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Injury patterns after skiing and snowboarding sports accidents

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ABSTRACT

Background: Alpine sports are associated with risk of serious injuries. To gain insight into factors that may help reduce injury severity, accident characteristics and injury patterns were analysed in a cohort of injured skiers and snowboarders.

Methods: All patients with Alpine sports-related injuries, reporting the injury to a leading medical assistance organization in the Netherlands in the period of 2013-2016, were contacted. Medical data were collected from the patients' files. Only ski and snowboard incidents were included. Injuries were classified according to the Abbreviated Injury Scale (AIS) and Injury Severity Scale (ISS). Data on the accident conditions, i.e. risk factors, were collected using retrospective patient-reported questionnaires. Risk factors for injuries with ISS≥9 were analysed by multivariate modelling.

Results: Of the 1588 included patients, 421 patients filled out the questionnaire. Skiers (n=1370) had more knee injuries (20.4% vs 7.4%, p<0.001), femur fractures (5.3% vs 0.5%, p=0.002) and lower leg fractures (27.5% vs 11.5%, p<0.001) compared to snowboarders (n=218). Skiers were also more seriously injured (ISS>9) (p=0.01). Injured snowboarders sustained more brain concussions (8.8% vs 15.7%, p=0.003) and lower arm fractures (5.4% vs 16.1%, p<0.001). Only 'a higher skills level' was borderline significant for predicting serious injury (OR: 4.0 95% CI: 0.86-18.50; p=0.08). No additional risk factors were identified.

Conclusions: Injury patterns after skiing and snowboarding accidents differ, injury severity differed not. Preventive measures should therefore aim to protect specific body parts depending on the type of Alpine sport. Experienced skiers and snowboarders may be more at risk for serious injuries.

Keywords: Snow sports, skiing, snowboarding, injuries, risk, prevention

KEY MESSAGES

"What is already know on this subject?"

- Skiing and snowboarding are sports associated with risk of injury
- Injury patterns after skiing and snowboarding accidents differ

"What this study adds"

- A comprehensive analysis of injury patterns and their severity after skiing and snowboarding accidents
- Recommendations for prevention of serious injuries by means of a risk analysis including potential intrinsic and extrinsic risk factors

INTRODUCTION

Skiing and snowboarding are popular Alpine sports. About one million Dutch citizens go abroad for an Alpine sport vacation every year(1). Incidents frequently occur during skiing and snowboarding and are associated with various traumatic injuries that can be severe and even life-threatening(2).

According to the literature, the risk of skiing or snowboarding injuries is increased by high speed, the presence of obstacles on the slope and lack of adequate protection(3-5). Additionally, age, gender and helmet use have repeatedly been described as risk factors for skiing or snowboarding injuries(2, 3, 6). Additionally, other studies focused on one specific type of injury, such as cruciate ligament injuries or lower leg fractures(7-10). However, these studies did not evaluate other potential risk factors such as weather conditions, snow condition, skills level or trauma mechanism(11-15). A general overview of injury patterns in relation to a broader scale of potential intrinsic and extrinsic risk factors is still lacking. In order to optimise preventive measures and to formulate recommendations for prevention of serious injuries, we aimed to provide a comprehensive analysis of injury patterns and their severity, caused by skiing and snowboarding incidents, in relation to patient characteristics and incident circumstances.

MATERIALS AND METHODS

Study design and setting

This retrospective cohort study included injured skiers and snowboarders registered in the database of Eurocross Assistance (ECA), one of the leading medical assistance organizations in the Netherlands. ECA covers approximately 30% of the Dutch health care and travel insurance market. On behalf of several insurance companies, ECA assists insured Dutch citizens who have encountered medical problems abroad. The ECA database includes information provided by the patients themselves, concerning injuries or other medical problems. The data includes demographic information of the subject and detailed information on the injuries. The precise diagnosis and treatment plan of the patient is obtained by the ECA medical team by contacting the local health care providers. In order to obtain data on the circumstances of the incident, all individuals reporting a medical problem related to a skiing or snowboarding incident were requested to fill out a digital questionnaire. Participation did not influence the insurance claim in any way and retrieved information was analysed anonymously. All respondents gave informed consent for use of their data. In case of non-response a reminder was sent after two weeks. All used data was collected, managed and protected by ECA and its privacy agreement.

