ACTIVE & SAFE

Evidence Summary: Snowboarding

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BC INJURY research and prevention unit

The British Columbia Injury Research and Prevention Unit (BCIRPU) was established by the Ministry of Health and the Minister's Injury Prevention Advisory Committee in August 1997. BCIRPU is housed within the Evidence to Innovation research theme at BC Children's Hospital (BCCH) and supported by the Provincial Health Services Authority (PHSA) and the University of British Columbia (UBC). BCIRPU's vision is *to be a leader in the production and transfer of injury prevention knowledge and the integration of evidence-based injury prevention practices into the daily lives of those at risk, those who care for them, and those with a mandate for public health and safety in British Columbia.*

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Evidence synthesis tool

SPORT	Snowboarding	**Target Group**	Recreational snowboarders	
Injury Mechanisms	Common injury mechanisms in snowboarding include technical errors, collisions with an inanimate object or a person, falls on a slope, after an aerial maneuver or/and a large drop to the ground, and falls from ski-lift			
Incidence/Prevalence	**Risk/Protective Factors**	**Interventions**	**Implementation/Evaluation**	**Resources**
Overall Injury rates are two to three times higher in snowboarders compared to skiers (2-3 per 1000 skier days) (Ackery, Hagel, Provvidenza, & Tator, 2007). Injury rates are reported between 1.7 and 16 injuries per 1000 snowboarder days (K. Russell, Hagel, & Francescutti, 2007; Toth, 2006). **Spinal Cord Injury (SCI)** Estimated incidence of SCI is 0.04 per 1000 snowboarder days (Toth, McNeil, & Feasby, 2005). **Head and Neck Injury** For skiers and snowboarders, incidence rates of head and neck injury have been reported between 0.09 and 0.46 per 1000 outings (K. M. Russell, Christie, & Hagel, 2010).	**Modifiable Risk Factors** *Helmet Use:* The pooled odds ratio (OR) indicated that skiers and snowboarders with a helmet were significantly less likely than those without a helmet to have a head injury (OR: 0.65; 95% CI: 0.55–0.79). Helmets were not associated with an increased risk of neck injury (OR: 0.89; 95% CI: 0.72–1.09) (K. M. Russell et al., 2010). *Wrist Guard Use:* According to RCTs and cohort studies, the risk of wrist injury (Relative risk: 0.23; 95% CI: 0.13-0.41), wrist fracture (RR: 0.29; 95% CI: 0.10-0.87), and wrist sprain (RR: 0.17; 95% CI: 0.07-0.41) is significantly reduce with the use of wrist guards. Among the case-control studies, wrist guards significantly decrease the odds of sustaining a wrist injury (OR: 0.46; 95% CI: 0.35-0.62). There is no significant association between wrist guard use and shoulder/finger/elbow injury (K. Russell et al., 2007). *Rented equipment:* Skiers and snowboarders that rent equipment have a higher risk of injury (OR: 2.58; 90% CI: 1.98-3.37) (Hume,	**Wrist Braces** The protective effect of wrist guard for wrist injuries demonstrates sufficient evidence to be effective (Hume et al., 2015). **Cost-Effectiveness** Limited evidence for studies evaluating cost to benefit ratio of countermeasure interventions (Hume et al., 2015).	**Prevention Program** A prevention program in collaboration with prevention-minded partners improves the implementation of measures (Bianchi & Brügger, 2015). **Policy** A compulsory wrist brace policy implemented with school students showed a large effect on reducing wrist fractures. However, the efficacy of implementing such policies outside of a school environment is unknown (Hume et al., 2015) . **Multifaceted Approach** A multifaceted approach, including education, legislation, and enforcement is effective in achieving full helmet compliance among all ages of skiers and snowboarders (Fenerty et al., 2016). **Limitations** Resources for evaluation are limited. Research should be supported to address the evaluation of existing	**Websites** Think first Canada (injury prevention booklet) http://data.injuryresearch.bc.ca Québec Association of Ski Areas (safety messages) https://maneige.ski SportMedBC (safety messages) https://sportmedbc.com Parachute Canada (safety messages) http://www.parachutecanada.org The National Ski Areas Association (NSAA) and Burton Snowboards- Smart Style (educational program, safety messages, and terrain parks videos) http://www.nsaa.org http://www.terrainparksafety.org Injury prevention center (safety messages) http://injurypreventioncentre

