

**Sophie Elspeth Steenstrup**

**Injury incidence and injury patterns in qualification runs  
versus final runs in FIS World Cup snowboard cross and  
ski cross**

**Master thesis in Sports Physiotherapy**  
Department of Sports Medicine  
Norwegian School of Sport Sciences, 2011



## Abstract

**Background:** No previous studies have investigated the injury incidence in individual qualification runs vs. final runs in heats of 4 or more athletes in FIS World Cup (WC) Snowboard Cross (SBX) and Ski Cross (SX). **Objective:** To investigate the injury incidence and injury patterns in individual qualification runs vs. final runs of SBX and SX during four seasons of the FIS WC. **Methods:** Injuries were recorded by the FIS Injury Surveillance System (FIS ISS) through retrospective athlete interviews at the end of four WC seasons (2006-2010). Time-loss injuries occurring during qualification runs and final runs of SBX and SX competitions were included. Injury incidence was expressed as the absolute injury rate (number of injuries per 100 athletes per season) and as the relative injury rate (number of injuries per 1000 runs). **Results:** For SBX the injury incidence in finals was 12.1/1000 runs compared to 6.1/1000 runs in qualifications (RR 1.9, 95% CI 1.1-3.5,  $p=0.019$ ). For SBX males the injury incidence was higher in finals (12.9/1000 runs) compared to qualifications (4.4/1000 runs) (RR 2.9, 95% CI 1.4-6.2,  $p=0.0065$ ). This was not the case for SBX females (finals 10.5/1000 runs vs. qualifications 9.3/1000 runs, RR 1.1, 95% CI 0.5-2.8,  $p=0.79$ ). For SX the injury incidence in finals was 12.4/1000 runs compared to 9.2/1000 runs in qualifications (RR 1.4, 95% CI 0.8-2.3,  $p=0.27$ ). The injury incidence for SX males was 13.6/1000 runs in finals vs. 8.8/1000 runs in qualifications (RR 1.5, 95% CI 0.8-3.1,  $p=0.21$ ). The injury incidence for SX females was 10.8/1000 runs in finals vs. 9.8/1000 runs in qualifications (RR 1.1, 95% CI 0.5-2.6,  $p=0.83$ ). The injury incidence per 100 athletes was 14.2 in SBX and 16.3 in SX. There were no differences in injury severity between run types in either discipline. **Conclusion:** The injury incidence was significantly higher in final runs vs. qualification runs in SBX in total, and for SBX males when analysed for sex. For SBX females and in SX no significant differences between the injury incidence in qualification and final runs were found. **Keywords:** Snowboard Cross, Ski Cross, FIS World Cup, Snowboarding injuries, Freestyle skiing injuries, FIS Injury surveillance System, Injury incidence, Epidemiology.

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## Abbreviations

ACL	Anterior Cruciate Ligament
CI	Confidence Interval
FIS	International Ski Federation
FIS ISS	International Ski Federation Injury Surveillance System
OSTRC	Oslo Sports Trauma Research Centre
OWG	Olympic Winter Games
RR	Relative Risk
SBX	Snowboard Cross
SX	Ski Cross
WC	World Cup
WSC	World Ski Championships

# **1. Introduction**

## **1.1 Background of SBX and SX**

Snowboard Cross (SBX) and Ski Cross (SX) are relatively new sports. The International Ski Federation (FIS) Snowboard World Cup (WC) was first held during the 1994/1995 season. Today it includes two freestyle disciplines (half pipe and big air), two alpine disciplines (parallel giant slalom and giant slalom) and SBX, which is a motocross-inspired mixture of the freestyle and alpine disciplines. SBX was added as a FIS WC event in the 1996/1997 season, and as a new event for the 2006 Olympic Winter Games (OWG).(1)

The Freestyle FIS WC was started in 1978 and today the WC events include five disciplines (moguls, dual moguls, aerials, half pipe and SX). SX was included in the FIS WC for the 2002/2003 season and is the latest OWG event, with its inclusion in Vancouver (CAN) in 2010. As for SBX, SX athletes use a combination of freestyle and alpine skills, and SX differs from the other freestyle events in that it is the only event without a judged component.(2)

SBX and SX differ from other snowboard and freestyle events in that there are one or two individual qualification runs followed by final heats. In final heats, four or more athletes start simultaneously atop an inclined course and compete against each other to reach the finish line first.

## **1.2. Injury risk and injury patterns**

Little is known about the injury risk and the specific injury patterns associated with WC SBX and SX. FIS established an injury surveillance system (the FIS ISS) prior to the 2006-2007 winter seasons. The objective of the FIS ISS is to provide data on injury trends in international skiing and snowboarding at the elite level with the long-term goal of reducing injury risk.(3) Recent data from the FIS ISS reported that the injury incidence in WC SBX and SX appears to be high. Florenes et al. found that about 1/3 of the athletes in WC alpine skiing, freestyle skiing and snowboarding sustained a time-loss injury of more than 28 days.(3) They also found that the number of injuries per 100 SX athletes per season for time-loss injuries was 33.8 and the injury incidence per 1000 runs was 16.6 for males and 21.8 for females.(4) For FIS WC snowboarders they



reported 37.8 time-loss and 13.8 severe injuries per 100 athletes per season.(3) In WC snowboarding and freestyle skiing the most common injuries were joint and ligament injuries and the knee was the most frequently injured body part.(3;4) The injury patterns in WC snowboarding athletes were found to differ from the injury patterns at the recreational level where wrist and upper body injuries were most common.(5-7) So far, there are no studies reporting injury patterns in recreational freestyle skiing. However, in recreational alpine skiing knee injuries are most common (8-12), and this pattern seems to be the same in and WC alpine skiing and WC freestyle skiing.(4;13)

### **1.3 Context and aims of the thesis**

On being asked by a reporter what she thought was the biggest challenge she had faced in reaching her goals in SX, Olympic 2010 Gold medallist Ashleigh McIvor (CAN) answered:

*“Injuries. This is a rough sport.”(14)*

Norwegian team SBX rider Stian Sivertzen posted retrospectively on his blog after a two month rehabilitation period, which included five days in coma, after suffering a fall in Vancouver on Friday 13.02.2009:

*“I got a serious injury during the trial Olympics in Canada when I fell during the 1/8<sup>th</sup> finals. I was first out of the start, but at the second jump I landed on the top of the jump, lost speed and the others overtook me. Quite far down the course I took too much risk to try to catch up with the guys in front of me. I landed right at the bottom of the step-down jump and had far too much compression to dampen the next jump. I was thrown forward onto the bottom of the next jump, and landed on my chest. I had to be carried out on a stretcher and was taken to hospital. I had a ruptured aorta, broken collar bone, contusions to my pelvis, neck and lower back.”(15)*

To our knowledge no previous studies have examined the injury incidence in individual qualification runs vs. final runs in heats. We do not know if the SBX and SX race formats of riding in individual qualification runs followed by final heats of four or more athletes influences injury incidence and injury patterns. As exemplified by Stian Sivertzen, athletes riding in heats of four may encounter some stress in relation to riding with other opponents. Whether this physical and psychological stress influences the risk of injury, is unknown. The purpose of this study was to investigate the injury incidence

and injury patterns in individual qualification runs vs. final runs of SBX and SX during four seasons of the FIS WC, including the FIS World Ski Championships (WSC) and the OWG. Our null hypothesis was that there would be no difference in injury incidence between qualification and final runs.

## 2. Theory

The snowboard WC is held every year during the period from July 1<sup>st</sup> to June 30<sup>th</sup>.(16) For the 2009/2010 season there were 129 riders competing in the SBX WC. Of these, 42 were women and 87 were men. The freestyle WC is also held every year in the time period from July 1<sup>st</sup> to June 30<sup>th</sup>.(16) SX differs from other freestyle disciplines by being motocross inspired, not having a judged component and having a single knock-out format. During the 2009/2010 WC season there were 122 SX athletes receiving WC points, 54 women and 68 men. To participate in the FIS WC SBX athletes must have a minimum of 50 SBX FIS points.(17) SX athletes need 50-100 FIS freestyle points or 50 FIS alpine points from any alpine event.(18) Both in SBX and SX athletes must reach 15 years of age during the WC season to be able to participate.(17;18) A description of SBX and SX race structure and courses, physical characteristics of athletes, the equipment used and relevant competition rules will be presented further.

### **2.1 Race structure and courses**

SBX and SX have a very basic concept: “the first athlete across the finish line wins.” SBX and SX race structures are essentially the same apart from the number of qualification runs. There are one (in SX) and two (in SBX) individual preliminary timed qualifying runs where the aim is to achieve the fastest time. The best ranked athletes from the qualification runs advance to the final heats. Finals are based on two formats, either 48 men and 24 ladies with six athletes per heat, or 32 men and 16 ladies with four athletes per heat. In the FIS WC, there are usually four athletes per heat. The first two athletes advance from round to round. The total number of runs for athletes reaching the final is usually six (male) and five (female) in SBX, and five (male) and four or five (female) in SX.(16)

SBX and SX courses are essentially the same, although in the FIS WC SBX and SX athletes do not compete on the same course. In the OWG however, SBX and SX athletes compete on the same course. Structures on the SX course have been modified from the Olympic SBX event. The courses are specially designed to test all of the athletes` skills, with features including turns of different types and sizes, jumps of varying size, flat sections and traverses, along with rollers, banks and ridges which are constructed on a normal ski slope (Picture 1, Figure 1). Because there are several

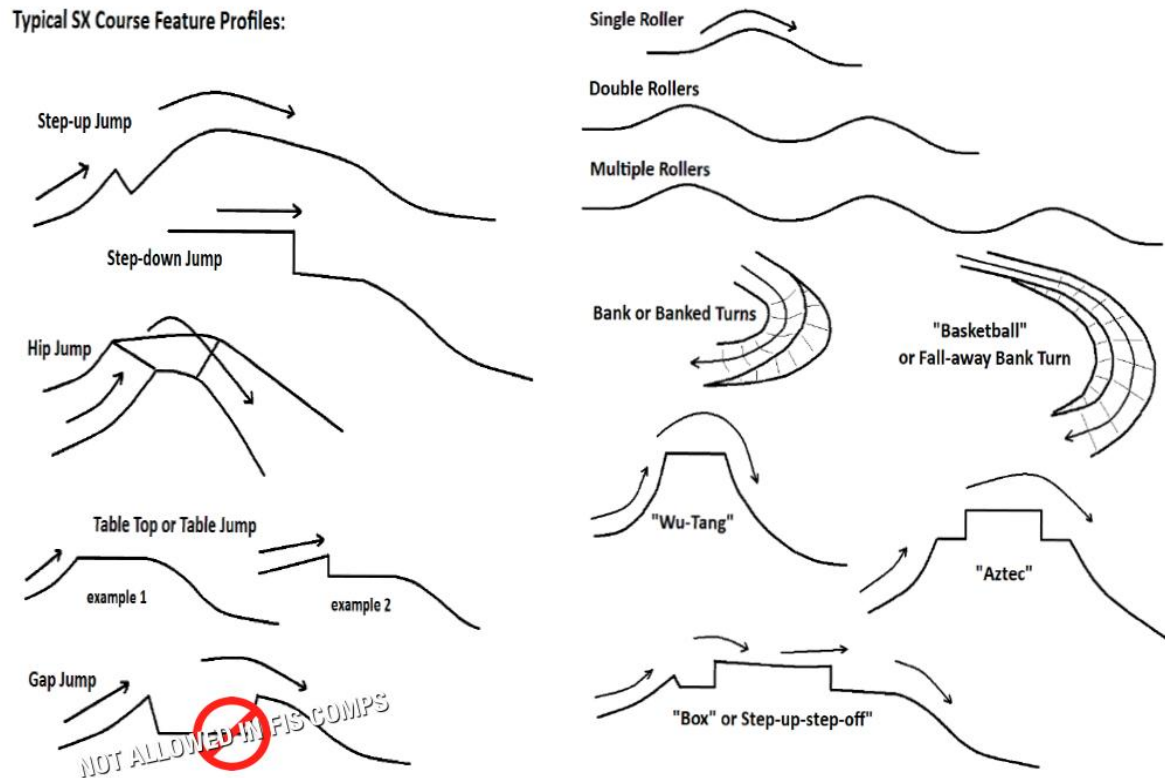
obstacles, crashes are frequent.(19) A SBX course is typically 500-900 m long, while a SX course is slightly longer (800 to 1200 m).(20;21) Courses have a minimum vertical drop of 100 m and a maximum vertical drop of 250 m. The same slope is used for women and men. The slope is of a medium inclination ( $14^{\circ}$ – $18^{\circ}$  on average) with varied terrain. The course is a minimum of 40 m wide. Under certain conditions, the course width may for short sections (50 m or less) be a minimum of 20 m. From the start to the first bank the course is straight for approximately 80 –150 m. During the first 80-150 m the course should not be too steep and is designed to separate the riders/skiers as quickly as possible after the start with three to five rollers or other terrain features between the start and the first turn (Picture 1, Figure 1).(16;20;21)



**Picture 1:** Part of the SBX course at the WC finals in Arosa (SUI), March 2011, showing 6 athletes riding over rollers. The 6 athletes/heat format was used for the first time in the WC in this event. Photo: author.