The study included Dutch patients that reported an Alpine sport related incident to ECA during the Alpine sport seasons 2013-2014, 2014-2015 and 2015-2016. All reported incidents took place in Austria, France, Switzerland and Italy. For this study, only skiing and snowboarding incidents were included. Cases with incomplete information on the medical diagnosis were excluded.

Data

Age, gender, country of injury, hospital admission and diagnoses were obtained from the ECA database. The reported injuries were coded and the Injury Severity Score (ISS) was calculated according to the

Abbreviated Injury Scale (AIS)(16). In case of doubt about classification according to the AIS, the least severe AIS score was chosen in order to avoid overestimation of the injury severity.

In the questionnaire, patients reported on intrinsic circumstances (*e.g.* skills level and previous alcohol consumption) and extrinsic circumstances (*e.g.* type of activity, helmet use, snow and weather conditions, incident location and mechanism) at the time of the incident. We categorised the intrinsic circumstance "skills level" according to the amount of weeks of skiing or snowboarding experience of the respondent. As the average Dutch skier and snowboarder goes skiing, respectively snowboarding, once a year and for one week. we defined a 10 weeks experience as 10 years' experience, and thus a high skills level.

Statistical analysis

All data were anonymised before analysis. Statistical analyses were performed using IBM SPSS Statistics for Windows, version 20.0 (IBM Corp., Armonk, N.Y., USA). Continuous variables are described as mean and standard deviation (SD) and categorical variables as number and percentage. Patient and injury characteristics were compared between the three seasons using ANOVA for normally distributed continuous data, the Kruskall-Wallis test for skewed continuous data, and the Chi-squared test or Fisher's exact test for categorical data. Specific injuries affecting less than 10 patients were excluded, as no conclusion could be drawn due to the lack of power in these groups. Univariate and multivariate logistic regression analysis was used to identify associations between possible risk factors and serious Alpine sport injuries. We defined a serious injury in case of ISS ≥ 9. This cut-off value was chosen to distinguish between the less serious injuries (e.g. contusions or closed bone fractures) and the more serious injuries (e.g. intra-thoracic and intra-abdominal injury). Risk factors for severe injury (ISS>15) were not determined because of the small patient group with an ISS > 15 (n=11). In the multivariate analysis we included variables with a univariate association of p≤0.25 with serious injury (ISS≥9). This

univariate p-value was chosen so the logistic regression analysis would not fail to identify variables known to be of importance(16). Due to the exploratory character of this descriptive observational study no hypothesis or power analysis was pre-specified. P-values <0.05 were considered as statistically significant.

RESULTS

Patient demographics

Of the initially identified 2134 files, 1588 concerned patients who sustained skiing (n=1370, 86.3%) or snowboarding injuries (n=218, 13.7%). Baseline characteristics of skiers and snowboarders are presented in Table 1. The snowboarding group was predominantly male and on average 14 years younger than the snowboarders. Serious injury (ISS ≥ 9) was more common among skiers (10.9% versus 5.5%, p=0.01). Contact information was available for 1395 patients. These subjects received the digital questionnaire, of whom 421 (31%) responded (Table 1). The patients with no available contact information were considered as non-respondents. Comparison of respondents with non-respondents showed that the response rate among skiers and snowboarders was comparable (26.9% and 24.3%, respectively). Most respondents were female and slightly older than the non-respondents (37.7 vs. 41.2 years on average; p<0.001). Skiing was the most frequently performed activity in both groups. The respondents group was more often admitted to the hospital and the ICU, although no difference in injury severity was found between the two groups (Table 1).

Skiing and snowboarding injuries

Differences in the specified injury distribution of the skiers and snowboarders are shown in Table 2.

Knee injuries, pelvic fractures, femur fractures and lower leg fractures were more frequent in skiers, while brain concussions, spleen injuries, thoracic spine fractures and lower arm fractures were more frequently seen in snowboarders.