	Lorimer, Griffiths, Carlson, & Lamont, 2015). *Ability:* The beginner snowboarders are more likely to sustain an injury (OR: 2.66; 90% CI: 2.08-3.40) (Hume et al., 2015). *Lessons:* No clear evidence demonstrates that skiers and snowboarders who take lessons have a different risk of injury (OR: 1.18; 90% CI: 0.96-1.45) (Hume et al., 2015). *Education:* No clear evidence that education (skiers and snowboarders) is a protective factor for all injuries (OR: 0.67; 90% CI: 0.38-1.17) (Hume et al., 2015). *Alcohol /Drug Use:* Abstinence from alcohol/drugs recommended in ski slopes (Hume et al., 2015). *Terrain Condition:* Inappropriate trail design and grooming can increase incidence on injuries at certain trail sites (Hume et al., 2015). *Type of Terrain:* Injuries sustained in TPs (skiers and snowboarders) are more likely to affect the head/neck complex (OR: 1.52; 95% CI: 1.24-1.87) (Audet et al., Unpublished work). Risk factors for injuries in TPs are snowboarding as activity (OR: 3.96; 95%		interventions or programs to determine their effectiveness and improve uptake (Hume et al., 2015).	.ca Ontario Snow Resorts Association (security promotion) https://www.skiontario.ca Canadian Ski Council (safety messages) https://www.skicanada.org Accident Prevention Office (safety messages and injury prevention videos) http://www.bfu.ch Oslo Sports Trauma Research Center (scientific literature on injury prevention) http://www.ostrc.no

	CI: 3.59-4.35), being a male (OR: 3.94; 95% CI: 3.61-4.30), are rated as expert (OR: 3.13; 95% CI; 2.90-3.38), have a younger age, and using features that promote aerial manoeuvres or/and large drops to the ground (e.g. jump, half-pipe) (Audet et al., Unpublished work). **Non-Modifiable Factors** *Age:* Snowboarders of younger age have been reported to have an increasing risk of injury (Audet et al., Unpublished work; Hume et al., 2015). *Sex:* For all injuries, incidence rates of males or females is similar (OR: 1.02; 90% CI: 0.81-1.29) (Hume et al., 2015). Skiers and snowboarders females are less likely to sustain a head injury than males (OR: 0.72; 90% CI: 0.65-0.79) (Hume et al., 2015). *Weather Conditions:* Poor visibility (poor vs good) increases the risk of injury in skiers and snowboarders (OR: 2.69; 90% CI: 1.43-5.07) (Hume et al., 2015).			

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Review of Sport Injury Burden, Risk Factors, and Prevention

Snowboarding

Incidence and Prevalence

The current overall incidence of recreational snowboarding injuries is reported to be 2 to 3 times higher than skiers (2-3 injuries per 1000 skier days) (Ackery, Hagel, Provvidenza, & Tator, 2007). In fact, injury rates range from 1.7 to 16 injuries per 1000 snowboarder days (K. Russell, Hagel, & Francescutti, 2007; Toth, 2006). The most common injury types observed are fractures, dislocations, sprains, contusions/lacerations, and wounds. Generally, the anatomic locations more likely to be involved when an injury occurs are the head, neck, spinal cord, shoulder, elbows, and wrists. It is well known that snowboarders are more affected by upper limbs injuries. Above all, mechanisms of injury frequently reported are technical errors, collisions with an inanimate object or a person, simple falls on ski slopes or after the execution of an aerial maneuver or/and a large drop to the ground, and falls from ski lifts.