Medium or long giant slalom type turns are included only when building a feature is not possible. Blind jumps or terrain features where a competitor is unable to see the landing from the take-off are avoided. Gap jumps are not permitted and a SBX/SX course should not contain a corner jump at the last feature (Figure 1). The course and features are designed so that competitors can attempt to gain speed and do not have to break before each feature.(20;21) The SBX/SX course includes 50% turns of varying size and with varying speeds between the features, 25% traverses, bumps and rollers and 5% jumps (1 to 4 m high) and landings.(20;21) During a run, athletes spend 25% of the time in the air. There are time-differences between sexes and between SBX and SX riders on the same course. The average speed during WC SX competitions has been found to be

68 km/ hour for men and 50 km/hour for women.(2) During the 2010 Vancouver OVG the average speeds registered on course were 58 km/h (SX men), 54 km/h (SX ladies), 50 km/h (SBX men) and 47 km/h (SBX ladies).(22)



**Figure 1.** SX/SBX course features (Downloaded from [www.canadaskicross.ca](http://www.canadaskicross.ca) 18.04.11, reproduced with permission from Keith Bradford, Canada Ski Cross/ Alpine Canada)

## 2.2 Physical characteristics of athletes

The physiological requirements of the athletes are diverse. SBX and SX athletes need strength, aerobic fitness, coordination and more to prevail in a contest and over an entire season. Physical endurance and strength are key factors, since the winning athlete must ride/ski up to five or six runs of 60 seconds or more.(19)

Platzer et al. compiled a physical test battery consisting of a bicycle ergometry test, a countermovement jump, an isokinetic leg power test, an isokinetic core test, isometric bench press and bench pull, a one legged static balance test and an indoor SBX start simulator, to evaluate if this test battery could predict snowboard performance.(19) FIS points in women showed significant correlations to all tests except the

countermovement jump. No significant correlations were found in the men's events, and the authors discussed that psychological factors, equipment and coordination might be more important. Overall WC points in women correlated with bicycle ergometry and leg power. The authors concluded that starting speed out of the SBX start gate, leg power, core power and aerobic capacity were important for Austrian WC SBX athletes. They discussed that performance on a battery of physical tests could predict WC ranking, especially for SBX females. In conclusion, physical fitness was a performance determining factor for women, but not for men.(19)

### **2.3 Equipment**

In SBX the snowboards minimal width is restricted. For a gliding surface length up to 135 cm the minimal width is 14cm. For a gliding surface length of more than 135 cm, the minimal width is 16 cm. There is no restriction on the type of board allowed and riders use either a freestyle board or a giant slalom type board which is designed to promote carving turns. Bindings must be fixed diagonally on the long axis of the board and the boots cannot overlap each other. Safety leashes are optional.(20)

Most SX athletes use normal giant slalom (alpine) racing skis, bindings and boots (Audun Grønvold, Norwegian SX coach, personal communication, May 2011). Unlike in alpine racing, there is no FIS regulation on the length of the skis or the side cut, but ski boots and bindings must be according to FIS Rules.(21)

In SBX the competitors are not allowed to wear anything on their hands besides gloves or use any kind of device to additionally support their balance, reduce or accelerate their speed, like ski poles etc. In SX athletes are naturally allowed to use ski poles. Pants and jacket (two pieces) are required and they must be loose. No one piece speed suits are allowed. Body Protectors (wrist, arms, hip etc.) are not mandatory and are usually used under the ski/snowboard suit. Back supports may be worn as long as the equipment does not offer an aerodynamic advantage. Helmets are mandatory during all official FIS WC training and competitions.(20;21)

### **2.4 Rules**

The rules for contact during a SBX and SX competitions are presented because they are especially relevant for the topic of this master thesis. The contact rules are slightly

different between SBX and SX due to the difference in equipment and nature of the disciplines.

### **Contact Rule SBX**

*“Intentional contact by pushing, pulling or other means which causes another competitor to slow down, fall or exit the course is not allowed and is an automatic disqualification sanction. Unavoidable "casual contact" may be acceptable. All contact infractions will be at the discretion of the course judges and competition Jury.”(20)*

### **Contact Rule SX**

*“Intentional contact by pushing, pulling or holding another competitors’ arm, leg or pole or other means, which causes another competitor to slow down, fall or exit the course is not allowed and is an automatic disqualification. A competitor is not allowed to bring their arm, leg or ski pole in front of another competitors’ body to avoid being passed. Blocking, by intentional movements of the body or leaving the natural skiing line is not allowed. The “natural skiing line” is defined as the fastest way between the features and around the gate line. All contact infractions will be at the discretion of the gate judges and the Jury.”(21)*

### **3. Concepts in epidemiological sports literature**

Risk can be defined as the likelihood that people who are without a disease, but exposed to certain factors (risk factors) will acquire the disease. The most basic expression of risk is incidence.(23) Injury incidence refers to the frequency of disease/injury occurrence and is calculated as the rate of new disease/injury occurrence. New injuries (cases) are registered within a specified population within a specified time period.(24) Literature concerning injury incidence in WC SBX/SX describes new injuries occurring in WC SBX/SX athletes during a run, competition or during one or several WC seasons. Injury incidence should be expressed in relation to the population exposed to the risk factor.(23) Exposures are factors (variables) that are tested for their relationship with the outcome of interest.(24)

In sports injury literature, exposure is the number of minutes, hours or days, or the number of runs or skiing days, the athlete has spent performing his/her sport. In football exposure is often presented as minutes or hours of participation in matches or training.(25) Studies concerning skiing and snowboarding have used a variety of methods of reporting exposure. Studies on recreational skiers/snowboarders typically record injury incidence per 1000 lift tickets sold (12) and per 1000 skier days.(26-28) In competitive skiing/snowboarding injury incidence is often recorded per 1000 runs (3;4;29;30) per 100 athletes per season (3) or per 1000 registered athletes.(31)

The varying methods of recording injury incidence make comparisons between studies difficult. Issues involved in conducting sports epidemiological studies have been reviewed and the general conclusions reached were that published injury reports were difficult to interpret and compare because of the differences in the data collection and analysis used by different researchers.(32) Johnson et al. summarised common problems in epidemiological skiing and snowboarding literature.(33) They discussed that the risk of injury associated with skiing was difficult to compare among unrelated studies because the population at risk was rarely provided, injury definitions were often not compatible, the severity threshold for inclusion was not defined, the quality of the diagnosis was variable, the data acquisition site varied in its remoteness from the injury site (ski patrol, clinic at ski area, local or regional clinic/hospital), or the bypass effect was not considered.(33) Hagel et al. suggested that snow sports such as skiing and



snowboarding were recognized as hazardous, but population-based injury rates or specific risk factors had been difficult to estimate as a result of a lack of complete data for both numerator (the injured population of skiers) and denominator (the uninjured population).(9) For instance, there are limitations in reporting the incidence of injuries per 1000 skier days. This assumes that a skier day is equivalent in terms of the number of hours of skiing, skiing style, and level of difficulty for all skiers, which is seldom the case.(7)

Regarding recording injury incidence among WC ski and snowboard athletes, Florenes et al. proposed that the injury incidence should be recorded per 1000 competition runs, as this method gives an account of the number of injuries that have actually happened during WC competitions.(4) In WC competitions recording injuries per 1000 runs is feasible (we can accurately count the number of runs) and this method will allow us to compare the injury incidence between studies, providing the methods correspond.

Studies examining injury incidence often present results as Relative Risk (RR). RR is the risk of an event (or of developing a disease/injury) relative to exposure.(24) For skiing/snowboarding studies this means that the RR is a measure of the association of the exposure (number of runs, number of skiing days) to the occurrence of injuries. The null value, or no effect, of the RR is 1.0, values <1.0 indicate a reduced risk and values >1.0 indicate an increased risk. As an example of a result presenting a RR, a finding from Florenes et al.(4) is presented:

*“We found a higher total injury rate in the other disciplines than in moguls/dual moguls (RR ski cross vs. moguls/dual moguls: 1.49, 95% CI 1.13 to 1.98”*

This means that the RR of obtaining an injury in SX is higher than in moguls/dual moguls because the RR is >1.0 (RR 1.49). In this result the Confidence Interval (CI) is also presented. CI`s are often used in hypothesis testing.(24) We can obtain CI`s for the means or proportions in a group of individuals or for the difference between two estimates.(34) The CI is a range of values either side of the estimate between which we can be 95% sure that the true value lies.(34) Thus it provides a band within which the estimate of the population mean is likely to fall instead of a single point.(24;34) CI`s are based on the fact that any statistics possess sampling error.(24) The main purpose of the CI is to indicate the (im)precision of the sample study result as an estimate of the

population value.(34) The range specified by the CI indicates how confident we can be in the observed result. A narrow CI indicates little imprecision (uncertainty) and a high degree of confidence.(34) CI's and p values are complementary. Presentation of CI's give a measure of the precision of study results for making inferences about the population of all such patients.(34) The p value is not an estimate of any quantity, but a measure of the strength of evidence against the null hypothesis or "no effect".(34) A Significant p value of  $p < 0.05$  corresponds to a 95% CI that excludes the value indicating equality.(34) Equality in our study is  $RR = 1.0$ . This means that if the 95% CI excludes the value  $RR = 1.0$  in our study, our result are significant at the  $p < 0.05$  level. In the example given by Florenes et al.(4), although the p value was not presented, the RR for SX compared to moguls/dual moguls was significant because the RR excluded the value 1.0.

## **4. Injury rate and injury patterns**

SBX and SX are purely competitive sports. Literature regarding injury incidence and injury patterns in recreational skiers and snowboarders does therefore not necessarily apply to WC SBX and SX athletes. There are only a few studies concerning injury incidence and injury patterns in WC SBX and SX. Therefore, to describe general findings about injury incidence and injury patterns in skiing and snowboarding, and to highlight differences in injury incidences and injury patterns between skiing and snowboarding, literature concerning recreational skiers and snowboarders is briefly presented. Subsequently, literature regarding injury incidence and injury patterns specifically in WC SBX and SX athletes is presented.