Risk factors for serious injury

A serious injury was present in 44 of the 421 patients that filled out the questionnaire (10.5%). Five potential risk factors for serious injury were entered in the multivariate model (*i.e.* age, skills level, helmet use, alcohol consumption and time of trauma) (Table 3). None of these were statistically significant, but skills level showed a trend in predicting serious injury, where the risk in the group with more than 10 weeks experience was borderline significant compared to the group with less than 5 weeks experience (odds ratio: 4.00; 95% confidence interval: 0.86-18.50; p=0.08) in the multivariate logistic regression analysis (Table 3). In addition, a trend in predicting a less serious injury was seen in the age-group of 19-59 years compared to the group ≤ 18 years (odds ratio: 0.41; 95% confidence interval: 0.15-1.11; p=0.09). We also analysed helmet use as risk factor for serious injury separately in the subgroup of respondents with head injuries. A total of 12 respondents sustained a head injury of which 11 respondents whore a helmet during the accident. Six of the helmet users (55%) and the one non-helmet user were not seriously injured (ISS<9).

DISCUSSION

To our knowledge, this is the first study to more broadly investigate the nature and severity of skiing and snowboarding injuries in relation to their potential risk factors among skiers and snowboarders.

This study identified differences in injury patterns and injury severity between skiers and snowboarders. Pelvic and lower extremity injuries, such as knee joint injuries, femur and lower leg fractures occurred more often amongst skiers, in line with other recent studies(17, 18). This may be explained by the fact

that skiers are more prone to rotational injuries, as their legs are individually fixed in a ski-boot and on separate skies(19). Previous research showed that wrist injuries are more common among snowboarders(17). A plausible explanation is that when falling backwards with both legs fixed on a snowboard, the natural reflex is to break the fall using one's extended arms. Our results furthermore show that snowboarders sustained more brain concussions, more thoracic spine injuries, spleen injuries and lower arm injuries, compared to skiers. These results are partly supported by the study of de Roulet et al(2), who also showed that more spleen injuries are sustained by snowboarders. However, their results did not show that snowboarders sustained more brain concussions, thoracic spine injuries or lower arm injuries. This might be due to the fact that, contrary to our study which includes both inpatients and patients treated in an outpatient setting, Roulet's study included only hospitalised patients thus excluding respondents with minor brain concussions, minor thoracic spine injuries (*e.g.* contusion) or lower arm injuries, who generally do not need hospitalisation. Regarding the differences between the respondents and the non-respondents group, the respondents group that responded to the questionnaire was more often admitted to the hospital and the ICU than the non-respondents group. More severe injuries might explain a longer inpatient treatment in the respondents group. However, our results do not confirm this (ISS= 4.3 vs ISS=4.4), indicating that even though some baseline characteristics differed between the respondents and non-respondents group, the severity of the injuries was comparable. As our study focuses mainly on the nature and the severity of the injuries, the respondents group was considered suitable to perform a risk analysis.

Risk analyses performed in other studies showed that male gender, a younger age(6), a higher skills level(20), less daily snowfall and injury sustained by a collision instead of a fall, are associated with more severe injuries(21). Our study, however, failed to replicate these findings. This might be attributable to the small group of seriously injured patients (ISS ≥ 9, n= 44). Serious injury was more often found among skiers (p=0.01). The risk analysis suggested that serious injury might be associated with age and skills

level. In the analysis, adults (19-59 years) seemed less at risk for serious injuries than children and adolescents under the age of 18 years. The trend in skills level indicated that more experienced skiers and snowboarders may be at higher risk for more serious injuries. This may be explained by the fact that more experienced individuals tend to acquire more speed during their activity, thus increasing the risk for high-impact injury. A second explanation may be that people with higher skills level tend to show increased risk taking behaviour. These hypotheses are supported by multiple studies which showed that a higher skills level is an independent risk factor for both a higher average mean speed and more risk-taking behaviour(22-24).