Incidence rates for head and neck injuries have been sporadically described, using different methods, and appear to have a relatively large range. For example, for skiers and snowboarders, incidence rates have been reported between 0.09 and 0.46 per 1000 outings (K. M. Russell, Christie, & Hagel, 2010). According to some authors, these rates may be higher in snowboarders (Toth, 2006; Toth, McNeil, & Feasby, 2005). Incidence rate of spinal cord injury has been reported to 0.04 per 1000 snowboarder days (Toth et al., 2005). Head and spinal cord injuries mostly occur after a fall related to a loss of control during an aerial maneuver or/and a large drop to the ground (Ackery et al., 2007). In rare cases, deaths have been registered while snowboarding.

Most of the relevant literature retrieved from systematic reviews focusing on incidence and prevalence data has been published between 2005 and 2010. Since, equipment optimization may have decreased the risk of injury over time (Hume, Lorimer, Griffiths, Carlson, & Lamont, 2015). Furthermore, incidence rates for head, neck and spinal cord injuries may have increased due to the spread of terrain parks (TPs) in ski areas since the early 2000s (Audet et al., Unpublished work). TPs are slopes in ski areas that contain features promoting aerial maneuvers and high drops to the ground (e.g. jump, half-pipe, rail, box).

Risk and Protective Factors

Hume et al. (2015) published a systematic review of the literature with meta-analysis that described the range of risk and protective factors for ski and snowboard related injuries. Mainly, modifiable factors like equipment (helmet use, wrist guard use, and rented equipment), ability, education, lessons, alcohol/drug use, terrain condition and type of terrain were identified. Non-modifiable factors included age, sex, and weather conditions.

Modifiable Factors

According to many authors (Ackery et al., 2007; Benson, Hamilton, Meeuwisse, McCrory, & Dvorak, 2009; Cusimano & Kwok, 2010; Hume et al., 2015; K. M. Russell et al., 2010), helmet use is clearly beneficial for reducing the risk of head injuries in skiing and snowboarding. One specific systematic review on helmet use demonstrated that skiers and snowboarders who wear a helmet are less likely to have a head injury (OR: 0.65; 95% CI: 0.55–0.79) without an increased risk of neck injury (OR: 0.89; 95% CI: 0.72–1.09) (K. M. Russell et al., 2010). Other equipment like wrist guards have demonstrated a protective effect on injuries in snowboarders (Hume et al., 2015). According to randomized control trials, wrist guard use has been shown to reduce the risk of wrist injury (RR: 0.23; 95% CI: 0.13-0.41), wrist fracture (RR: 0.29; 95% CI: 0.10-0.87), and wrist sprain (RR: 0.17; 95% CI: 0.07-0.41) with no increasing risk of shoulder/finger/elbow injury (K. Russell et al., 2007).

Snowboarders who rented their equipment were at increased risk of injury, compared to those having their own equipment (OR: 2.58; 90% CI: 1.98-3.37) (Hume et al., 2015). This finding should be interpreted with caution; rental locations are often visited by people with less experience/ability and that can be a confounding variable of the association. Thus, this could represent the population characteristics rather than rented equipment as a risk factor for injury. In fact, beginners are more likely to sustain an injury than more skilled snowboarders (OR: 2.66; 90% CI: 2.08-3.40) (Hume et al., 2015). More specifically, with the most precarious being the first four days of exposure caused by repeated falls. Conversely, snowboarders with greater ability injured themselves in falls after the execution of an aerial maneuver and/or a large drop to the ground (Ackery et al., 2007; Audet et al., Unpublished work; Hume et al., 2015; Toth et al., 2005). Education as a risk factor for injury in snowboarding have less support in the literature.

