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Snowboarding injuries in Australia: Investigating risk factors in wrist fractures to enhance injury prevention strategies

Short title: Wrist fractures in snowboarding

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Snowboarding injuries in Australia: Investigating risk factors in wrist fractures to enhance injury prevention strategies

Abstract:

Objective: To investigate risk factors associated with wrist fractures in snowboarders to inform future snowsport safety strategies.

Design: A prospective case-control study using a non-probability convenience sample was conducted with data collected via a respondent completed questionnaire. Those presenting with injuries other than wrist fractures acted as the control.

Participants: Snowboarders with a snowboard-related injury who presented to one of 10 medical centres and physiotherapy clinics in resort medical centres and gateway communities across the Australian snowsport season in 2007.

Results: The 611 respondents reported 802 injuries (61.3% were males and 51.5% were aged 16-25 years). Protective equipment was worn by 57.0% of respondents. The main reason for not wearing a wrist guard was that they did not see the need, of these 12.9% experienced a wrist fracture. Most injuries occurred on-piste, in a terrain park or in a lesson. The main mechanism of injury was falling over. The major risk factors for wrist fractures were age < 16 years (OR 3.97, CI 2.54 to 6.22), being on holidays in the alpine area (OR 2.77, CI 1.47 to 5.21) and a first day snowboard participant (OR 2.02, CI 1.15 to 3.64). A direct logistic regression indicated that three variables had a statistically significant contribution to the model (age <16 years, being on holidays in the region and not wearing a wrist guard).

Conclusions: The key risk factors in this Australian study reflect other international studies, providing a clear market segment for targeted snowsport safety messages for those under 16 years, visitors to the alpine regions and those not wearing wrist guards.

Keywords: snowboarding; risk factors; risk management; snowsports; injury prevention

Introduction

This research explores factors that contribute to the risk of wrist fractures for snowboarders in Australia, in order to identify targets for injury prevention strategies (1). Previous research indicates that snowboarders could make up from 20% to 50% of the more than 220,000 Australians over 14 years of age who participate in snowsports each year (2-4). International estimates of injury rates in snowsports suggest that there are around three injuries per 1,000 'skier days', i.e. participation days [(4)]. In Australia there are more than two million 'skier days' per year (5), which would suggest an estimated 6,000 snowsport related injuries per year in Australia. With the emergence of newer snowsport disciplines, such as snowboarding, there have been changes in the mechanism and types of snowsport injuries [(6)].

There is debate over the extent to which wrist guards protect against upper limb injuries (7, 8), . Despite there being evidence that wrist guards may protect against wrist fractures, two studies suggest that snowboarders do not see the need to wear wrist guards, while some participants believe that wrist guards will actually contribute to injuries, suggesting that snowsport safety messages may not be reaching the target audiences.

A thorough understanding of snowsport injuries will help in the creation of informational and educational programs aimed at targeted snowsport participants. Preventing injuries, particularly severe injuries, mitigates the physical and psychosocial reasons for not returning to the activity(1). Something for consideration by resort managers is that as many as 17% of injuries may be to people working in the snowsport industry, raising concerns regarding occupational health and safety and the ongoing availability of staff [4].

The relative newness of snowboarding compared with alpine skiing, and the fact that it is appealing to a market that may be more likely to be higher risk takers, [9] presents a challenge to researchers and those who are responsible for managing snowsport safety. To help inform these groups, this research addresses three questions: i) which snowboarders are most at risk of a wrist fracture?, ii) where and how do most injuries occur? and, iii) what are the behaviors and attitudes towards protective equipment usage? Answers to these questions will aid in the development of injury prevention and snowsport safety strategies.

Methods

A prospective case-control study, using a non-probability convenience sample, was conducted drawing upon ten medical centres and physiotherapy practices within and adjacent to six of the largest snowsport resorts across two states in Australia. The staff in each of these practices volunteered to collect data on injuries sustained by snowboarders on the slopes during the 2007 season. As is seen in recent research designs [10, 11] cases were those people presenting with wrist fractures from snowboarding, while controls were those people presenting with other snowboarding injuries. For this study, an 'injury' was deemed to be an on-snow incident requiring medical treatment from the various practices involved.