### ***4.1 Injury rate and injury patterns in recreational snowboarding and skiing***

Injury incidence in recreational skiers and snowboarders has been reported as 1 injury per 1000 skier days for alpine skiing and 3 per 1000 skier days for snowboarding.(26) Others have reported an injury incidence of 2.79 per 1000 skiing days for alpine skiers (28), 2.68 per 1000 skier days for skiers and snowboarders on slopes and in terrain parks (35) and 2.2 injuries per 1000 skier days for skiers and snowboarders.(36) The injury patterns in recreational snowboarding and alpine skiing differ. A brief summary of skiing and snowboarding epidemiological studies is therefore presented (Table 1).

**Table 1.** Epidemiological studies on injury patterns in recreational alpine skiing and snowboarding

Authors Publication year	Study design	Study population	Study period	Injury patterns Skiers and Snowboarders
Levy et al. (37)	Descriptive Epidemiological Prospective study	350 Ski/ SB 1775 Ski 568 SB*	1982-1998 1989-1999	Head injuries: Mild 81%, Concussion 69%. Severe brain injuries 14 %, Mortality 4%. Fracture 34 %, Contusions 27%, Sprains 26% Upper Ex.: 54.4%, Lower Ex.: 19.2 % Head-neck 50% higher <b>SB</b> vs. <b>ski</b> . Trunk: <b>SB</b> twice as likely vs. <b>ski</b> Upper Ex: <b>SB</b> 3 times as likely vs. <b>ski</b> Lower Ex.: <b>SB</b> lower rate vs. <b>ski</b>
Made & Elmqvist (26)	Descriptive Epidemiological ( 3 surveys)	28831 Ski $\alpha$ 18996 SB $\alpha$ 21500 Denominators	1995-2000	<b>Ski</b> : Lower Ex: Beginners 68.2%, Experts 44.3% ; Upper Ex: Beginners: 15.4%, Experts: 30.5%, Head/neck: Beginners: 15.6%, Experts: 24.1% <b>SB</b> : Lower Ex: Beginners: 20.7%, Experts: 26.3%, Upper Ex: Beginners: 56.8%, Experts 47.9%, Head neck: Beginners: 18.9%, Experts: 22.3%
Goulet et al. (10)	Case Control	22078 Ski/SB	2001-2004	<b>Ski</b> : Sprains 32%, Contusions 29%, Fractures 20% <b>SB</b> : Contusions 31%, Fractures 28%, Sprains 18% <b>Ski</b> : 57.3 % Lower Ex. <b>SB</b> : 76.9 % Upper Ex.
Wasden et al. (39)	Retrospective cohort	794 Ski 348 SB	2001-2005	Head: <b>Ski</b> : 20.4%, <b>SB</b> : 27.3% Lower Ex.: <b>Ski</b> : 51.3%, <b>SB</b> : 26.2% Upper Ex: <b>Ski</b> : 12.7%, <b>SB</b> : 11.7% Abdomen/organ: <b>Ski</b> : 11.2%, <b>SB</b> : 22.4% Spinal: <b>Ski</b> : 13.4%, <b>SB</b> : 20.7%
Brooks et al. (35)#	Cross sectional study	5508 Ski 9273 SB	2000-2004	<b>Ski</b> : Sprain: 66% (slope), 40.5 % (park), Lower Ex: 60.2%(slope), 35.4%(park), Upper Ex. 23.3%(slope), 29.1% (park) <b>SB</b> : Sprain: 48.3%(slope), 38.6% (park); Lower Ex.: 23.4%(slope), 19.5% (park); Upper Ex.: 56.1%(slope), 49.8% (park)
Ogawa et al. (5)	Descriptive epidemiological	SB: 19539	1996-2008	Upper Ex.: 41.6%, Trunk: 20.8%, Head/face: 19.1%, Lower Ex.: 12.5%. Fractures: 37.3%, Bruises: 20.8%, Lacerations/contusions: 10.7%

**Abbreviations:** *SB: snowboarders, Ski: skiers, Lower Ex.: lower extremity. Upper Ex.: upper extremity, \*: only snowboarding injuries analysed in the study,  $\alpha$ : Injuries reported in skiers/snowboarders vs. denominators, # Study has investigated injuries in traditional slopes vs. terrain parks, Slope: traditional ski slope, Park: terrain park*

## **4.2 Injury rate and injury patterns in WC snowboarding**

Injuries among competitive WC snowboarders differ from those seen in recreational snowboarders, with fewer wrist injuries and more knee and back injuries (Table 2).(30) Among international elite snowboarders participating in the FIS WC, the injury risk for the big air, SBX and half pipe events was high, while the injury risk for parallel giant slalom and giant slalom was lower.(29) Torjussen & Bahr reported an injury incidence in FIS WC snowboarding athletes of 1.3 per 1000 runs for all snowboarding disciplines in total.(29) For WC SBX the injury incidence was 2.1 per 1000 runs. There were no differences in injury incidence between junior and senior riders or between sexes (Table 2).(29)

In comparison, a recent study on the injury incidence in FIS WC snowboarders found that there were 37.8 time-loss and 13.8 severe injuries per 100 athletes per season.(3) Florenes et al. found that about 1/3 of the athletes in WC alpine skiing, freestyle skiing and snowboarding sustained a time-loss injury leading to an absence from participation of more than 28 days.(3) There was a higher rate of time-loss injuries in snowboarding compared to the other disciplines (RR time-loss injury snowboarding vs. freestyle skiing 1.37 (95% CI 1.08-1.74) and RR snowboarding vs. alpine skiing 1.27 (95% CI 1.02-1.58). There were no sex differences in injury incidence in snowboarding disciplines. The knee was the most commonly injured body part in all snowboarding disciplines and joint and ligament injuries were the most common injury types. Fractures/bone stress and contusions were equally the second most common injury category (Table 2).(3)

Engebretsen et al. investigated the rate of injuries during the 2010 OWG (Table 2). They reported that in SBX 73% of females and 11% of males suffered an injury.(31) The injury incidence was 16 (SBX females) and 4 (SBX males) per 1000 registered athletes. There were 40.0% time-loss injuries, and 78.9% of SBX injuries happened during training (Table 2).(31)

**Table 2.** Injury rate and injury patterns in WC SBX and SX

Authors (publ.year)	Study design	Study population	Study period	Injury Rate	Injury Patterns
Torjussen & Bahr (29)	Retrospective athlete interview	258 SB	April 2002-March 2003	SBX total: 2.1/1000R SBX males: 2.0/1000R SBX females: 2.3/1000R	Knee 18% Shoulder 13% Back 13% Wrist 8%
Florenes et al. (3)	Retrospective athlete interview	416 FS 421 SB	2006-2008 WC seasons	FS: Time-loss: 27.6/100A Severe: 14.4/ 100 A SB: Time-loss: 37.8/100A Severe: 13.8/100 A	Joint/ligament: FS: 43.3 %, SB: 38.6% Fractures/bone stress: FS: 21.7 %, SB: 17.6% Knee: FS: 29.3%, SB: 18.9% Head/face: FS:12.7 %, SB: 12.9% Shoulder/clavicle: FS: 10.2%, SB: 13.3 %
Florenes et al. (4)	Retrospective athlete interview	662 FS 269 SX	2006-2009 WC seasons	SX:Time-loss: 33.8/100 A Severe: 14.9/100 A SX Incidence: Total: 18.5/1000 R Males: 16.6/1000 R Females: 21.8/1000 R	All FS disciplines: Joint/ligament:42.6 % Fractures/Bone stress:18.9 % Knee: 26.5% Head/face: 13.4% Shoulder/Clavicle: 11.0%
Engebreetsen et al. (31)	Retrospective injury registration	68 SX 57 SBX	2010 Olympic Winter Games	SX: Total: 13/ 1000 rA Males: 5/1000 rA Females: 8/1000 rA SBX: Total: 20/1000 rA Males: 4/1000 rA Females:16/1000rA	All alpine/snowboard: n (%) # Sprain: 28 (54.9%) Contusion: 28 (35 %) Knee: 24 (61.5%) Head: 17 (56.6 %)

**Abbreviations:** SB: Snowboard, FS: Freestyle, SBX: Snowboard Cross, SX: Ski Cross, /1000 R: Incidence per 1000 runs, /100 A: incidence per 100 athletes, /1000 rA: incidence per 1000 registered athletes, #Percentages of the n in the injury category for all disciplines in the2010 Olympic Winter Games

### **4.3 Injury rate and injury patterns in WC freestyle skiing**

A previous study has reported that there were 2.8 injuries per 1000 skier-days during four WC freestyle ski seasons (1976-1980).(27) This study however was undertaken before SX emerged as an event and only included the disciplines of ballet, moguls and aerials.(27) Since Dowling performed his study, the sport of freestyle skiing has changed. Changes in equipment design and movement patterns have been noted in the past decade of freestyle skiing, with the addition of new freestyle disciplines (SX and half pipe) and the removal of ballet.(2) Both elite and recreational freestyle skiers now belong to the “New School” era with spectacular tricks and stylish jumps.(40)

Similarly to WC alpine skiing and snowboarding where the knee was the most commonly injured body part (3;13); the knee has been reported to be involved in the majority of freestyle skiing injuries (Table 2).(4)

Florenes et al. reported an injury rate of 38.5 injuries per 100 athletes per season for all WC freestyle competitors (Table 2).(3) The same study found that there were 27.6 time-loss injuries per 100 freestyle athletes per season and that 14.4% of these were severe injuries (time loss > 28 days absence). The most common injury types in freestyle skiing were joint and ligament injuries and fractures and bone stress, and the most common body parts injured were the knee and the head/face.(3) This finding was in correspondence with a previous study which reported that 25% of active freestyle mogul and aerial skiers had suffered one or more ACL ruptures during their career.(41) Florenes et al. did not investigate the individual injury incidence of all the different freestyle disciplines.(3)

Regarding the specific injury incidence for WC SX athletes, Florenes et al. reported that a total of 106 injuries (36%) occurred during WC/WSC competitions, corresponding to an injury rate for all freestyle disciplines in total of 15.6 injuries per 1000 runs (Table 2).(4) The number of injuries per 100 SX athletes per season for time-loss injuries was 33.8; with 14.9 severe injuries per 100 athletes. The injury incidence per 1000 runs in SX was 16.6 for males and 21.8 for females. There were no sex differences in the absolute injury rate in any discipline or severity category.(4) The study investigated the total number of runs during SX competitions, and the injury incidence during qualifying runs and final runs specifically, was not investigated.

Engebretsen et al. investigated the rate of injuries for SX during the 2010 OWG (Table 2). They reported that 23% of female and 15% of male SX athletes suffered an injury.(31) The injury incidence was 8 (SX females) and 5 (SX males) per 1000 registered athletes. There were 23.1% time-loss injuries, and most injuries (61.5%) happened during training (Table 2).(31)



## 5. Injury prevention

To prevent injuries among snowboarders and freestyle skiers, knowledge about why and how injuries occur is needed.(42) Van Mechelen et al. proposed a four step injury prevention model.(42) Firstly, the extent of the injury problem in snowboarding and freestyle skiing must be identified and described. Secondly, the factors and mechanisms which play a part in the occurrence of snowboarding and freestyle injuries have to be identified. The third step is to introduce measures that are likely to reduce the future risk and/or severity of sports injuries. This measure should be based on the etiological factors and the mechanism as identified in the second step. Finally, the effect of the measures must be evaluated by repeating the first step.(42) One example of a head injury prevention programme for recreational skiers and snowboarders was implemented in the USA.(43) This head injury prevention study is presented relating to the first three steps of injury prevention presented by Van Mechelen et al. The authors have so far not published the results of the intervention (step 4).