Our study has several limitations. First, although the respondents group was considered representative for the entire study population regarding the two main topics of this study, (i.e., injury severity and skiing/snowboarding), the response rate to the questionnaire was low (31%). There are several potential explanations for the low response rate. The patients may have mistaken the ECA for the insurance company that collaborates with ECA. This may have negatively influenced the response rate, despite the explicit explanation that participation would not influence the insurance claim in any way. Furthermore, it is possible that the response rate was low due to the retrospective design of this study which resulted in patients who did not remember the accident and thus did not respond. Regarding the second limitation, it is reasonable to assume that no significant results were found in the risk-analysis due to the sample size of the group of respondents with ISS ≥ 9 (n=44). In addition, in the risk analysis we did not include a measure for the level of physical fitness. A recent study of Muller et al(25) showed that young competitive ski racers who are above average physically fit sustain less serious injuries. Even though no literature is, to our knowledge, available about the level of physical fitness associated with Alpine sport injuries, it is reasonable to assume that individuals who are less fit will be prone to more serious injuries. The underlying hypothesis is that less fit individuals have less stamina and that they are not used to the intensity of Alpine sport activities. Finally, also the risk of recall bias cannot be ruled out due to the

retrospective design of this study. It is possible that respondents that were more seriously injured had a better memory of the circumstances of the accident, given the greater impact.

The main strength of this study is that it presents a complete overview of injury patterns and potential risk factors associated with Alpine sport injuries. Unfortunately, this study failed to identify risk factors as a result of the small number of respondents in the risk-analysis. Further research on this topic should include larger study groups, preferably using a prospective study design. Inclusion of a measure for physical fitness, risk-taking behaviour and speed would further improve the quality of future studies, as these factors are found to be associated with more severe injuries(22, 23, 26).

In conclusion, skiers are more prone to pelvic and lower extremity injuries, while snowboarders are more prone to brain concussion, thoracic spine injuries, spleen injuries and lower arm injuries. Social awareness should be raised for these different types of injury patterns in order to promote the use of specific preventive measurements. Further, a higher skills level seems to be a risk factor for serious injuries. We would recommend individuals with high skills levels to take into consideration the increased risk of severe injury that comes along with high speed and to be aware of their behaviour on the slopes.

CONTRIBUTORSHIP STATEMENT

K.A. Bartlema and F.S. Luppino contributed to the design of the research. S.C. Maat and S. Groene contributed to the data collection. S.C. Maat and P. Krijnen contributed to the analysis of the results. S.C. Maat, P. Krijnen, F.S. Luppino, I.B. Schipper and K.A. Bartlema contributed to interpretation of the results. S.C. Maat contributed to writing the manuscript. P. Krijnen, F.S. Luppino, I.B. Schipper and K.A. Bartlema commented on the manuscript.

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COMPETING INTERESTS STATEMENT

S.C. Maat, F.S. Luppino, I.B. Schipper, P. Krijnen and K.A. Bartlema declare that they have no conflict of interest.

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ETHICAL APPROVAL

The principles of the World Medical Association's Declaration of Helsinki do not apply to retrospective cohort studies. Therefore, no ethical approval was required. All respondents gave informed consent for use of their data.

REFERENCE

1. Statistics Netherlands (CBS). Trend report tourism, recreation and leisure. 2016.
2. de Roulet A, Inaba K, Strumwasser A, Chouliaras K, Lam L, Benjamin E, et al. Severe injuries associated with skiing and snowboarding: A national trauma data bank study. Journal Trauma Acute Care Surgery. 2017;82(4):781-6.
3. McBeth PB, Ball CG, Mulloy RH, Kirkpatrick AW. Alpine ski and snowboarding traumatic injuries: incidence, injury patterns, and risk factors for 10 years. Am J Surgery. 2009;197(5):560-3.
4. Xiang H, Kelleher K, Shields BJ, Brown KJ, Smith GA. Skiing- and snowboarding-related injuries treated in U.S. emergency departments, 2002. Journal Trauma. 2005;58(1):112-8.
5. Wijdicks CA, Rosenbach BS, Flanagan TR, Bower GE, Newman KE, Clanton TO, et al. Injuries in elite and recreational snowboarders. Br Journal Sports Medicine. 2014;48(1):11-+.
6. Basques BA, Gardner EC, Samuel AM, Webb ML, Lukasiewicz AM, Bohl DD, et al. Injury patterns and risk factors for orthopaedic trauma from snowboarding and skiing: a national perspective. Knee Surgery, Sports Traumatology, Arthroscopy : official journal of the ESSKA. 2016.
7. Ruedl G, Ploner P, Linortner I, Schranz A, Fink C, Patterson C, et al. Interaction of potential intrinsic and extrinsic risk factors in ACL injured recreational female skiers. Int J Sports Med. 2011;32(8):618-22.
8. Ruedl G, Webhofer M, Linortner I, Schranz A, Fink C, Patterson C, et al. ACL injury mechanisms and related factors in male and female carving skiers: a retrospective study. Int J Sports Med. 2011;32(10):801-6.