The anonymous respondent-completed questionnaire was designed to build upon knowledge gained via previous research into snowsport injuries [4, 12]. Collected data included demographics, snowboarding experience levels, levels of instruction, protective equipment usage, and wrist guard design. Respondents provided information regarding their snowboard injury including: the mechanism of injury, time and date, location within the resort where the injury occurred, the location of the injury to the body, and the type of injury.

Data was entered into PASW Statistics 18.0 for analysis. The prevalence of wrist fractures was explored across the case group and the control group, and chi-squared analysis (with Yates Continuity Correction for two by two tables) was conducted. Odds ratios (OR) and 95% confidence intervals (CI) were calculated for the risk factors identified in previous research: age [13], gender [6], wrist guard usage [8, 14], and experience levels [14]. Additional risk factors that were considered included the reason for being in the snowsport resort region and participation in previous snowboarding lessons. Direct logistic regression was performed to assess the impact of

a number of factors on the likelihood that respondents would experience a wrist fracture. The model contained four independent variables (age, days of snowboarding experience, reason for being in the region and wrist guard usage).

Results

The 611 snowboarders presented with 802 injuries, including bruising (82.1% of respondents), dislocations (7.2%), concussions (1.8%) and fractures (38.2%). Of the 802 injuries 108 were wrist fractures (17.7%), including two cases of bilateral wrist fractures. The age range was 8-57 years (mean=22.1 years, S.D. 8.1, mode=15 years), 270 were males less than 25 years of age (45.7%). People with less than seven days snowboarding experience were the largest group by experience (239, 39.6%) (Table 1). Less than half of the respondents indicated that they normally wore at least one piece of protective equipment (49.6%), as distinct from what they were wearing at the time of their injury. Almost half of respondents had experienced a previous snowboard injury (265, 46.5%, mean injuries=2.1, mode=0). Significant differences emerged between the cases and controls in age and snowboard experience (Table 1) with the cases (i.e. those with a wrist fracture) being generally younger and less experienced than the controls.

Insert Table 1

For the 457 (74.8%) who indicated that they did not normally wear wrist guards when they were snowboarding, the main reasons, using categories from previous research [15, 16], were: 155 did not see the need (33.9%); 111 indicated they were uncomfortable to wear (24.3%); 66 couldn't get hold of them (14.4%); 57 believed that wrist guards would contribute to injuries (12.5%); and 38 did not believe they would provide protection (8.3%). Of the 155 who did not see the need for wearing wrist guards, 20 (12.9%) experienced a wrist fracture; of the 38 who thought that wrist guards would not provide protection, 3 (7.9%) experienced a wrist fracture, while for the 57 who believed that wrist guards would contribute to injury, 6 (10.5%) experienced a wrist fracture.

The main location of the respondents at the time of their injury was "on-piste", that is a maintained area within resort boundaries (Table 2). Of the 33 who indicated that they were injured on a terrain park box or rail, 18 (54.5%) were aged 16-25 years, while of the 33 who were injured going over a terrain park kicker or jump, 22 (66.7%) were aged 16-25 years (one person did not indicate their age). Of the 83 people injured in the terrain park, in the half-pipe or on the slope style course, 65 were aged less than 25 years (78.3%). Of the 42 injured during a snowboarding lesson, 17 (40.5%) were aged under 16 years.

Insert Table 2*?*

Mechanisms of injury are listed in Table 3.

Insert Table 3 ?

Only 286 respondents (46.8%) provided information on their location within the resort at the time of injury as well as the mechanism of their injury. Of these, the most common injury events

were falling over on-piste (n=165, 57.7% of responses), being out of control while on-piste (n=23, 8.0%), and falling over in a lesson (n=22, 7.7%).

Odds ratios and 95% confidence intervals were calculated for potential risk factors in wrist fractures (Table 4). The most notable were: those aged under 16 years; being in the alpine area for a holiday; and first time participants.