Levy et al. had found that head injury was the leading cause of death and critical injury in skiing and snowboarding accidents (step 1).(37) Because most traumatic brain injuries resulted from a direct impact mechanism, they believed that the use of helmets could reduce the incidence and severity of head injuries occurring on the ski slopes (step 2).(37) They therefore undertook a social-marketing campaign and a helmet loaner programme in ski-rental shops to increase helmet use among skiers and snowboarders. The authors believed that efforts to increase helmet use had significant potential to decrease the incidence and severity of brain injuries (step 3).(43) To complete the four-step injury prevention process, the authors should re-evaluate the injury incidence and severity of head injuries to see if the increased use of helmets has had an effect. The results of this intervention have so far not been published, so we do not know if this helmet use decreased the injury incidence (step 4).

In WC SBX and SX, epidemiological studies are still evaluating and describing the extent of the injury problem (step 1). However, video analysis (Bakken et al. 2011, Randjelovic et al. 2011, ongoing studies) of injury situations and injury mechanisms in WC SBX and SX will give valuable insight into the factors and mechanisms that play a part in SBX and SX injuries (step 2).

## **6. Causes of injuries**

### **6.1 Risk factors**

A critical step in the four step injury prevention process described by van Mechelen et al.(42) is to establish the causes of injuries. This includes obtaining information about why a particular athlete may be at risk in a given situation (risk factors), and how injuries occur (injury mechanisms).(44) Firstly, one must identify those factors associated with an increased risk of injury. Risk factors may influence the risk of sustaining an injury or predispose the athlete to injury.(44) These risk factors are termed internal or external risk factors.(23) Internal (intrinsic) risk factors are part of the riders/skiers constitution that may make them predisposed to injury. Riders/skiers are exposed to external (extrinsic) risk factors when they participate in training or competitions, which may make them susceptible to injury.(23) Internal risk factors can be age, sex, body composition, health, physical fitness level, anatomy and snowboarding/skiing skill level. External risk factors can be opponents on a SBX /SX course, use of protective equipment (helmets, wrist- and back guards), equipment such as the snowboard/skis, the exposure (time exposed to training and competitions) and the environment (weather, visibility, height/steepness of jumps or banks, snow and ice conditions). A risk factor may be part of or a collection of factors that together produce a sufficient cause for an injury to occur.(23)

Epidemiological studies have attempted to identify potential risk factors in recreational skiers and snowboarders (Table 3). Studies identifying risk factors for WC level snowboarders and freestyle skiers have not been found.

**Table 3.** Potential risk factors among recreational skiers and snowboarders

<b>Authors (publ.year)</b>	<b>Study design</b>	<b>Study population</b>	<b>Study period</b>	<b>Potential Risk Factors</b>
Gajdzinska et al. (45)	Retrospective questionnaire	100 SB	2005	Excess speed 37 % Insufficient skills 28 % Other people 18 % Bad weather 8 % Poor route preparation 6 % Faulty equipment 3 %
Zygmuntowicz & Czerwinski (46)	Retrospective questionnaire	211 SB	2006-2007	Technical mistakes 81% Tiredness 14% Icy slopes 13% Other people 4% Faulty equipment 1%
Hasler et al. (47)	Survey	Skiers: 782 patients 496 controls	2007-2008	Low speed High readiness for risk New equipment Old and Powder snow Drug consumption
Girardi et al. (11)	Retrospective interview	2511 Skiers 843 SB	2002-2005	Male sex Non-local resident Age > 60
Hasler et al. (48)	Case Control	SB: 306 patients 253 controls	2007-2008	Low readiness for speed Bad weather/visibility Old snow Not wearing a helmet Icy slopes

**Abbreviations:** SB: snowboarders

## 6.2 Injury mechanisms

The presence of internal and external risk factors causes an athlete to be susceptible to injury, but the presence of these risk factors on their own are not sufficient to produce injuries.(44) Injuries occur when energy, usually mechanical energy, is transferred to the body in amounts or at rates that exceed the thresholds for human tissue damage.(49) Bahr & Krosshaug discussed that regardless of whether a biomechanical or an epidemiological model is used to describe the interaction between the different risk factors, a precise description of the inciting event is critical.(44) An inciting event is necessary to cause an injury and is the final link in a chain that causes an injury. Therefore a precise description of the inciting event is a key component to understanding the causes of injuries in sports.(44) The term injury mechanism is used to describe the inciting event in medical literature.(44) Bahr & Krosshaug introduced a detailed description of the injury mechanism to understand the multi-factorial cause of

injury.(44) This description included aspects of specific sports situations (the situation described by a sports specific point of view), the athlete and opponents behavior (a qualitative description of the athletes action and interaction with the opponent), gross biomechanical characteristics (description of whole body biomechanics), and detailed biomechanical characteristics (description of joint/tissue biomechanics).(44) To understand which component of the apparent mechanisms that is actually responsible for an injury, it is also important to distinguish between mechanisms of injury and mechanisms of no injury.(50) A number of different methodological approaches have been used to study the mechanisms of injury in sports. These include surveys with injured athletes, laboratory motion analysis, cadaver studies or mathematical stimulations and video analysis.(51) Krosshaug et al. proposed that the only research approach that had the potential to record the kinematics of real injury situations was analysis of injury videos.(51)

No previous studies that have specifically investigated injury mechanisms in SBX or SX. Epidemiological studies have found that the injury rates and injury patterns between recreational and WC snowboarders differ. Thus, it is reasonable to believe that different injury mechanisms apply at the WC vs. the recreational level. Therefore, only the few studies that have described injury mechanisms in WC snowboarders will be briefly presented. It seems that many injuries in SX happen in relation to jumping and landing (Stefan Randjelovic, personal communication May 2011). Therefore, two studies describing ACL injury situations in relation to jumping and landing in WC mogul skiing and alpine skiing will be briefly presented.

### ***6.3 Injury mechanisms in WC snowboarding***

An ongoing video analysis of injury situations in WC SBX has found that in SBX finals the majority of injuries happen in conjunction with jumping on elements of the SBX course (Arnhild Bakken, personal communication, May 2011). Jumping on corner jumps and riding over rollers (Figure 1) at high speeds are suggested as particularly difficult elements on the SBX course. In corner jumps the entrance to the jump is often narrow and athletes often find themselves fighting for space in the air (Stian Sivertzen, Norwegian SBX rider and Jonte Grundelius, Norwegian SBX coach, personal communication, May 2011). It is however not yet clear what the injury mechanisms in

SBX during jumping and landing are. Video analysis (Bakken et al. 2011, ongoing study) will convey new knowledge about this.

During the 2010 OWG, 34 % of injuries for skiers and snowboarders were caused by a non-contact trauma. Contact with a stagnant object was the cause of injury in 14% of cases, and field or play conditions in 9% of injuries.(31) These injury mechanisms were not described in greater detail in the study and skiers and snowboarders were grouped together. Torjussen & Bahr reported that in FIS WC SBX riders the main mechanisms of injuries were falling at an obstacle (52%) and collisions with competitors (44%).(29)

Torjussen & Bahr suggested that while the “opposite edge phenomenon” could cause head and wrist injuries in recreational snowboarders, elite SBX athletes did not injure their wrist as frequently because they had greater edge control and did not fall backwards onto their wrists. (30) The “opposite edge” phenomenon, is where a strong ventro-dorsal rotation is created when a rider catches snow with the valley-side edge.(39)

The higher rate of knee injuries in elite compared to recreational snowboarders could be caused by differences in riding styles. Jumping promotes injuries for both elite and recreational snowboarders.(29) The fixation of both feet is assumed to protect against knee injuries but it is likely that this effect is reduced as the impact energy and torsion forces increase with the higher and more spectacular jumps performed by WC athletes.(29)

#### ***6.4 Injury mechanisms in WC freestyle skiing***

SX resembles alpine skiing in the equipment used (giant slalom (GS) alpine racing skis, boots and bindings), in the race format (a modified GS course with additional elements where skiers race on time, or to reach the finish line first) and the fact that most SX athletes are previous alpine skiers (Audun Grønvold, Norwegian SX coach, personal communication, May 2011). It could therefore be possible that injury mechanisms described for WC alpine skiing could be relevant for SX. It should also be remembered that according to FIS rules, WC alpine skiers can qualify for participation in WC SX events with FIS points in alpine disciplines and not necessarily with FIS SX points.(18)

It seems that many injuries in SX happen while jumping (take-off and landing phases) (Audun Grønvold, Norwegian SX coach and Stefan Randjelovic, personal communication, May 2011). It is therefore interesting to present two studies that have examined injuries while jumping/landing in moguls and alpine skiing.

Heir (2006) presented at a conference, findings from video analysis of WC freestyle mogul skiers (n=11) who had ruptured their ACL (Stig Heir, personal communication, May 2011). He reported that most ACL ruptures occurred at landings from jumps on the mogul hill. Landing injuries may have stemmed from the skiers being off-balance to the side or rear, and landing on the injured leg. An athlete's altered balance and placing weight on an injured leg were the key factors leading to ACL ruptures. Likewise, injured skiers usually believed their injuries occurred during a landing. Although unpublished, these findings provide us with ideas regarding the skiers position and imbalance during jumping/landing injuries which would be interesting to pursue in future video analysis of injury mechanism in freestyle skiing.

Bere et al. described one of the main injury mechanism in WC alpine skiing as landing after a jump.(52) These injuries (n=4) happened in downhill skiing. The skiers were out of balance backwards in-flight after a jump and landed on the ski tails with nearly extended knees. The suggested loading mechanism was a combination of tibiofemoral compression and anterior drawer of the tibia related to the femur.(52) Downhill courses are steeper than SX courses and downhill skiers travel at higher speeds than SX athletes. Thus, it would be interesting to know if also SX athletes could demonstrate a similar landing pattern (although at much lower speeds than downhill skiers), as it is thought that SX athletes spend 25% of the time on the course in flight after jumps.(2) It is interesting that also in this study the skiers were out of balance backwards.

The two studies were not performed on SX athletes, and it is therefore not known if the injury situations apply in SX. It would be interesting to perform a visual analysis of jumping-related injury situations in SX to examine the similarities or differences compared to the injury situations described in moguls and alpine skiing. Video analysis (Randjelovic et al. 2011, ongoing study) will convey new knowledge about this.

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# **Article: Injury Incidence and Injury Patterns in Qualification Runs versus Final Runs in FIS World Cup Snowboard Cross and Ski Cross**

Sophie E. Steenstrup, PT,<sup>1</sup> Tone Bere, PT, MSc,<sup>1</sup> Roald Bahr, MD, PhD,<sup>1</sup> and Lars Nordsletten, MD, PhD,<sup>1,2,3</sup>

From the <sup>1</sup>Oslo Sports Trauma Research Center, Department of Sports Medicine, Norwegian School of Sport Sciences, Oslo, Norway, <sup>2</sup>Orthopaedic Department, Oslo University hospital, Oslo, Norway, <sup>3</sup>University of Oslo, Norway

## **1.Introduction**

Snowboard Cross (SBX) and Ski Cross (SX) are relatively new sports. They are a motocross-inspired mixture of freestyle and alpine events. SBX was added as an International Ski Federation (FIS) World Cup (WC) event in the 1996/1997 season and was included in the 2006 Olympic Winter Games (OWG).(1) SX was included in the FIS WC for the 2002/2003 season and was a new OWG event in Vancouver (CAN) in 2010.(2)

In SBX and SX four or six athletes start simultaneously on an inclined course and race to reach the finish line first. The courses have obstacles such as banks, compressions, jumps and giant slalom type turns. There are one (in SX) or two (in SBX) individual preliminary timed qualifying runs. The best ranked athletes from the qualification runs advance to the final heats. In FIS WC final runs, there are usually 32 men and 16 ladies with four athletes per heat. The first two athletes advance to further heats.(3) Because SBX and SX are relatively new sports, little is known about the injury incidence and injury pattern.