9. Burkner A, Simmen HP. [Fractures of the lower extremity in skiing - the influence of ski boots and injury pattern]. Sportverletzung Sportschaden : Organ der Gesellschaft Orthopadisch-Traumatologische Sportmedizin. 2008;22(4):207-12.
10. Patton A, Bourne J, Theis JC. Patterns of lower limb fractures sustained during snowsports in Otago, New Zealand. New Zealand Medical Journal. 2010;123(1316):20-5.
11. Moore SJ, Knerl D. Let it snow: How snowfall and injury mechanism affect ski and snowboard injuries in Vail, Colorado, 2011-2012. Journal Trauma Acute Care Surgery. 2013;75(2):334-8.
12. Ogawa H, Sumi H, Sumi Y, Shimizu K. Skill level-specific differences in snowboarding-related injuries. Am Journal Sports Medicine. 2010;38(3):532-7.
13. Brooks MA, Evans MD, Rivara FP. Evaluation of skiing and snowboarding injuries sustained in terrain parks versus traditional slopes. Injury Prevention: Journal International Society Child Adolescent Injury Prevention. 2010;16(2):119-22.
14. Hume PA, Lorimer AV, Griffiths PC, Carlson I, Lamont M. Recreational Snow-Sports Injury Risk Factors and Countermeasures: A Meta-Analysis Review and Haddon Matrix Evaluation. Sports Medicine (Auckland, NZ). 2015;45(8):1175-90.
15. Rust DA, Gilmore CJ, Treme G. Injury patterns at a large Western United States ski resort with and without snowboarders: the Taos experience. American Journal Sports Medicine. 2013;41(3):652-6.
16. Bursac Z, Gauss CH, Williams DK, Hosmer DW. Purposeful selection of variables in logistic regression. Source Code Biology Medicine. 2008;3:17.
17. Coury T, Napoli AM, Wilson M, Daniels J, Murray R, Milzman D. Injury patterns in recreational alpine skiing and snowboarding at a mountainside clinic. Wilderness Environmental Medicine. 2013;24(4):417-21.
18. Castellani C, Singer G, Kaiser M, Petnehazy T, Wernitznigg D, Kaulfersch C, et al. An epidemiologic analysis of winter sport accidents on ski slopes comparing two seasons. Journal Sports Medicine Physical Fitness. 2018.
19. Bohm H, Senner V. Effect of ski boot settings on tibio-femoral abduction and rotation during standing and simulated skiing. Journal Biomechanics. 2008;41(3):498-505.
20. Goulet C, Hagel B, Hamel D, Legare G. Risk factors associated with serious ski patrol-reported injuries sustained by skiers and snowboarders in snow-parks and on other slopes. Can J Public Health. 2007;98(5):402-6.
21. Moore SJ, Knerl D. Let it snow: how snowfall and injury mechanism affect ski and snowboard injuries in Vail, Colorado, 2011-2012. The journal of trauma and acute care surgery. 2013;75(2):334-8.
22. Ruedl G, Sommersacher R, Woldrich T, Kopp M, Nachbauer W, Burtscher M. [Mean speed of winter sport participants depending on various factors]. Sportverletzung Sportschaden : Organ der Gesellschaft Orthopadisch-Traumatologische Sportmedizin. 2010;24(3):150-3.
23. Ruedl G, Abart M, Ledochowski L, Burtscher M, Kopp M. Self reported risk taking and risk compensation in skiers and snowboarders are associated with sensation seeking. Accident; Analysis Prevention. 2012;48:292-6.
24. Thomson CJ, Carlson SR. Increased patterns of risky behaviours among helmet wearers in skiing and snowboarding. Accident; Analysis Prevention. 2015;75:179-83.
25. Muller L, Hildebrandt C, Muller E, Fink C, Raschner C. Long-Term Athletic Development in Youth Alpine Ski Racing: The Effect of Physical Fitness, Ski Racing Technique, Anthropometrics and Biological Maturity Status on Injuries. Front Physiol. 2017;8:656.
26. Schneiders W, Rollow A, Rammelt S, Grass R, Holch M, Serra A, et al. Risk-inducing activities leading to injuries in a child and adolescent population of Germany. Journal Trauma. 2007;62(4):996-1003.

