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Helmet use and injury severity among pediatric skiers and snowboarders in Colorado☆,☆☆,★

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ABSTRACT

Introduction: Skiing and snowboarding are popular winter recreational activities that are commonly associated with orthopedic type injuries. Unbeknownst to most parents, however, are the significant but poorly described risks for head, cervical spine and solid organ injuries. Although helmet use is not mandated for skiers and snowboarders outside of resort sponsored activities, we hypothesized that helmet use is associated with a lower risk of severe head injury, shorter ICU stay and shorter hospital length of stay.

Methods: The trauma registry at a level I pediatric trauma center in the state of Colorado was queried for children ages 3–17 years, who sustained an injury while skiing or snowboarding from 1/1/1999 to 12/31/2014. Injury severity was assessed by Abbreviated Injury Severity (AIS) score, injury severity score (ISS) and admission location. Head injury was broadly defined as any trauma to the body above the lower border of the mandible. Regression analysis was used to test associations of variables with injury severity.

Results: 549 children sustained snow sport related injuries during the 16 year study period. The mean patient age was11 ± 3 years, most were male (74%) and the majority were Colorado residents (54%). The overall median ISS was 9 (IQR 4–9) and 78 children (14%) were admitted to the ICU. Colorado residents were nearly twice as likely to be wearing a helmet at the time of injury, compared to visitors from out-of-state (adjusted OR 1.86, 95% CI 1.24–2.76, $p = 0.002$). In a multivariate analysis injury severity was significantly associated with injury while skiing ($p = 0.026$), helmet use ($p = 0.0416$), and sustaining a head injury ($p < 0.0001$). In a separate multivariate analysis ICU admission was associated with head injury ($p < 0.0001$) and wearing a helmet ($p = 0.0257$); however, those wearing a helmet and admitted to the ICU had significantly lower ISS ($p = 0.007$) and head AIS ($p = 0.011$) scores than those who were not wearing a helmet at the time of injury.

Conclusion: Visitors from out of state were less likely to be wearing a helmet when injured and more likely to be severely injured, suggesting Colorado residents have a better understanding of the benefits of helmet usage. Helmeted skiers and snowboarders who were admitted to the ICU had significantly lower ISS and head AIS scores than those who were not helmeted. Pediatric skiers, snowboarders and their parents should be educated on the significant risks associated with these activities and the benefits of helmet usage.

Level of evidence: III.

Skiing and snowboarding are popular winter recreational activities in the state of Colorado. The high velocity of participants, who must navigate over uneven, sometimes unfamiliar terrain in variable lighting and snow conditions, places them at risk for significant injury [1,2]. Although head injuries account for a small fraction of skiing and snowboarding-related injuries, they are the leading cause of snow sport-related death and disability [3]. In a recent study more than 25% of children younger than the age of 16 who sustained an injury while participating in snow sports sustained a head injury [4]. Furthermore, as few as one-third of children who participate in snow sports have been found to wear a helmet [5,6]. Despite these findings, Colorado law does not mandate helmet use and the vast majority of ski resorts across the country do not require helmets [7]. Our goal in performing this study was to characterize the types of injuries sustained by children who participate in snow sport activities, in order to identify factors that may be associated with greater injury severity, morbidity and mortality.

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We were particularly interested in understanding the relationships between helmet usage and head injury. We hypothesized that helmet use is associated with a lower risk of severe head injury, shorter ICU stay and shorter hospital length of stay.

1. Materials and methods

1.1. Identification of patients

This study was reviewed and approved by the Colorado Multiple Institutional Review Board (COMIRB). Data were extracted from the trauma registry at Children's Hospital Colorado, the only American College of Surgeons (ACS) verified level I pediatric trauma center in the state of Colorado. Inclusion criteria were: children ages 3–17 years, who presented for treatment following a skiing- or snowboarding-related injury, during a 16-year period (January 1, 1999–December 31, 2014).

1.2. Data classification

Data collected included: age, gender, state or country of residence (Colorado resident or visitor from out-of-state), time of day and day of week the injury occurred, location of injury (state/resort), type of snow sport (skiing or snowboarding), mechanism of injury (fall or collision), presence or absence of a helmet at the time of injury, level of hospital care [observation, ward, or intensive care unit (ICU) admission], abbreviated injury severity score (AIS), injury severity score (ISS), and Glasgow coma score (GCS). A head injury was broadly defined as any trauma to the body above the lower border of the mandible; this included very minor injuries such as simple scalp lacerations. A collision was defined as impact with anything other than the ground. Injuries were categorized into four groups: head (head injury only), head plus other (head injury plus other injury), other injury (injury without head injury), or no significant injury (no injury).