Insert Table 4?

For the direct logistic regression the full model containing all predictors was statistically significant, X^2 (4, N=590) = 48.432, p<.001, indicating that the model was able to distinguish between respondents who experienced a wrist fracture and those that did not. The model as a whole explained between 7.9% (Cox and Snell R square) and 13.0% (Nagelkerke R squared) of the variance in wrist fractures and correctly classified 82.2% of cases. As shown in Table 5, only three of the independent variables made a unique statistically significant contribution to the model (age, reason for being in the region and wearing a wrist guard). The strongest predictor of reporting a wrist fracture was age being under 16 years, followed by not wearing a wrist guard and being in the region for a holiday/vacation. These results indicate that respondents under the age of 16 years were more than three times more likely to report a wrist fracture than those 16 years and over.

Insert Table 5?

Wrist guard design was investigated across the design characteristics of the most commonly available wrist guards for sale and hire/rent drawing upon descriptors adopted in previous research [12]. For the 76 people (12.4%) who indicated that they were wearing a wrist guard at the time of their injury, 10 experienced a wrist fracture. Where the design data is available, all people who experienced a wrist fracture while wearing a wrist guard (n=8) were wearing a short wrist guard, with 50% using a short, palm-side only design. Those with wrist fractures were more likely to have hired / rented their wrist guards than those who did not experience a wrist fracture (50% *cf.* 39%) (Table 6).

Insert Table 6*?*

As shown in Table 7 the dominant design of wrist guard worn by snowboarders who experienced a wrist fracture was a palm-side only design (60%). When considered in conjunction with the length of the wrist guard, the short palm-side design accounted for 50% of wrist fractures when wearing wrist guards at the time of injury.

Insert Table 7*?*

Study limitations

Case control studies are common when studying sporting injuries, however they have 'limited power in reliably identifying risk factors because of their retrospective nature and issues relating to the appropriate selection of both cases and controls' [17]. Finch (2006) further suggests that no

epidemiological study can clarify the direct mechanisms of injury, however epidemiological studies, including case-control studies, do help to provide pointers towards risk factors that may be modified in the future through injury prevention strategies. The choice of using controls who have injuries other than wrist fractures, as is the situation here, may enhance the matching on case and controls regarding factors such as risk taking (not explored here), but not the mechanism of injury, such as whether they fell onto an outstretched arm(18). The lack of available data indicating the total numbers of snowsports participants at the sites, i.e. the denominator data, is also problematic for a study such as this. Without this data it is not possible to determine injury rates, or to evaluate the impact of snowsport safety strategies over time. A proportionately small number of respondents reported on wrist guard design, leading to a lack of statistically significant odds ratio analysis in this area. Also, as the data was voluntarily collected by staff at each medical practice there is no method of determining the proportion of the injured population that was surveyed, whether it is a representative sample, if there was selection bias, or what the rate of refusal might have been. The small sample size, especially for those who were wearing wrist guards at the time of the injury means that it is not possible to generalize these results to other populations.

Discussion

Who is most at risk?

Of the 611 injured snowboarders, most were males aged 16-25 years. Those with less than seven days experience were the largest group by experience level, comparable with a previous study where 34.8% of injured snowboarders had less than seven days experience [(4)]. There were 67 who were first time participants which was 11.1% of all responses, but 17.8% of those with a wrist fracture. This information suggests the necessity of targeting safety communication to new or inexperienced, particularly young male, snowboarders.

Resort Location, Activity and Mechanism of Injury

The significance of the number of on-piste injuries to snowboarders may be a result of more people being in these areas. It may also be attributable to the fact that most new snowsport participants have yet to develop the skills to participate off-piste. What is not known is to what extent environmental factors such as slope grooming, obstacles, slope angle, trail design, usage or crowding may have upon injury levels in groomed areas. For example, with well-groomed, open trails, people may travel faster and put themselves at greater risk when they do not have the knowledge or experience to maintain control or predict when they may be in a situation outside their skill level.