Table 1. Characteristics of patients with Alpine sport-related injuries by response to the questionnaire

	All patients	Skiers	Snowboarders	p-value	Non- respondents	Respondents	p-value
All patients, n(%)	1588 (100)	1370 (85.3)	218 (13.6)	-	1167 (73.5)	421 (26.5)	-
Activity, n(%)							0.43
Skiing					1002 (85.9)	368 (87.4)	
Snowboarding					165 (14.1)	53 (12.6)	
Sex (male), n(%)	818 (51.5)	674 (49.2)	144 (66.1)	<0.001	632 (54.2)	186 (44.2)	<0.001
Age, mean (SD)	38.6 (17.7)	40.5 (17.7)	26.6 (11.7)	0.00	37.7 (17.5)	41.2 (17.9)	0.00
Age group, n(%)							
< 18	277 (17.4)	214 (15.6)	63 (28.9)	0.00	214 (18.3)	63 (15.0)	0.02
19-59	1100 (69.3)	949 (69.3)	151 (69.3)		813 (69.7)	287 (68.2)	
>60	211 (13.3)	207 (15.1)	4 (1.8)		140 (12.0)	71 (16.9)	
Country, n(%)							
Austria	1157 (72.9)	1017 (74.2)	140 (64.2)	<0.001	856 (73.4)	301 (71.5)	0.70
France	244 (15.4)	191 (13.9)	53 (24.3)		173 (14.8)	71 (16.9)	
Switzerland	84 (5.3)	69 (5.0)	15 (6.9)		60 (5.1)	24 (5.7)	
Italy	103 (6.5)	93 (6.8)	10 (4.6)		78 (6.7)	25 (5.9)	
Hospital admission, n(%)	892 (56.2)	762 (55.6)	130 (59.6)	0.44	624 (53.5)	268 (63.7)	0.001
ICU admission, n(%)	40 (2.5)	34 (2.5)	6 (2.8)	0.81	23 (2.0)	17 (4.0)	0.03
ISS-total, mean (SD)	4.4 (4.1)	4.5 (3.9)	4.2 (5.3)	0.72	4.5 (4.6)	4.4 (2.4)	0.64
ISS group, n(%)							
<9	1426 (89.8)	1220 (89.1)	206 (94.5)	0.01	1049 (89.9)	377 (89.5)	0.85
≥9	162 (10.2)	150 (10.9)	12 (5.5)		118 (10.1)	44 (10.5)	

Table 2. Distribution of specific types of injury within anatomical region, after skiing or snowboarding