Florenes et al. reported an injury incidence among FIS WC snowboard athletes of 37.8 time-loss injuries (absence  $\geq 1$  day) per 100 athletes per season.(4) So far, the specific injury incidence in WC SBX events is unknown. However, during the 2010 OWG, 73% of female and 11% of male SBX athletes suffered an injury.(5) The injury incidence was 16 (SBX females) and 4 (SBX males) per 1000 registered athletes. There were 40.0% time-loss injuries, and most injuries (78.9%) happened during training.(5)

In FIS WC freestyle skiing, Florenes et al. reported an injury incidence of 27.6 time-loss injuries per 100 athletes per season.(4) The injury incidence in WC SX events was 33.8 time-loss injuries per 100 athletes per season, and the injury incidence (per 1000 runs) was 16.6 for males and 21.8 for females.(6) During the 2010 OWG, 23% of female and 15% of male SX athletes suffered an injury.(5) The injury incidence was 8 (SX females) and 5 (SX males) per 1000 registered athletes. There were 23.1% time-loss injuries, and most injuries (61.5%) happened during training.(5)

No previous studies have investigated the injury incidence and injury patterns in individual qualification runs vs. final runs in heats of four or six athletes. It is not known whether competing in heats of four or more athletes influences the risk of injury.

The purpose of this study was to investigate the injury incidence and injury patterns in individual qualification runs vs. final runs of SBX and SX during four seasons of the FIS WC, including the FIS World Ski Championships (WSC) and the OWG. Our null hypothesis was that there would be no difference in injury incidence between qualification and final runs.

## **2. Materials and Methods**

### **2.1 Injury recording**

Injuries were recorded by the FIS Injury Surveillance System (FIS ISS) through retrospective athlete interviews at the end of four WC seasons (2006-2010). For all seasons all athletes from the teams of Germany, Switzerland, Canada, Finland, France, Norway, Italy, Sweden and Austria were included. In addition complete WC teams from 13 SBX and nine SX nations were included for three of the seasons (2007-2010) to increase the study population. All athletes included were registered in the FIS database and had started in at least one FIS WC competition.

Interviews of SBX athletes were conducted in Lake Placid, USA (March 2007), Valmalenco, Italy (March 2008 and March 2009) and La Molina, Spain (March 2010). Interviews of SX athletes were conducted in Madonna Di Campiglio, Italy (March 2007), Valmalenco, Italy (March 2008), La Plagne, France (March 2009) and Sierra Nevada, Spain (March 2010). The WC season was defined as starting at the first WC competition of the season and included the last WC competition of the season, where the interviews took place.

All interviews were conducted by physicians or physiotherapists from the Oslo Sports Trauma Research Centre (OSTRC). The interviewers filled in a standardised interview form for each athlete (Appendix 1). If the athlete reported an injury, the interviewers also completed an injury form (Appendix 2) for each injury. The injury form included information about the date and place of injury occurrence, injury circumstance, body part injured, side (left/right), injury type, injury severity and the specific diagnosis. If athletes were not present at the competitions where the interviews were conducted (due to injury or other reason), or if the athlete did not understand English, the team coaches, physicians or physiotherapists were interviewed.

### **2.2 Injury definition**

Only injuries occurring during the FIS WC, the WSC or the OWG were included in this study. To register an accurate injury exposure during SBX and SX competitions, only injuries occurring during qualification and final runs of SBX and SX competitions were included. Injuries occurring during official training, other training or outside of

competition were excluded. Based on an injury consensus statement on injury surveillance in football (7), a modified injury definition was used. An injury was defined as any physical complaint sustained by an athlete that occurred during competition or training and required attention by medical personnel. An injury that resulted in a rider/skier being unable to take full part in future competition or training was referred to as a time-loss injury. The severity of injuries was classified according to the duration of absence from training or competition. The severity of injuries was classified as slight (no absence), minimal (1-3 days absence), mild (4-7 days absence), moderate (8-28 days absence) and severe (> 28 days absence).(7) In this study, only time-loss injuries were included.

### **2.3 Statistics**

To calculate exposure, the number of started runs during SBX and SX competitions was counted for each athlete per competition. This information was obtained from the official FIS website.(3) The race calendar for SX and SBX for each season was downloaded to indentify the WC, WSC and OWG competitions. Athletes from the included nations were identified from the start list and his/her runs were counted manually per competition. The qualification run result list, race ladder and final result list were used to obtain information about the number of runs each athlete had performed during each competition. The number of runs for each athlete was summed per competition, per year and for the four seasons. Exposure files were created in Microsoft Office Excel (version 2007) for each competition over the four seasons.

The injury incidence was expressed as the absolute injury rate (expressed as the total number of injuries per 100 athletes per season) and as the relative injury rate (expressed as the number of injuries per 1000 runs), each with the corresponding 95% Confidence Intervals (CI). Calculations were based on the Poisson model and Z tests were used to compare injury incidence between qualification and final runs, and to compare the incidence of moderate and severe injuries in qualification vs. final runs. Relative Risk (RR) with 95% CI was computed to compare injury risk between qualification and final runs and between sexes. A two-tailed p level of < 0.05 was considered statistically significant.

## **2.4 Ethics**

The study was reviewed by the regional committee for medical research ethics, South-Eastern Norway Regional Health Authority, Norway, and approved by the Norwegian Social Science Data Services.



### 3. Results

#### 3.1 Athletes included

A total of 713 WC SBX and SX athletes, 259 females and 454 males, were interviewed during four WC seasons (Table 1).

**Table 1.** Number of athletes interviewed in SBX and SX during four WC seasons (2006-2010).

<b>Discipline and sex</b>	<b>2006-2007</b>	<b>2007-2008</b>	<b>2008-2009</b>	<b>2009-2010</b>	<b>Sum of 4 seasons</b>
<b>SBX</b>					
Males	43	58	58	66	225
Females	20	36	30	34	120
Total	63	94	88	100	345
<b>SX</b>					
Males	48	65	57	59	229
Females	23	29	47	40	139
Total	71	94	104	99	368
Total athletes interviewed					713

#### 3.2 Exposure

For SBX the total number of runs during the 2006-2010 seasons was 5672, with 3435 qualification runs and 2237 final runs. For SX the total number of runs during the 4 seasons was 5413, with 2183 qualification runs and 3230 final runs (Table 2).

**Table 2.** Number of runs in SBX and SX qualification and final runs during the 2006-2010 WC seasons.

<b>Discipline</b>	<b>2006-2007</b>	<b>2007-2008</b>	<b>2008-2009</b>	<b>2009-2010</b>	<b>Sum 4 seasons</b>
<b>SBX</b>					
Qualification					
Males	248	650	703	647	2248
Females	122	371	363	331	1187
<b>Sum runs</b>					<b>3435</b>
Finals					
Males	169	433	496	377	1475
Females	91	228	239	204	762
<b>Sum runs</b>					<b>2237</b>
<b>SX</b>					
Qualification					
Males	127	318	440	484	1369
Females	62	130	309	313	814
<b>Sum runs</b>					<b>2183</b>
Finals					
Males	183	378	623	657	1841
Females	99	200	491	599	1389
<b>Sum runs</b>					<b>3230</b>

### 3.3 Injury incidence

A total of 108 time-loss injuries (absence  $\geq 1$  day) were recorded among the 713 athletes included. In SBX there were 48 time-loss injuries (females 19 and males 29 injuries) and in SX there were 60 time-loss injuries (females 23 and males 37 injuries). SBX and SX females had 11 and 8 injuries during qualification runs and 8 and 15 injuries respectively during final runs. SBX and SX males had 10 and 12 injuries during qualification runs and 19 and 25 injuries respectively during finals (Table 3).

**Table 3.** Time-loss injuries (absence  $\geq 1$  day) acquired among SBX and SX athletes during qualification and final runs during the 2006-2010 WC seasons.

<b>Discipline</b>	<b>2006-2007</b>	<b>2007-2008</b>	<b>2008-2009</b>	<b>2009-2010</b>	<b>Sum 4 seasons</b>
<b>SBX</b>	<b>Injuries</b>				
Qualification runs	2	5	4	10	21
Final runs	1	11	8	7	27
Sum injuries SBX	3	16	12	17	48
<b>SX</b>					
Qualification runs	0	5	10	5	20
Final runs	3	7	14	16	40
Sum injuries SX	3	12	24	21	60
<b>Total sum SBX/SX</b>	<b>6</b>	<b>28</b>	<b>36</b>	<b>38</b>	<b>108</b>

For SBX the injury incidence in final runs was 12.1/1000 runs compared to 6.1/1000 runs in qualification runs (RR 1.9, 95% CI 1.1-3.5,  $p=0.019$ ) (Table 4). For SBX males, the injury incidence was higher in final runs (12.9/1000 runs) compared to qualification runs (4.4/1000 runs) (RR 2.9, 95% CI 1.4-6.2,  $p=0.0065$ ). This was not the case for SBX females (finals 10.5/1000 runs vs. qualification 9.3/1000 runs, RR 1.1, 95% CI 0.5-2.8,  $p=0.79$ ).

For SX the injury incidence in finals was 12.4/1000 runs compared to 9.2/1000 runs in qualifications (RR 1.4, 95% CI 0.8-2.3,  $p=0.27$ ) (Table 4). The injury incidence for SX males was 13.6/1000 runs in finals vs. 8.8/1000 runs in qualifications (RR 1.5, 95% CI 0.8-3.1,  $p=0.21$ ). The injury incidence for SX females was 10.8/1000 runs in finals vs. 9.8/1000 runs in qualifications (RR 1.1, 95% CI 0.5-2.6,  $p=0.83$ ).

**Table 4.** Injury incidence per 1000 runs (with 95% CI) in SBX and SX qualification runs and final runs for males and females (n= 713).

<b>Discipline and sex</b>	<b>Qualification runs</b>	<b>Final runs</b>	<b>Total</b>
SBX total	6.1 (3.5-8.7)	12.1 (7.5-16.6)	8.5 (6.1-10.9)
SBX females	9.3 (3.8-14.7)	10.5 (3.2-17.8)	9.7 (5.4-14.1)
SBX males	4.4 (1.7-7.2)	12.9 (7.1-18.7)	7.8 (5.0-10.6)
SX total	9.2 (5.1-13.2)	12.4 (8.5-16.2)	11.1 (8.3-13.9)
SX females	9.8 (3.0-16.6)	10.8 (5.3-16.3)	10.4 (6.2-14.7)
SX males	8.8 (3.8-13.7)	13.6 (8.3-18.9)	11.5 (7.8-15.2)

For SBX and SX the injury incidence (injuries per 100 athletes) was not significantly different between females and males (SBX: RR females vs. males 1.3, 95% CI 0.7-2.3, p=0.38; SX: RR females vs. males 1.02, 95% CI 0.61-1.7, p= 0.93) (Table 5).

**Table 5.** Injury incidence per 100 athletes including 95% CI.

<b>Discipline</b>	<b>Females</b>	<b>Males</b>	<b>Total</b>
SBX	16.7 (9.4-23.9)	12.9 (8.2-17.6)	14.2 (10.2-18.2)
SX	16.5 (9.8-23.3)	16.2 (11.0-21.4)	16.3 (12.2-20.4)

### 3.4 Severity of injuries

The majority of injuries (62%) during qualification and final runs were moderate (absence 8-28 days) and severe (absence >28 days). There were 16 moderate injuries in SBX (6 in qualification and 10 in final runs) and 11 moderate injuries in SX (3 in qualification and 8 in final runs). There were 14 severe injuries in SBX (8 in qualification and 6 in final runs) and 26 severe injuries in SX (11 in qualification and 15 in final runs). There were no significant differences in injury severity in qualification runs vs. final runs in SBX or SX (Table 6).