Injuries in terrain parks accounted for almost 30% of the snowboard injuries. Terrain parks, half pipes and slope style courses, where 84 of the injuries occurred, are prime attractions for youth, the group with the highest frequency of injury. This indicates that future snowsport safety tactics and strategies may need to be focused towards this group by exploring what, if any, differences exist in snowboarder sub-cultures that may be leveraged to support injury prevention strategies. As with the study limitations, in the absence of information on the proportion of snowboarders

who use parks vs. on-piste it is not possible to conclude that park injuries are more common than on-piste, it just may simply be that more snowboarder use the parks.

The incidence of injuries during lessons may be explained by the relatively high percentage of new or inexperienced snowboarders taking lessons in snowsport schools. This indicates that snowboard instructors must be armed with injury prevention information and education that they can use during their lessons and pass along to their students, which could lead to a reduction of injuries during and after lessons.

Protective equipment usage

Forty-three percent of respondents were not wearing any form of protective equipment at the time of their injury despite there being extensive discussion about the benefits of using protective equipment in snowsports.[19-24]. Low rates of helmet and wrist guard usage give rise to further questions such as whether the role of protective equipment is being effectively conveyed to participants and, secondly, if participants are indeed ignoring the message about the potential protective role of wrist guards and helmets, then why? The fact that many indicated that they did not see need or that wrist guards would not protect against an injury, or may add to injuries, suggests that there is a communication issue, while the concern about comfort relates to equipment design. This suggests further research directions that may effect the adoption of appropriate protective equipment usage(25).

Risk factors in wrist fractures

The results presented here (Table 4) support that people under 16 years are four times more likely to experience a wrist fracture than other age groups. The increased risk of wrist fractures for people under 16 years raises the concern that injuries may occur in growth plate areas, resulting in longer term complications and health costs [26]. The difference in the results from the odds ratio (univariate) when compared to the logistic regression (multivariate) may be a result of the univariate analysis not incorporating the combined influence of the variables, such as age with being in the region for a holiday. In contrast, the multivariate analysis involves multiple variables simultaneously and thus considers a broader impact from data, such as the combination of age, not wearing a wrist guard, and being in the region for a holiday.

First time participants (i.e. first day) are twice as likely to experience a wrist fracture than those with more than one day's experience. This suggests that more effective strategies are required to inform first time participants about how to minimize the risk of a wrist fracture. The results from this study did not support the contribution of gender or having had previous snowboard lessons as contributing factors to wrist fractures.

Another notable insight from this research is the greater risk faced by those in the alpine region for a holiday or vacation, with tourists being nearly three times more likely to experience a wrist fracture when compared with those who live in the region for the season or permanently. Safety communication may need to be placed in locations likely to be frequented by tourists to the area to help mitigate this risk factor. It should be recalled that this study does not provide any information on the levels of exposure, or the participation hours, of respondents. For example, it

may be assumed that vacationers may participate less during the season than local residents, but it is not possible to conclude that from the available data.

Previous research on the protective value of wrist guards in snowboarding has focused on whether they were used or not, but the reality is that wrist guards vary greatly in design, wearing position, length and protection location, and thus far there is no published research that looks at outcomes based upon these design elements. Not all wrist guards are the same, thus it is problematic to conclude that all wrist guards provide the same protection. Our sample size for those wearing wrist guards was too small to draw any conclusions regarding the role of wrist guard design in protection or contribution to injury. The wide confidence intervals we observed could be explained if some wrist guard designs protect against injury, while others may contribute to injuries. For example no one wearing a long, back-of-wrist or both-sides design experienced a wrist fracture. Further research with a larger sample size and more detail of the wrist guard design, brands and models, the injury type and location of injury (relative to the wrist guard) is needed to explore what if any role the different wrist guard designs play in injury prevention.