1.3. Data analysis

Patients were stratified by sport (skiing or snowboarding), helmeted or not helmeted, injury severity (ISS and AIS) and admission location. Chi-square and Kruskal–Wallis tests were used for group comparisons. Linear, logistic, and multinomial regressions were used to test the associations of variables in univariate and multivariate analyses.

2. Results

There were 549 children treated for snow sport-related injuries during the 16-year study period. The mean age was 11 ± 3 years (range 3–17 years) and 74% (405/549) were male. The majority of injured children were Colorado residents (54%, 295/549) and the vast majority of injuries occurred in Colorado (499/552). Four children were injured in Wyoming, two in New Mexico, one in Pennsylvania and in 46 cases the location was not identified.

Cervical spine injuries, some of which were significant, were sustained by 2.7% of skiers and snowboarders. Intraabdominal injuries were evenly distributed between skiers and snowboarders, with the exception of splenic injuries, which were much more common among snowboarders (14.7%). And, not surprisingly, upper extremity orthopedic injuries were more commonly sustained by snowboarders (27.2%), while skiers were more susceptible to lower extremity (49.3%) and pelvic fractures (4.1). (See Table 1.)

Table 1
Cervical Spine, Intraabdominal and Orthopedic Injuries.

	Skier N = 365 (%)	*Snowboarder N = 184 (%)*
C-spine	10 (2.7)	5 (2.7)
Intraabdominal Injuries		
Liver	10 (2.7)	2 (1.0)
Spleen	12 (3.2)	27 (14.7)
Kidney	9 (2.5)	5 (2.7)
Pancreas	0	1 (0.5)
Orthopedic Injuries		
Upper extremity	43 (11.8)	50 (27.2)
Lower extremity	180 (49.3)	40 (21.7)
Pelvis	15 (4.1)	3 (1.6)

2.1. Factors associated with helmet use

Fifty-seven percent of children were helmeted at the time of injury (314/549; Table 2). Although males made up a larger percentage of injured patients (73.8%, 405/549), their comparative helmet use rate (59%; 239/405) was a little bit higher than females (52%; 75/144). Colorado residents who were injured while skiing or snowboarding comprised 53.7% of the population under study. The other 46.3% were visitors from another state or country. Interestingly, Colorado residents were nearly two times more likely to be helmeted at the time of injury (adjusted p = 0.0003, OR 1.86, CI 1.24–2.76; 64%, 189/295), when compared to visitors from out-of-state (49%, 125/254).

Table 2 demonstrates the influence of helmet use on the location of hospital admission. Sixty-three patients were admitted for "Observation"; these patients were observed overnight in the emergency department (ED) or on the ward and had a length of stay (LOS) of ≤24 h. There were 408 patients admitted to the ward; these patients had a LOS > 24 h and were categorized as "Floor Admission". Seventy-eight patients were admitted to the ICU and categorized as "ICU Admission". In univariate analyses the presence or absence of a helmet at the time of injury did not influence the location of admission. Removing "Observation" patients from the analysis led to a higher proportion of helmeted patients being admitted to the ICU, however, the association was not significant. Similarly, univariate analysis of helmet use and non-use did not significantly influence injury category, or the presence or absence of a head injury. In summary, univariate analysis of age, gender, type of snow sport, presence of a head injury, and admission location were not significantly associated with helmet use or non-use (Table 2). Furthermore, there

Table 2
Univariate Factors and Helmet Use.

		No Helmet N = 235 (%)	*Helmet N = 314 (%)*	*Unadjusted P-value*
Gender	Male	166 (70.64)	239 (76.11)	0.149
	Female	69 (29.36)	75 (23.89)	
Sport	Skier	159 (67.66)	206 (65.61)	0.614
	Snowboarder	76 (32.34)	108 (34.39)	
Residence	CO resident	106 (45.11)	189 (60.19)	<.001
	Out of state resident	129 (54.89)	125 (39.81)	
Admission location (w/ observation patients)	Observation	23 (9.79)	40 (12.74)	0.121
	Floor admission	185 (78.72)	223 (71.02)	
	ICU admission	27 (11.49)	51 (16.24)	
Admission location (w/o observation patients)	Floor admission	185 (87.26)	223 (81.39)	0.080
	ICU admission	27 (12.74)	51 (18.61)	
Injury category	Head injury only	49 (20.85)	78 (24.84)	0.103
	No head injury, other injury	166 (70.64)	206 (65.61)	
	Head injury plus other injury	19 (8.09)	21 (6.69)	
	No injury	1 (0.43)	9 (2.87)	
Head injury	No	167 (71.06)	215 (68.47)	0.514
	Yes	68 (28.94)	99 (31.53)	
ICU LOS	Mean (SD)	3.15 (4.38)	2.51 (4.05)	0.533
Total LOS	Mean (SD)	2.18 (2.13)	2.59 (2.56)	0.052