**Table 6.** Injury incidence (number of injuries per 1000 runs with 95% CI) for moderate (8-28 days) and severe (>28 days) injuries in qualification and final runs

<b>Discipline/Severity</b>	<b>Qualification</b>		<b>Total</b>
	<b>runs</b>	<b>Final runs</b>	
SBX Moderate	1.7 (0.3-3.1)	4.5 (1.7-7.2)	2.8 (1.4-4.2)
SBX Severe	2.3 (0.7-3.9)	2.7 (0.5-4.8)	2.5 (1.2-3.8)
SX Moderate	1.4 (-0.2-2.9)*	2.5 (0.8-4.2)	2.0 (0.8-3.2)
SX Severe	5.0 (2.1-8.0)	4.6 (2.3-6.7)	4.8 (3.0-6.6)

\*less than 5 cases, should be interpreted with caution

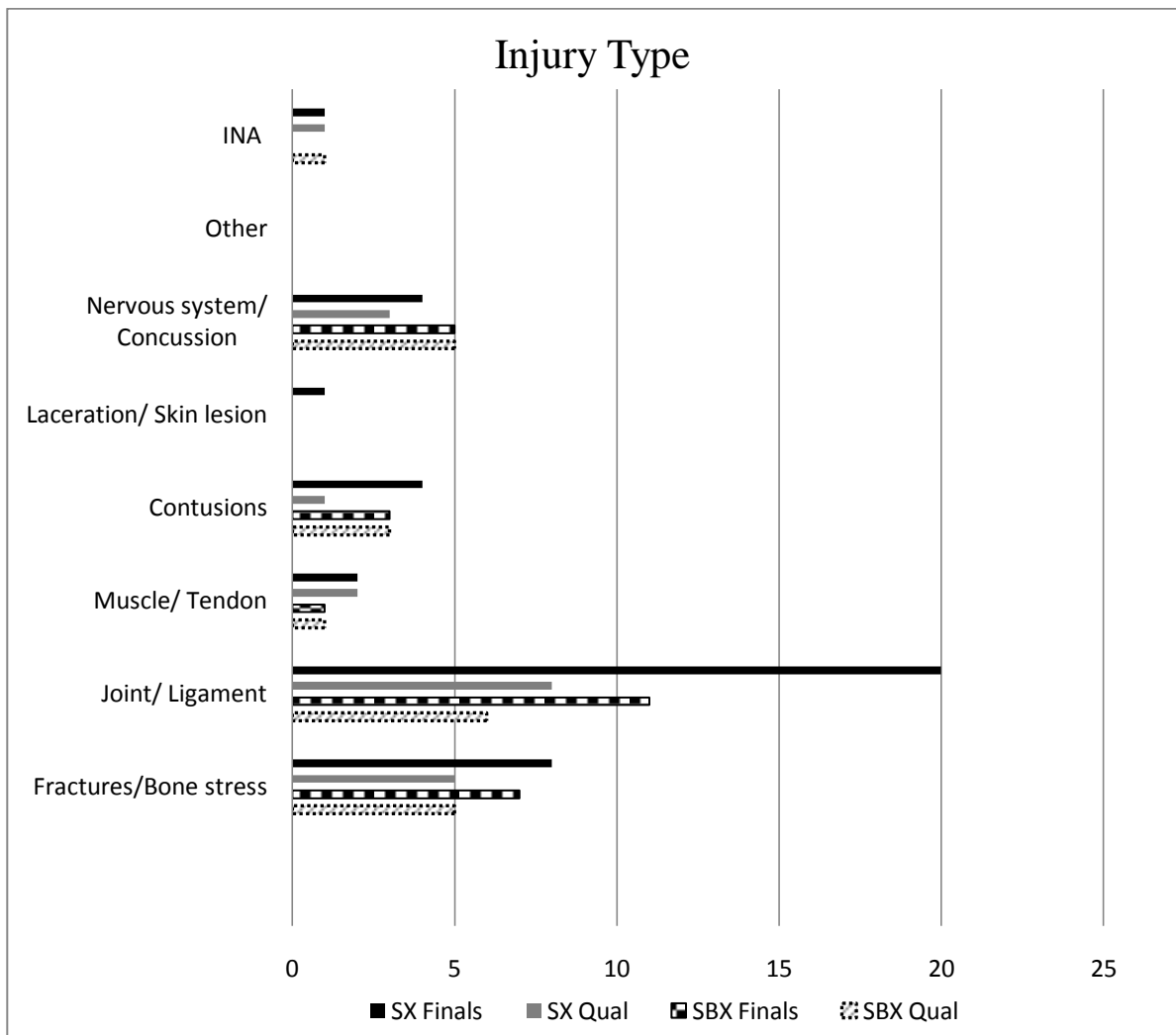
### 3.5 Injury type

In SBX and SX overall the most common injury types were joint and ligament injuries, followed by fractures and bone stress. These injuries were most common in both qualification and final runs. In SBX qualification runs nervous system/ concussion

injuries were equally the second most common injury category. In both SBX and SX the number of joint and ligament injuries in final runs was higher than the number of joint and ligament injuries in qualification runs. In total, there were 31 joint and ligament injuries in SBX and SX final runs and 14 joint and ligament injuries in qualification runs. Fractures and bone stress as the second most common injury category had 15 injuries in final runs and 10 injuries in qualification runs for SBX and SX combined (Figure 1).

The knee was the most commonly injured body part. Of the 45 joint and ligament injuries, 33 (73%) were knee injuries (11 in SBX and 22 in SX). Of these, 31 (94%) were moderate and severe injuries.

**Figure 1.** Injury types in SBX and SX qualification and final runs.



INA= Information not available

## **4. Discussion**

This is the first study to examine the injury incidence in qualification and final runs of WC SBX and SX. The principal finding was that the injury incidence was significantly higher in final runs vs. qualification runs in SBX and for SBX males. For SBX females and in SX the injury incidence in final runs was not significantly higher than in qualification runs. Our null hypothesis can be rejected for SBX and SBX males, but not for SX or SBX females.

### **4.1 Methodological considerations**

All injury recording during the four WC seasons was through retrospective interviews with athletes, medical personnel or coaches. Recall bias is a challenge with retrospective interviews. A methodological study however found that retrospective interviews were the best method to record injuries among WC skiers and snowboarders.(8) In our experience, athletes might have underreported minor injuries. Athletes might forget that they had to rest for one to two days because of a minor injury, and might not report this. They might have attitudes that prevent them from reporting minor injuries, because they view these injuries as everyday occurrences. If an athlete suffered an injury in a competition and subsequently had two travel days to reach the next race location, he/she might not think of this as absence from training, because there was no training scheduled while travelling. The severity of injuries might therefore also in some cases have been underreported. Another challenge with injury reporting through retrospective athlete interviews is the differentiation between acute and overuse injuries. If e.g. a SBX athlete had constant pain in her heel, and crashed in a competition, receiving a diagnosis of an acute bone bruise of the heel, she might have trouble differentiating between this as a new injury occurring from one specific run, or as an acute exacerbation of a previous overuse injury.

To identify the run where the injury occurred, FIS WC start lists, race ladders and result lists were studied to estimate where the athlete did not finish a run and subsequently did not start the next run. This could lead to an inaccurate registration of the run type (qualification or final) where the injury occurred. Athletes who suffered e.g. an upper limb injury could complete the competition although they were injured. In our experience, athletes would complete the competition as long as they were mechanically

able to. An athlete suffering a hand injury in the 1/8<sup>th</sup> final might therefore not only complete the run but subsequently go on to compete in the 1/4<sup>th</sup> final. Our method of registration would in these cases not be able to identify the run where the athlete suffered an injury, and the injury would in these cases have to be excluded. We had however no other way of identifying the run type where injuries occurred, as this could not be identified by the interview form.

When interpreting the results for moderate and severe injuries in qualification and final runs, moderate SX injuries had a low number of injuries (n=3) and this result should therefore be interpreted with caution.

We only found significant differences between qualification and final runs in SBX and SBX males. If we had data from additional WC seasons this would increase the sample size and the number of injuries, thereby increasing the power of our study.

#### **4.2 Qualification runs vs. final runs**

From our data we cannot determine why riding in heats of four gave a higher risk of injury compared to riding individually for SBX males, or why this risk was not found in SBX females or in SX. Because there were a higher number of males compared to females in both SBX and SX (Table 1), the exposure correspondingly was higher for males in both qualification and finals (Table 2). In addition, males often competed in one additional final run compared to females, as males most often started final runs with a 1/8<sup>th</sup> final whereas females often went straight to the 1/4<sup>th</sup> finals. In SX there was a higher number of final runs (3230 runs) compared to qualification runs (2183) while in SBX there was a higher number of qualification runs (3435) compared to final runs (2237). This is because in SX there is only one qualification run whereas there are two qualification runs in SBX.

It has been supposed that more injuries happen in final runs because of external factors such as space constraints on the course and competition for the ideal line. Further, it is suggested that many injuries in SBX and SX happen in conjunction with jumps (Arnhold Bakken and Stefan Randjelovic , personal communication, May 2011). Torjussen & Bahr reported that in FIS WC SBX riders the main mechanisms of injuries were falling at an obstacle (52%) and collisions with competitors (44%).(9) Although prohibited by the FIS rules of contact (10;11), athletes occasionally are in intentional or unintentional

contact with each other during heats. How athletes cope in final heats is influenced by their skiing/riding preferences as an athlete. Some athletes prefer to lie behind in the heat and subsequently trying to overtake the leading athletes, whereas others prefer to lie in front and in that way avoid contact with other athletes. It is thought that lying in the front of the heat gives the athlete more opportunity to follow his/her ideal race line and minimises the chance of contact with other athletes. Lying behind in the heat makes it more difficult for athletes to follow their ideal race line and might increase the chance of contact, because several athletes are trying to overtake each other (Stian Sivertzen, Norwegian team SBX rider, personal communication, May 2011).

Regarding internal factors, it has been suggested that psychological factors such as nervousness, stress, excitement, the ability to handle pressure and to make correct split second decisions about race tactics are thought to influence how athletes handle competing in heats. The athlete`s ability to make quick and sensible tactical decisions when their ideal race line is compromised by other athletes is seen as an important psychological factor. It has been suggested that SBX may promote a risk taking attitude for competitors to stay at the top of their sport.(9) An SBX rider describes that how athletes handle the mental pressure in heats is essential for how they perform. In final heats athletes will give a maximum effort and can take more risks than when riding alone because so much is at stake (Stian Sivertzen, personal communication, May 2011).

Physiological factors such as aerobic fitness, strength and explosiveness are also thought to influence how well athletes handle competing in final heats.(12) Athletes reaching the finals compete in five or six runs of 60 seconds or more, in addition to training and warm-up runs. It is therefore thought that fatigue might influence the athletes abilities in finals. Platzer et al. reported that performance on a battery of physical tests could predict WC ranking, especially for SBX females.(12) Physical fitness was a performance determining factor for women, but not for men. No significant correlations were found in the men`s events, and the authors discussed that psychological factors, equipment and coordination might be more important.(12)

We cannot determine why male and not female SBX riders had a higher risk of injuries in final runs. Male sex and high speed were found to be factors associated with risk-



taking behaviour in recreational skiers and snowboarders.(13;14) Male SBX and SX athletes attain higher average speeds compared to women.(2;15) We do not know if speed influences the injury risk in SBX and SX and if there are speed differences between individual qualification runs and final runs.