Conclusion

Understanding the risk factors which may lead to snowsport injuries can facilitate more effective injury prevention strategies to assist all participants in managing their injury risk. While based upon a small sample size, the results of this Australian study support previous research that indicates that age, experience and wrist guard usage are factors related to the risk of snowboard injuries, in particular wrist fractures. The data also suggests that being a tourist to the alpine region is an additional risk factor. Given that some respondents do not think wrist guards protect against injury or that they may add to injury, safety strategies may need to emphasize education for participants in the role and effect of wrist guards. We call for further research into the importance of wrist guard designs. In addition, more work is needed to determine the efficacy of injury prevention and snow sport safety strategies targeted towards the high risk groups we have identified.

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Table 1 Characteristics of case and control groups

	All responses (n=611)	Cases: wrist fracture (n=108)	Controls: no wrist fracture (n=503)	Chi-squared analysis (df, N), p value
Gender				(1, 594), p=.33
Male	364 (61.3%)	60 (56.6%)	304 (62.3%)	
Female	230 (38.7%)	46 (43.4%)	184 (37.7%)	
Age group (years)				(3, 599), p<.01
< 16	133 (22.2%)	48 (45.3%)	85 (17.2%)	
16-25	307 (51.3%)	44 (41.5%)	263 (53.3%)	
26-40	138 (23.0%)	14 (13.2%)	124 (25.2%)	
> 40	21 (3.5%)	0 (0.0%)	21 (4.3%)	
Snowboard experience				(5, 605), p=.02
1 day	67 (11.1%)	19 (17.9%)	48 (9.6%)	
2-6 days	172 (28.4%)	34 (32.1%)	138 (27.7%)	
7-13 days	72 (11.9%)	16 (15.1%)	56 (11.2%)	
14-27 days	85 (14.0%)	14 (13.2%)	71 (14.2%)	
4-8 weeks	65 (10.7%)	6 (5.7%)	59 (11.8%)	
> 8 weeks	144 (23.8%)	17 (16.0%)	127 (25.5%)	
Snowboard lessons				(4, 604), p=.07
No lessons	129 (21.4%)	20 (19.0%)	109 (21.8%)	
1-5	364 (60.3%)	310 (60.3%)	63 (60.0%)	
6-10	50 (8.3%)	12 (11.4%)	38 (7.6%)	
11-15	16 (2.6%)	6 (5.7%)	10 (2.0%)	
> 15	45 (7.5%)	4 (3.8%)	41 (8.2%)	
Protection worn at time of injury				N/A
Nil	263 (43.0%)	59 (54.6%)	204 (40.6%)	
Helmet	156 (25.5%)	39 (36.1%)	117 (23.2%)	
Wrist guard	76 (12.4%)	10 (9.3%)	66 (13.1%)	
Hip/butt	14 (2.3%)	2 (1.9%)	12 (2.4%)	
Back	2 (0.3%)	0 (0.0%)	2 (0.4%)	

Table 2 Resort location and activity at time of injury where responses provided (n=411)

	N (% of cases*)
On-piste	245 (67.3%)
Terrain park total	67 (18.4%)
box or rail	34 (9.3%)
kicker or jump	33 (9.1%)
During a snowboarding lesson	42 (11.5%)
Off-piste	17 (4.7%)
Own kicker or jump	15 (4.1%)
Slope style course	12 (3.3%)
Half-pipe	5 (1.4%)
One foot out: skating	5 (1.4%)
During a race	3 (0.8%)
* *Multiple responses possible*	

Table 3 Mechanism of injury where responses were provided (n=352)

	N (% of cases*)
I fell over	250 (79.9%)
I was out of control	33 (10.5%)
I was riding or getting off a lift	24 (7.7%)
Someone ran into me	23 (7.3%)
I ran into someone else	14 (4.5%)
I hit a tree or lift	7 (2.2%)
My binding broke or released	1 (0.3%)
* *Multiple responses possible*	

