national snowboarding events, head injuries only occurred in freestyle events (half-pipe and big air).<sup>11</sup> Helmets are not mandatory at most US ski areas but perhaps should be mandatory in terrain parks.

Many terrain park features are designed for jumps and aerial manoeuvres. Terrain park injuries were from high falls and more likely to involve back injury. Snowboarders landing from a jump are more likely to fall backwards and sustain axial skeleton injury.<sup>3</sup> Spine injuries are increasing, particularly among snowboarders, and as previously suggested, the advent of terrain parks and increased snowboarding popularity may explain this increase.<sup>1921–23</sup>

Goulet *et al* reported that snow-park injuries were more likely to be severe and require ambulance evacuation than slope injuries; severe injuries were defined as fractures, internal injury to head, chest or abdomen, and concussion.<sup>2</sup> The current study also reports a higher likelihood of severe injury and need for hospital transport in terrain parks versus slopes. Goulet *et al* found that snowboarders only had a higher risk of severe extremity injuries in snow-parks compared to slopes. In contrast this study found that severe snowboarding injuries in terrain parks were more likely to involve head and back, not extremities. Both studies suggest that it is primarily the nature and design of terrain parks that leads to severe injury, although activity type likely contributes. Evidence exists that snowboarding may inherently be more dangerous than skiing, and it has now been shown that terrain parks may be more dangerous than slopes.<sup>624</sup> Terrain parks attract many snowboarders, and evidence suggests that an injury problem has arisen from this combination.

Terrain parks contain metal features like rails and boxes to slide along, and striking a body part on the feature may result in injury.<sup>25</sup> Chest/abdomen injuries were almost twice as likely in snowboarders than in skiers injured in terrain parks. The fixed leg position restricts lower body movement and may predispose to trunk or upper body movement that leads to injury.<sup>11</sup> The triad of male gender, aerial manoeuvres (jumping) and abdominal trauma, specifically splenic injury, has been labelled ‘boarder belly’ or ‘snowboard spleen’.<sup>2627</sup>

Exposure data for time spent or runs completed in terrain parks compared to slopes was not available; rates of injury in terrain parks versus slopes could not be calculated. Ski patrol injury report forms did not distinguish between different self-rated ability based on terrain. Only injuries reported to and which received treatment from ski patrols were analysed. Injuries bypassing ski patrols and seen directly by another healthcare provider, and follow-up information on treatment and outcome of injuries requiring hospital transportation were not available for analysis. Ski patrol assessment is assumed to be correct. Moderate to almost perfect agreement has been shown between ski patrol injury reports and self-reported follow-up information.<sup>28</sup> Misclassification of data on ski patrol injury reports is possible, but such misclassification would likely occur similarly to those injured in terrain parks and on traditional slopes.

This study’s findings suggest an injury problem related to types of activities and manoeuvres performed in terrain parks. Future research could identify injury risk factors for each terrain

park feature. Injury programmes might target at-risk populations which use terrain parks and ski areas which contain them. Detailed examination of injury events in terrain parks could lead to design changes that decrease injury; for example, less difficult features for beginners, and marking the difficulty of terrain park features with the same ratings as traditional slopes.<sup>29</sup> Formal instruction targeting young male snowboarders and focusing on technical jumping and landing skills may reduce injury.<sup>25</sup> Lessons could be mandatory before access to difficult terrain parks is granted.

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**Table 1**

Characteristics of individuals sustaining skiing or snowboarding injuries on slopes or in terrain parks at two western ski areas, 2000–05

Characteristics	Slopes		Terrain parks		Missing data N (%)
	(N = 10828)		(N = 3953)		
	N	%	N	%	
Activity					
Alpine skiing	4883	45	625	16	0 (0)
Snowboarding	5945	55	3328	84	
Gender					
Male	5767	53	3218	82	27 (0)
Female	5049	47	727	18	
Age (y)					
1–12	1779	17	354	9	78 (1)
13–24	3840	36	2706	69	
25–39	2705	25	737	19	
40+	2452	23	143	4	
Ability					
Beginner	3676	35	298	8	353 (2)
Intermediate	4505	42	1688	44	
Expert	2444	23	1870	48	
Owned equipment					
No	4457	42	593	15	447 (3)
Yes	6100	58	3236	85	
Wore helmet					
No	8543	80	2860	73	157 (1)
Yes	2174	20	1074	27	
Ski school					
No	9707	90	3842	98	104 (1)
Yes	1057	10	88	2	
Wind					
Calm	8055	77	3065	80	78 (1)
Medium	2127	20	673	18	
High	302	3	79	2	
Clear visibility					
No	1800	17	375	10	501 (3)
Yes	8702	83	3457	90	
Injury mechanism					
Fall: high <sup>*</sup>	486	4	2197	56	
Fall: medium <sup>†</sup>	767	7	772	20	
Fall: level	2751	25	171	4	

Characteristics	Slopes		Terrain parks		Missing data
	(N = 10828)		(N = 3953)		
	N	%	N	%	
Collision	1514	14	126	3	
Unknown	5310	49	687	17	

\* High fall defined as terrain park elevated jump, cliff, or other indication of likely greater height.