In other sports using a heat format challenges have been described. In BMX heats it was reported that crashes, often involving several participants, occurred frequently. Injuries were sustained through impact on the track and/or collisions with the rider`s own or other competitors bicycles.(16) In horse racing (flat racing) heats a high rate of concussions was found for jockeys. This reflected the high speeds and the fact that falls tended to occur when horses were closely bunched together.(17) External risk factors for WC short track speed skaters were identified to include the number of skaters (three to five) in a race and the number of people falling in a single collision.(18) Regarding internal factors, in mountain biking heats it was suggested that riders had an extreme nature and were “pumped up” during final heats, enabling them to complete events even with significant injuries as long as they were mechanically able to ride.(19)

In our study, we found that the injury incidence in qualification runs and final runs was not significantly different in SX and for SBX females. Especially for SBX and SX females, the injury incidence was high in both qualification and final runs. Factors regarding why many injuries occur in qualification runs are therefore important to consider. It is thought that attempting to qualify from preliminary rounds to final rounds may lead to athletes pushing themselves beyond their limits.(20) In the same way that athletes take risks in final runs to win the heat, athletes may take too much risk to try to advance from the qualification runs. Injury rates were compared in practice sessions vs. races in motocross, road racing and trial.(20) The injury rate was significantly higher in practice sessions compared to races (injury rate practice 122 compared to 39 in race heats). This indicated that competitors rode more aggressively in practice sessions to acquire better starting positions, and that competitors took more risks during practice.(20) It was expressed by SBX and SX coaches and a SBX rider that they thought the risk of injury might be highest in qualification runs of SBX and SX. This was because the athletes may not yet be fully acquainted with the course because of too little training time, athletes might have difficulty judging their speed and timing onto elements, and because less skilled riders/skiers might push themselves beyond their

capabilities (take too much risk) in qualification runs to try to qualify to the finals (Jonte Grundelius, Norwegian SBX coach, Stian Sivertzen and Audun Grønvold, Norwegian SX coach, personal communication, May 2011).

Engebretsen et al. expressed surprise about the fact that the majority of SBX and SX injuries during the 2010 OWG happened during training, as the athletes were alone on the course without perceiving stress from additional competitors and poor course choices.(5) This finding was not met with surprise by SBX and SX coaches. During training sessions athletes ski/ride a few runs individually to inspect and get acquainted with the course. They then purposefully train in heats of two to four athletes to achieve realistic race training. Training sessions are therefore more like final heats than individual qualification runs, and stress from other competitors is a part of training sessions (Jonte Grundelius and Audun Grønvold, personal communication, May 2011).

#### **4.3 Injury incidence**

Torjussen & Bahr found that the injury incidence for WC SBX riders was 2.1 per 1000 runs.(9) This study had a greater exposure rate than our current study and included warm-up and training runs. They used an exposure factor of 13.7 runs per competition for SBX (9), compared to our exposure of two to six runs. Compared to their study, our injury incidence was higher (8.5/1000 runs). We found a lower total injury incidence per 100 athletes for SBX (14.2) compared to Florenes et al. who had registered all FIS WC snowboarding disciplines together (37.8).(4) Florenes et al. registered all injuries that occurred during the WC season (also injuries outside of competitions, injuries during on-snow training and basic training not on snow), compared to our study where we only included injuries occurring during qualification and final runs. Compared to WC alpine skiing the total injury incidence in SBX per 1000 runs in this study was higher than for slalom (4.9), but lower than for the other alpine disciplines (giant slalom, super-G and downhill).(21)

For SX we found an incidence of 11.1 injuries per 1000 runs, and 16.3 injuries per 100 athletes, which was lower than previously reported by Florenes et al.(6) We analysed data from 4 WC seasons compared to 3 in the previous study.(6) This could have influenced the difference in injury incidence. The injury incidence per 1000 runs in SX

in the current study was higher than for all alpine skiing disciplines except for downhill (17.2).(21)

In SBX and SX male final runs, the injury incidence per 1000 runs in this present study was 12.9 and 13.6 respectively. This is higher than previously reported for giant slalom (9.2), super-G (11.0) and moguls/ dual moguls (9.2), but lower than for downhill skiing (17.2), freestyle half pipe (23.9) and aerials (19.2).(6;21)

#### **4.5 Injury patterns**

Our results regarding injury patterns correspond to recent studies in that joint and ligament injuries were the most common, and that the knee was the most commonly injured body part in both run types and disciplines.(4;6) We found no sex differences in injury patterns in WC SBX and SX and this is supported by previous studies.(4;6;9) Contrary to this, sex differences were found in injury risk during the 2010 OWG, where female SBX and SX athletes suffered more injuries than males.(5) The authors did not analyse these figures further. We found no significant differences in injury severity in qualification runs vs. final runs. Florenes et al. reported injury severity per 100 athletes in previous studies and we can therefore not compare our results.(4;6) We examined injury severity per 1000 runs to show the difference in severity between qualification and final runs.

#### **4.6 Further perspectives**

Although we have identified that more injuries happen in SBX finals, we do not know if more injuries happen early in finals (1/8<sup>th</sup> to 1/4<sup>th</sup> finals) or in the semi finals or big/small finals. One could theorize either that less injuries happen late in finals because only the most skilled athletes have qualified to the final stages, or that more injuries happen later in the competition because of the athletes` fatigue and the fact that so much is at stake. Although we registered the run where injury occurred, we did not analyse this further. Future epidemiological studies could examine this.

We do not know if the number of athletes competing on the course at the same time influences the injury risk. In our data material, all races were held with a four athletes per heat format. It would be interesting in future studies to also examine the injury risk

in competitions such as the X-Games which have a six athlete per heat format. This could be done in a similar study as ours.

We found that the injury incidence was significantly higher in SBX finals in total, and for males when analysed for sex. However, the injury incidence was also high in qualification runs, especially for SBX and SX females. Video analysis of injury situations in final runs of WC SBX and SX will bring new knowledge about why and how injuries happen in final runs (Bakken et al. 2011, Randjelovic et al. 2011, ongoing studies). However, future studies should also examine, by video analysis, how injuries occur in qualification runs. We must also identify if the injury mechanisms in qualification and final runs are different.

Future studies should investigate whether and how course elements affect injury risk in both qualification and final runs. It has been suggested that making the first elements out of the start more difficult may help separate the athletes before the first bank, thereby minimising athlete contact and space constraints (Jonte Grundelius, personal communication, May 2011). Elements that are built too close to each other, or jumps and rollers built too close to a turn or bank are thought to potentially create a risk of injury (Audun Grønvold, personal communication, May 2011). Future video analysis of injury situations in both qualification and final runs will be beneficial in identifying both how the heat format could potentially influence injury risk and if elements have an influence on the injury situations. How the athletes handle the elements riding/skiing alone vs. in a heat with other athletes should be examined by comparing video footage of qualification and final runs. Only by visually comparing and analysing performance in the two run types can we identify differences between qualification and finals.

One method of examining mechanisms that lead to injuries compared to mechanisms that do not lead to injuries would be to compare uninjured athletes (controls) riding/skiing on the same course and in the same run, in the same situation and on the same element, as injured riders/skiers. This could be done by video analysis of both situations. To examine internal factors such as stress perceived by the athletes, or if the athletes felt their ideal line and race tactics were compromised, an interview of injured and uninjured athletes could be combined with the video analysis.

It should be investigated how to reduce the injury incidence without changing the nature of the sport. The nature of SBX and SX is high speeds, difficult elements, and a competition for space and the ideal line between athletes. If any parts of the sport are to be changed in the future for injury prevention purposes, it is important for the sports of snowboarding and freestyle skiing that SBX and SX remain true to their motocross-like original form.

Coaches have raised the question of whether athletes should be required to have an increased skill level before being able to participate in the WC. Today SBX athletes need 50 SBX FIS points to participate in the SBX WC (22) and SX athletes need 50-100 FIS freestyle points or 50 FIS alpine points from any alpine event.(23) Coaches have questioned if this entry criteria should be raised. It has been suggested that some lower ranked athletes do not possess the necessary skills to cope with technical WC and Olympic courses (Jonte Grundelius, personal communication, May 2011).

Which preparations the athletes themselves could make regarding physical and psychological factors to minimise risk of injury is unknown. Platzer et al. (12) found that performance on a battery of physical tests could correspond to WC performance in SBX women, but we have little knowledge about whether physical and psychological factors can influence the risk of injury. Future studies should try to identify what the physical and psychological requirements of SBX and SX are. We will not know which factors could predispose to, or protect from, injury before we know which physiological and psychological requirements are needed.

## **5. Conclusion**

The injury incidence was significantly higher in final runs compared to individual qualification runs in SBX overall and for SBX males. This was not the case for SBX females or for SX. The injury severity did not differ between qualification and final runs and there were no sex differences. Joint and ligament injuries and knee injuries were the most common injuries in both run types and disciplines. Future video analysis studies should attempt to identify injury situations and injury mechanisms in both qualification and final runs of WC SBX and SX.

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## ***Appendix 1***



# Injury Surveillance Study - Interview

FIS World Cup Freestyle, 2010/11

Oslo Sports Trauma  
RESEARCH CENTER

Athlete Name: \_\_\_\_\_

Trainer: \_\_\_\_\_

Nation: \_\_\_\_\_ Discipline: \_\_\_\_\_

MD/PT: \_\_\_\_\_

Contact (e-mail/cell): \_\_\_\_\_

Athlete  
Male   
Female

Week	Date	Site	Race / Competition	Start: Yes	Injury: Yes	If "yes" on injury, fill out form Other notes
49	11.12.2010	Ruka, FIN	MO	<input type="checkbox"/>	<input type="checkbox"/>	
12-14.12.10					<input type="checkbox"/>	
50	15.12.2010	Meribel, FRA	DM	<input type="checkbox"/>	<input type="checkbox"/>	
16.12.2010					<input type="checkbox"/>	
50-51	17.-21.12.2010	Beida Lake, CHN	MO	<input type="checkbox"/>	<input type="checkbox"/>	
			3xAE	<input type="checkbox"/>	<input type="checkbox"/>	
50	18.-19.12.2010	Innichen/San Candido, ITA	2xSX	<input type="checkbox"/>	<input type="checkbox"/>	
22.12.10 - 06.01.11					<input type="checkbox"/>	
1	7.1.2011	St. Johann (Tirol), AUT	SX	<input type="checkbox"/>	<input type="checkbox"/>	
08-11.01.11					<input type="checkbox"/>	
2	12.-13.1.2011	Alpe d Huez, FRA	SX	<input type="checkbox"/>	<input type="checkbox"/>	
14.01.2011					<input type="checkbox"/>	
2	15.-16.1.2011	Mont Gabriel, CAN	DM	<input type="checkbox"/>	<input type="checkbox"/>	
			AE	<input type="checkbox"/>	<input type="checkbox"/>	
15.01.2011					<input type="checkbox"/>	
2	16.1.2011	Les Contamines, FRA	SX	<input type="checkbox"/>	<input type="checkbox"/>	
17-20.01.11					<input type="checkbox"/>	
3	21.1.2011	Kreischberg, AUT	HP	<input type="checkbox"/>	<input type="checkbox"/>	
21-23.01.11					<input type="checkbox"/>	
3	21.-23.1.2011	Lake Placid, USA	2xMO	<input type="checkbox"/>	<input type="checkbox"/>	
			AE	<input type="checkbox"/>	<input type="checkbox"/>	
24-27.01.11					<input type="checkbox"/>	
4	28.-29.1.2011	Calgary, CAN	MO	<input type="checkbox"/>	<input type="checkbox"/>	
			AE	<input type="checkbox"/>	<input type="checkbox"/>	