Education (OR: 0.67; 90% CI: 0.38-1.17) and lessons (OR: 1.18; 90% CI: 0.96-1.45) (Hume et al., 2015) in skiers and snowboarders are not associated with an increasing or a decreasing risk of injury. However, various methods described by authors can explained that situation. Consumption of alcohol and/or drug in ski areas has also been studied. Intake of these substances affects judgment and decreases reaction time to a stimulus. Qualitative evidence support that consumption of alcohol and/or drug are a risk factor for injuries (Hume et al., 2015). Terrain condition in TPs has been cited in the literature as a risk factor for injury in snowboarding. Increased risk of injury can be caused by an inappropriate trail design and/or grooming at certain trail sites (Hume et al., 2015). Further, the type of terrain is a risk factor for severe injuries (Audet et al., Unpublished work). A systematic review shows that, for skiing and snowboarding, TPs involve more head/neck (OR: 1.52; 95% CI: 1.24-1.87) (Audet et al., Unpublished work) and spinal injuries than regular slopes (Ackery et al., 2007; Audet et al., Unpublished work). Specifically, risk factors for injuries in TPs are activity (snowboarders over skiers, OR: 3.96; 95% CI: 3.59-4.35), sex (males over females, OR: 3.94; 95% CI: 3.61-4.30), snowboarding ability (experts over beginners and intermediates, OR: 3.13; 95% CI; 2.90-3.38), age (youngers snowboarders over older snowboarders), and using features that promote aerial maneuvers or/and large drops to the ground (e.g. jump, half-pipe) (Audet et al., Unpublished work). Analyses with adjustment for confounders should give more accurate results on helmet use in TPs.

Non-modifiable Factors

Non-modifiable risk factors have also been identified in the literature. Snowboarders of younger age have been reported to have an increased risk of injury (Hume et al., 2015). For all injuries, females appear to have a similar risk than males (OR: 1.02; 90% CI: 0.81-1.29) (Hume et al., 2015). However, a clear difference was found for a decreasing risk of head injury in skiers and snowboarders females (OR: 0.72; 90% CI: 0.65-0.79) (Hume et al., 2015). Finally, weather conditions can impact injury occurrence in snowboarders. One study reports that as compared to good conditions, poor visibility increases the risk of injury (OR 2.69; 90% CI: 1.43-5.07) (Hume et al., 2015).

Opportunities for Prevention: Effective Interventions, Cost-Effectiveness, Implementation and Evaluation

Research examining the effectiveness of interventions to reduce the burden on injury in snowboarding is scarce. Before 2015, there was one study examining the effectiveness of educational programs on injury reduction, and three on wrist guard interventions (Hume et al., 2015). For snowboarding, no evidence was retrieved for effectiveness of an education program. Although, the protective effect of wrist guard use, for wrist injuries, demonstrates in three studies sufficient evidence to be effective (Hume et al., 2015). Due to the variety of interventions or statistics, no meta-analysis has been done.

A systematic review of the literature indicates that interventions for recreational snowboarders must target beginners to reduce the risk of injury caused by falls and young males to reduce the risk of severe injury caused by aerial maneuvers and/or large drops to the ground. This review is based on the current evidence of syntheses in the literature on injury prevention in snowboarding context. Nevertheless, there is no strong evidence on implementation for countermeasures/programs specific to snowboarding. Directions for future work in this area is suggested in some studies including Hume et al. (2015), an implementation plan for countermeasure interventions needs to consider the current socio-cultural and technological context. In addition, implementation strategies need collaborative efforts across multi-sectoral partnerships (e.g. health-care providers, health-care funders, ski areas workers). A multifaceted approach, including education, legislation, and enforcement, has been shown to be effective for full helmet compliance among skiers and snowboarders of all ages (Fenerty et al., 2016). Generally, it has been demonstrated that using various approaches may have a positive impact on the implementation of countermeasures/programs (Gielen & Sleet, 2003; Sleet & Moffett, 2009).

Conclusion

This systematic review, mainly based on syntheses of the literature related to injury prevention in snowboarding, provides current information about incidence/prevalence, risk and protective factors, intervention effectiveness, and on the implementation of interventions. Modifiable factors that can have an influence on injury risk are equipment (helmet use, wrist guard use, and rented equipment), snowboarding ability, education, lessons, alcohol/drug use, terrain condition, and type of terrain whereas non-modifiable factors are age, sex, and weather conditions. Few research have been conducted to know the effectiveness of interventions. Currently, only evidence on wrist

guard interventions supports the effectiveness of this countermeasure to prevent injuries. Thresholds in the literature are existing for cost-effectiveness, implantation and evaluation of interventions.

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