† Medium fall defined as mogul or small jump.

**Table 2**

Multivariate relative risk comparing selected injury characteristics among combined snowboarders and skiers injured in terrain parks to those injured on ski slopes at two western ski areas, 2000–05

	% with outcome		Multivariate *	
	Slopes (N = 10828)	Park (N = 3953)	RR	95% CI
Type of injury				
Fracture	29.7	39.8	1.09	1.03 to 1.15
Concussion	6.5	14.6	1.64	1.44 to 1.88
Sprain/strain/dislocation	56.3	38.9	0.87	0.83 to 0.92
Abrasion/laceration/bruise	20.2	22.7	0.97	0.90 to 1.06
Location of injury				
Head	8.9	15.5	1.31	1.16 to 1.48
Face	4.6	7.1	1.25	1.05 to 1.49
Neck	2.2	2.7	1.14	0.86 to 1.51
Back	4.9	11.2	1.96	1.67 to 2.29
Chest/abdomen	4.0	5.5	1.05	0.86 to 1.28
Lower extremity/hip	40.0	22.0	0.85	0.80 to 0.91
Upper extremity/shoulder	41.3	46.6	0.92	0.88 to 0.96
Taken to hospital	51.9	63.0	1.06	1.02 to 1.10

\* Multivariate model includes adjustments for ski area, season, sex, age, ability, helmet use, skis or snowboard, equipment ownership, ski school, wind, visibility.



**Table 3**

Multivariate relative risk comparing selected injury characteristics among snowboarders only and skiers only, injured in terrain parks versus slopes at two western ski areas, 2000–05

	Snowboarders			Skiers		
	% with outcome		Multivariate*	% with outcome		Multivariate*
	Slopes (N = 5945)	Park (N = 3328)	RR (95% CI)	Slopes (N = 4883)	Park (N = 625)	RR (95% CI)
Type of injury						
Fracture	38.6	41.3	1.0 (1.01 to 1.15)	18.9	32.2	1.35 (1.15 to 1.57)
Concussion	7.8	14.5	1.59 (1.36 to 1.85)	5.0	15.5	2.13 (1.61 to 2.82)
Sprain/strain/dislocation	48.3	38.6	0.90 (0.84 to 0.95)	66.0	40.5	0.76 (0.69 to 0.84)
Abrasion/laceration/bruise	20.0	22.1	1.00 (0.90 to 1.10)	20.5	25.4	0.96 (0.82 to 1.12)
Location of injury						
Head	10.5	15.3	1.26 (1.10 to 1.45)	6.9	17.0	1.70 (1.32 to 2.18)
Face	3.7	6.2	1.16 (0.93 to 1.44)	5.7	12.2	1.53 (1.15 to 2.02)
Neck	2.5	2.7	1.15 (0.83 to 1.59)	1.9	2.7	1.12 (0.61 to 2.06)
Back	5.6	11.3	1.92 (1.61 to 2.29)	4.1	10.6	2.20 (1.58 to 3.07)
Chest/abdomen	4.3	5.9	1.18 (0.94 to 1.47)	3.7	3.7	0.74 (0.45 to 1.20)
Lower extremity/hip	23.4	19.5	0.84 (0.76 to 0.93)	60.2	35.4	0.72 (0.65 to 0.81)
Upper extremity/shoulder	56.1	49.8	0.93 (0.89 to 0.98)	23.3	29.1	1.03 (0.88 to 1.20)
Taken to hospital	53.2	63.5	1.07 (1.02 to 1.11)	50.3	60.3	1.09 (1.01 to 1.18)

\* Multivariate model includes adjustments for ski area, season, sex, age, ability, helmet use, equipment ownership, ski school, wind, visibility.

**Table 4**

Multivariate relative risk comparing selected injury characteristics among snowboarders injured to skiers injured in terrain parks only at two western ski areas, 2000–05

	% with outcome		Multivariate*	
	Skiers (N = 625)	Snowboarders (N = 3328)	RR	95% CI
Type of injury				
Fracture	32.2	41.3	1.31	1.14 to 1.50
Concussion	15.5	14.5	0.81	0.65 to 1.02
Sprain/strain/dislocation	40.5	38.6	1.02	0.91 to 1.15
Abrasion/laceration/bruise	25.4	22.1	0.81	0.69 to 0.95
Location of injury				
Head	17.0	15.3	0.81	0.69 to 0.95
Face	12.2	6.2	0.41	0.31 to 0.54
Neck	2.7	2.7	0.89	0.50 to 1.58
Back	10.6	11.3	1.06	0.80 to 1.41
Chest/abdomen	3.7	5.9	1.65	1.03 to 2.63
Lower extremity/hip	35.4	19.5	0.65	0.57 to 0.75
Upper extremity/shoulder	29.1	49.8	1.66	1.44 to 1.90
Taken to hospital	60.3	63.5	1.03	0.95 to 1.11

\* Multivariate model includes adjustments for ski area, season, sex, age, ability, helmet use, equipment ownership, ski school, wind, visibility.