Table 4 Odds ratios and 95% confidence intervals for potential risk factors

	Cases (n=108)	Controls (n=503)	Odds ratio (95% confidence interval)
Gender			
Male	60 (56.6%)	304 (62.3%)	.79 (.52 to 1.21)
Female	46 (43.4%)	184 (37.7%)	
Age group (years)			
< 16	48 (45.3%)	85 (17.2%)	3.97 (2.54 to 6.22)
> 16	58 (54.7%)	408 (82.8%)	
Snowboard experience			
First timer vs all others			
1 day	19 (17.9%)	48 (9.7%)	2.04 (1.15 to 3.64)
> 1 day	87 (82.1%)	449 (90.3%)	
Beginners (<7 days) vs others			
< 7 days	53 (50.0%)	186 (37.4%)	1.67 (1.10 to 2.55)
7 days or more	53 (50.0%)	311 (62.6%)	
Wrist guard usage at the time of injury			
No	97 (90.7%)	438 (86.9%)	1.46 (.73 to 2.95)
Yes	10 (9.3%)	66 (13.1%)	
Reason for being in alpine region			
Holiday	95 (88.8%)	369 (74.1%)	2.77 (1.47 to 5.21)
Living or working for season	12 (11.2%)	129 (25.9%)	
Previous snowboard lessons			
No	20 (19.0%)	109 (21.8%)	.84 (.50 to 1.43)
Yes	85 (81.0%)	390 (78.2%)	

Table 5 Logistic regression predicting likelihood of wrist fracture

	B	S.E.	Wald	*df*	*p*	Odds ratio	95% C.I. for O.R. lower	95% C.I. for O.R. upper
Age category (< 16 years)	1.280	.237	29.146	1	.000	3.595	2.259	5.722
Reason for being in the region (on holidays)	.838	.367	5.221	1	.022	2.312	1.127	4.744
Wearing a wrist guard at the time of injury	.852	.387	4.851	1	.028	2.344	1.098	5.004
Days experience (< 7 days)	.282	.233	1.470	1	.225	1.326	.840	2.094
Constant	-3.502	.509	47.363	1	.000	.030		

Table 6 Wrist guard design and ownership where wrist guard worn at time of injury (n=76)

	Cases (wrist fracture, n=10)	Controls (no wrist fracture, n=66)
Wrist guard length		
Short	8 (80%)	42 (64%)
Long	0 (0%)	16 (24%)
Missing data	2 (20%)	8 (12%)
Wrist guard length and protection		
Short, palm-side only protection	5 (50%)	16 (24%)
Short, dorsal only or palm and dorsal protection	2 (20%)	25 (38%)
Long, palm-side only protection	0 (0%)	6 (9%)
Long, dorsal only or palm and dorsal protection	0 (0%)	8 (12%)
Missing data	3 (30%)	11 (17%)
Wrist guard stiffness		
Soft	2 (20%)	2 (3%)
Stiff (some flex)	4 (40%)	35 (53%)
Rigid (no flex)	4 (40%)	23 (35%)
Missing data	0 (0%)	6 (9%)
Wrist guard position		
Build into glove/mitten	1 (10%)	4 (6%)
Inside glove/mitten	4 (40%)	20 (30%)
Outside glove/mitten	4 (40%)	29 (44%)
Missing data	1 (10%)	13 (20%)

Wrist guard ownership		
My own	2 (20%)	28 (42%)
Borrowed	1 (10%)	3 (5%)
Rent/hire	5 (50%)	26 (39%)
Missing data	2 (20%)	9 (14%)

Table 7 Odds ratios and 95% confidence intervals for design characteristics of wrist guards used at the time of injury (n=76)

	Cases (%) (n=10)	Controls (%) (n=66)	Odds ratio (95% confidence interval)
Protection location:			
Palm-side only design	6 (60%)	23 (35%)	2.28 (.58 to 8.98)
Dorsal (rear) or both sides design	4 (40%)	35 (53%)	
Missing data	0	8 (12%)	
Protection location and wrist guard length:			
Short, palm-side only design	5 (50%)	16 (24%)	4.17 (.89 to 19.52)
Short or long, dorsal or both sides design	3(30%)	40 (61%)	
Missing data	2 (20%)	10 (15%)	