28.01.2011					<input type="checkbox"/>	
4	29.1.2011	Grasgehren, GER	SX	<input type="checkbox"/>	<input type="checkbox"/>	
30.01-10.02.11					<input type="checkbox"/>	
6	11.2.2011	Blue Mountain, CAN	SX	<input type="checkbox"/>	<input type="checkbox"/>	
12.02.2011					<input type="checkbox"/>	
6	12.2.2011	Moscow, RUS	AE	<input type="checkbox"/>	<input type="checkbox"/>	
13-18.02.11					<input type="checkbox"/>	
7	19.2.2011	Minsk/Raubichi, BLR	AE	<input type="checkbox"/>	<input type="checkbox"/>	
20-25.02.11					<input type="checkbox"/>	
8	26.2.2011	Marianske Lazne; CZE	DM	<input type="checkbox"/>	<input type="checkbox"/>	
27.02-02.03.11					<input type="checkbox"/>	
9	3.3.2011	Grindelwald, SUI	SX	<input type="checkbox"/>	<input type="checkbox"/>	
04-05.03.11					<input type="checkbox"/>	
9	6.3.2011	Meiringen-Hasliberg, SUI	SX	<input type="checkbox"/>	<input type="checkbox"/>	
07-10.03.11					<input type="checkbox"/>	
10	11.-12.3.2011	Are , SWE	MO	<input type="checkbox"/>	<input type="checkbox"/>	
			DM	<input type="checkbox"/>	<input type="checkbox"/>	
11-12.03.11					<input type="checkbox"/>	
10	13.3.2011	Branas, SWE	SX	<input type="checkbox"/>	<input type="checkbox"/>	
14-18.03.11					<input type="checkbox"/>	
11	19.-20.3.2011	Myrkdalen-Voss, NOR	DM	<input type="checkbox"/>	<input type="checkbox"/>	
			SX	<input type="checkbox"/>	<input type="checkbox"/>	
19.03.2011					<input type="checkbox"/>	
11	20.3.2011	La Plagne, FRA	2xHP	<input type="checkbox"/>	<input type="checkbox"/>	

Number of injuries: \_\_\_\_\_

Number of injury forms: \_\_\_\_\_



The athlete has read and understood the Athlete Information form and consents to participate in the FIS Injury Surveillance System

\_\_\_\_\_  
Athlete signature

## ***Appendix 2***

# Injury Surveillance Study - World Cup Teams Interview

## Injury report / Verletzungsmeldung / Rapport de blessure

### Athlete information/ Informationen zum Athleten/Données sur l'athlète

Name/ Name/Nom:

Country/  
Land/Pays:

Gender/  
Geschlecht/  
Sexe:

 Male/ Mann/Homme  
 Female/ Frau/Femme

### Injury information/ Information zur Verletzung/Information sur la blessure

Discipline:

### Injury 1

Date of injury:

Body part injured/ Verletzter Körperteil/Partie du corps blessée:

- Head-face/ Kopf-Gesicht/Tête-Face
- Neck-cervical spine/ Nacken-Halswirbel/Nuque-Vertèbre cervicale
- Shoulder-clavicular/ Schulter-Schlüsselbein/Epaule-Clavicule
- Upper arm/ Oberarm/Bras
- Elbow/ Ellbogen/Coudes
- Forearm/ Unterarm/Avant-bras
- Wrist/ Handgelenk/Poignet
- Hand-finger-thumb/ Hand-Finger-Daumen/Main-Doigt-Pouce
- Chest (sternum-ribs-upper back)/ Brustkasten (Brustbein-Rippen-Brustwirbelsäule)/Thorax (Sternum-Côtes-Haut du dos)
- Abdomen/ Bauch/Abdomen
- Lower back-pelvis-sacrum/ Lendenwirbelsäule-Becken-Kreuzbein/Bas du dos-Pelvis-Sacrum
- Hip-groin/ Hüfte-Leiste/Hanche-Aine
- Thigh/ Oberschenkel/Cuisse
- Knee/ Knie/Genoux
- Lower leg-Achilles tendon/ Unterschenkel-Achillessehne/Jambe-Tendon d'Achille
- Ankle/ Fussgelenk/Chevilles
- Foot-heel-toe/ Fuss-Ferse-Zehen/Pied-Talon-Orteils
- Information not available/ Information nicht verfügbar/Information non disponible

Did you use any protection?

- Helmet
- Back/ Wirbelsäule/Dos
- Shoulder/ Schulter/Epaule
- Elbow/ Ellbogen/Coudes
- Wrist/ Handgelenk/Poignet
- Hip-pants
- Knee/ Knie/Genoux
- Leg-shin
- Teeth
- Pole-protection
- Jacket with different protection
- Other

Specific diagnosis/ Genaue Diagnose/Diagnostic spécifique:

Circumstances:

- FIS World Cup/World Championship(WCS)
- Other FIS competition
- Other competition
- Official FIS WC/WCS training
- Official FIS training
- Other training activity on snow
- Basic training, not on snow (weight lifting, running etc.)

Injury type/ Art der Verletzung/Genre de la blessure:

- Fractures and bone stress/ Frakturen und Ermüdungsbrüche/Fracture et fracture de fatigue
- Joint (non-bone) and ligament/ Gelenke (nicht Knochen) und Bänder/Joint (articulation) et ligament
- Muscle and tendon/ Muskel und Sehnen/Muscle et tendon
- Contusions/ Quetschungen/Contusions
- Laceration and skin lesion/ Fleischwunden und Hautverletzung/Plaie et lésion de la peau
- Nervous system including concussion/ Nervensystem inkl. Gehirnerschütterung/Système nerveux y compris commotion cérébrale
- Other/ Andere/Autres
- Information not available/ Information nicht verfügbar/Information non disponible

Absence from training and competition/ Abwesenheit von Training und Wettkämpfen/Absence à l'entraînement et en compétitions:

- No absence/ Keine Absenz/Pas d'absence
- 1 to 3 days/ 1 bis 3 Tage/1 à 3 jours
- 4 to 7 days/ 4 bis 7 Tage/4 à 7 jours
- 8 to 28 days/ 8 bis 28 Tage/8 à 28 jours
- >28 days/ >28 Tage/>28 jours
- Information not available/ Information nicht verfügbar/Information non disponible

Side/ Seite/Part:

- Right/ Rechts/Droite
- Left/ Links/Gauche
- Not applicable/ Nicht anwendbar/Non applicable

## Injury information/

Information zur Verletzung/Information sur la blessure

## Injury 2

Discipline:

Date of injury:

Body part injured/ Verletzter Körperteil/Partie du corps blessée:

- Head-face/ Kopf-Gesicht/Tête-Face
- Neck-cervical spine/ Nacken-Halswirbel/NUque-Vertèbre cervicale
- Shoulder-clavicular/ Schulter-Schlüsselbein/EpauLe-Clavicule
- Upper arm/ Oberarm/Bras
- Elbow/ Ellbogen/Coudes
- Forearm/ Unterarm/Avant-bras
- Wrist/ Handgelenk/Poignet
- Hand-finger-thumb/ Hand-Finger-Daumen/Main-Doigt-Pouce
- Chest (sternum-ribs-upper back)/ Brustkasten (Brustbein-Rippen-Brustwirbelsäule)/Thorax (Sternum-Côtes-Haut du dos)
- Abdomen/ Bauch/Abdomen
- Lower back-pelvis-sacrum/ Lendenwirbelsäule-Becken-Kreuzbein/Bas du dos-Pelvis-Sacrum
- Hip-groin/ Hüfte-Leiste/Hanche-Aine
- Thigh/ Oberschenkel/Cuisse
- Knee/ Knie/Genoux
- Lower leg-Achilles tendon/ Unterschenkel-Achillessehne/Jambe-Tendon d'Achille
- Ankle/ Fussgelenk/Cheville
- Foot-heel-toe/ Fuss-Ferse-Zehen/Pied-Talon-Orteils
- Information not available/ Information nicht verfügbar/Information non disponible

Did you use any protection?

- Helmet
- Back/ Wirbelsäule/Dos
- Shoulder/ Schulter/EpauLe
- Elbow/ Ellbogen/Coudes
- Wrist/ Handgelenk/Poignet
- Hip-pants
- Knee/ Knie/Genoux
- Leg-shin
- Teeth
- Pole-protection
- Jacket with different protection
- Other

Circumstances:

- FIS World Cup/World Championship(WCS)
- Other FIS competition
- Other competition
- Official FIS WC/WCS training
- Official FIS training
- Other training activity on snow
- Basic training, not on snow (weight lifting, running etc.)

Injury type/ Art der Verletzung/Genre de la blessure:

- Fractures and bone stress/ Frakturen und Ermüdungsbrüche/Fracture et fracture de fatigue
- Joint (non-bone) and ligament/ Gelenke (nicht Knochen) und Bänder/Joint (articulation) et ligament
- Muscle and tendon/ Muskel und Sehnen/Muscle et tendon
- Contusions/ Quetschungen/Contusions
- Laceration and skin lesion/ Fleischwunden und Hautverletzung/Plaie et lésion de la peau
- Nervous system including concussion/ Nervensystem inkl. Gehirnerschütterung/Système nerveux y compris commotion cérébrale
- Other/ Andere/Autres
- Information not available/ Information nicht verfügbar/Information non disponible

Absence from training and competition/ Abwesenheit von Training und Wettkämpfen/Absence à l'entraînement et en compétitions:

- No absence/ Keine Absenz/Pas d'absence
- 1 to 3 days/ 1 bis 3 Tage/1 à 3 jours
- 4 to 7 days/ 4 bis 7 Tage/4 à 7 jours
- 8 to 28 days/ 8 bis 28 Tage/8 à 28 jours
- >28 days/ >28 Tage/>28 jours
- Information not available/ Information nicht verfügbar/Information non disponible

Side/ Seite/Part:

- Right/ Rechts/Droite
- Left/ Links/Gauche
- Not applicable/ Nicht anwendbar/Non applicable

Specific diagnosis/ Genaue Diagnose/Diagnostic spécifique:



## ***Appendix 3***

Keith Bradford to me

From Keith Bradford [kbradford@canski.org](mailto:kbradford@canski.org)

To "sophistrup@gmail.com" [sophistrup@gmail.com](mailto:sophistrup@gmail.com)

Date Wed, Apr 27, 2011 at 5:52 PM

Subject FW: Permission to use image of SX Course features

Mailed-by: canski.org Apr 27

Hi Sophie,

Thanks for your email. We're fine with you doing this, provided there's a credit for Canada Ski Cross/Alpine Canada.

Regards,

Keith

From: Sophie Steenstrup [mailto:[sophistrup@gmail.com](mailto:sophistrup@gmail.com)]

Sent: Tuesday, April 26, 2011 9:39AM

To: [admin@canadaskicross.ca](mailto:admin@canadaskicross.ca)

Subject: Permission to use image of SX Course features

Hi,

I am a Norwegian physiotherapist currently writing a master's thesis about injuries in World Cup SX and SBX at the Norwegian School of Sports sciences. I am currently writing a section describing SX courses and features, and I therefore would like to ask permission to use the image of a SX course and its features from your website (attachment). The image will be referenced with the name of permission giver and your website address.

If this e-mail does not reach the correct person to answer this question, could you please forward it appropriately?

Thank you for your cooperation,

Best regards,

Sophie E. Steenstrup