Type of injury	Skiing (n=1370)	Snowboarding (n=218)	P-value
Head/neck, n(%)			
Brain[1]	14 (1.0)	1 (0.5)	0.42
Concussion	119 (8.8)	34 (15.7)	0.002
Face			
Facial bone fracture	23 (1.7)	2 (0.9)	0.56
Thorax			
(Hemo)pneumothorax	23 (1.7)	3 (1.4)	1.00
Rib fracture	54 (4.0)	5 (2.3)	0.33
Rib contusion	22 (1.6)	6 (2.8)	0.26
Abdomen			
Kidney[2]	8 (0.6)	3 (1.4)	0.19
Spleen[2]	7 (0.5)	4 (1.8)	0.05
Spinal fracture			
Cervical	8 (0.6)	3 (1.4)	0.19
Thoracic	35 (2.6)	11 (5.1)	0.05
Lumbar	50 (3.7)	8 (3.7)	0.59
Upper extremity			
Muscles/tendons	11 (0.8)	2 (0.9)	0.70
Shoulder/AC-luxation	83 (6.1)	19 (8.8)	0.18
Upper arm fracture	210 (15.5)	40 (18.4)	0.27
Lower arm fracture	73 (5.4)	35 (16.1)	<0.0001
Lower extremity			
Muscles/tendons	23 (1.7)	3 (1.4)	0.51
Knee joint / ligaments / meniscus	276 (20.4)	16 (7.4)	<0.0001
Other joints	24 (1.8)	3 (1.4)	0.48
Femur fracture	72 (5.3)	1 (0.5)	<0.0001
Lower leg fracture	371 (27.5)	25 (11.5)	<0.0001
Pelvic fracture	62 (4.6)	4 (1.8)	0.04

[1]: Brain injury: including nerve, vascular, cerebral, cerebellar injury

[2]: Including: Hematoma, contusions or lacerations

Table 3. Univariate and multivariate analysis of risk factors for serious injury (ISS ≥9).

	Univariate analysis			Multivariate analysis	
	ISS<9	ISS≥9	p-value	Odds Ratio (95%CL)	p-value
Total	377 (89.5)	44 (10.5)	-		
Activity					
Skiing	328 (87.0)	40 (90.9)	0.46	Not entered	
Snowboarding	49 (13.0)	4 (9.1)			
Gender					
Male	166 (44.0)	20 (45.5)	0.86	Not entered	
Female	211 (56.0)	24 (54.5)			
Age					
< 18	55 (14.6)	8 (18.2)	0.20	[Reference]	
19-59	262 (69.5)	25 (56.8)		0.41 (0.15-1.11)	0.09
≥ 60	60 (15.9)	11 (25.0)		0.90 (0.29-2.82)	0.85
Skills level					
0-5 weeks	52 (14.6)	2 (5.1)	0.22	[Reference]	
5-10 weeks	56 (15.8)	5 (12.8)		2.67 (0.49-14.75)	0.26
>10 weeks	247 (69.6)	32 (82.1)		4.00 (0.86-18.50)	0.08
Alcohol consumed					
No (n=405)	354 (99.4)	37 (97.4)	0.16	[Reference]	
Yes (n=4)	2 (0.6)	1 (2.6)		8.65 (0.65-116.06)	0.10
Fall					
Fallen from standing position	33 (9.2)	5 (13.2)	0.70	Not entered	
Collision	68 (18.5)	7 (18.4)			
Fallen while skiing/snowboarding	267 (72.6)	26 (68.4)			
Helmet use					
No	39 (10.9)	7 (17.9)32	0.17	[Reference]	
Yes	319 (89.1)	31 (82.1)		0.51 (0.20-1.33)	0.17
Location on slope					
Middle of the slope	273 (84.8)	29 (87.9)	0.50	Not entered	
Crossing of slopes	30 (9.3)	1 (3.0)			
At ski-lift exit	19 (5.9)	2 (6.3)			
Kind of slope					
Easy (Green + Blue)	167 (47.4)	19 (54.3)	0.44	Not entered	
Advanced (Red + Black)	185 (52.6)	16 (45.7)			
Weather condition					
Cloudy	90 (26.2)	12 (30.8)	0.89	Not entered	
Foggy	30 (8.7)	4 (10.3)			
Snowing	15 (4.4)	2 (5.1)			
Sunny	209 (60.8)	21 (53.8)			
Time of accident					
After 13:00 pm	139 (39.6)	20 (51.3)	0.22	1.31 (0.65-2.63)	0.45
Before 13.00 pm	212 (60.4)	19 (48.7)		[Reference]	
Day of accident					
Before third vacation day	214 (60.1)	21 (53.8)	0.45	Not entered	
After third vacation day	142 (39.9)	18 (46.2)			