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Personal and Environmental Factors in Relation to Injury Risk in Downhill Skiing

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Abstract

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A case-control study was conducted among Dutch downhill skiers. This article presents data on the circumstances of the accident leading to injury and on personal and environmental risk factors for both cases ($n = 572$) and controls ($n = 576$). Most accidents (84%) happened on the pistes and ski lifts were involved in about 6% of them. Bad condition of the ski run (30%) and lost balance (24%) were the direct causes most frequently mentioned. Risk seemed to be constant for particular days and moments of the day. Injury risk for the individual appeared to rise with increasing duration of exposure, although very small durations had an elevated risk as well. A relatively low risk was observed for skiers who reported to be only moderately rested ($OR = 0.4$) and for those who admitted a certain fear of having a ski accident ($OR = 0.6$). A relatively high risk was observed for the presence of icy spots ($OR = 1.4$), while poor visibility ($OR = 0.4$), the presence of clouds ($OR = 0.5$), and perceived coldness ($OR = 0.5$) were associated with a relatively low injury risk. No recommendations for prevention can be based on these results. Most factors mentioned are not open to manipulation and further quantification should involve prospective study designs and independent measurements of these factors.

Key words

downhill skiing, injury, risk factor, weather, snow quality, fear, education, menstruation

Introduction

Much has been written about the risks of downhill skiing in recent decades. Most authors agree that nowadays the incidence of serious injury needing substantial medical treatment ranges between 2 and 4 per 1000 skier days (15, 26, 32). Although a large number of potential risk factors are mentioned in the literature, only a small number of studies have been aimed at quantifying the effect of these factors on the injury risk of downhill skiing (6). The inclusion of a comparable control group of uninjured skiers is still not common practice and an adequate multivariate analysis of the data is almost never performed (20).

During the 1984/1985 season, a case-control study was conducted among Dutch skiers (6–10). In this study information was collected concerning a broad spectrum of putative risk factors. This article focusses firstly on the circumstances directly prior to injury for which no meaningful information can be gathered from the controls. Secondly, data on several personal and environmental factors for both cases and controls will be presented. Data presented on personal factors will include smoking, sleeping, education, menstruation, fear of an accident, and duration of period at risk. The section on environmental factors will include snow quality, visibility, marking of pistes, perceived temperature, and cloud cover.

Methods

Cases and controls during the 1984/1985 season were obtained from the records of a company covering roughly one-third of the market for ski insurance in the Netherlands. Most Dutch skiers are insured. The cases selected were skiers who had filed claims for medical costs as a result of a ski injury that made skiing or other activities impossible for more than 1 day. For every case of injury selected, an equal number of uninjured skiers was chosen by taking the next claim from an uninjured skier, received by the insurance company for other reasons (e. g., loss or theft). A postal questionnaire was sent shortly after the ski holiday to the population thus defined.

Data analysis was performed in two stages with the aid of BMDP and GLIM statistical software (1, 12). First an elementary analysis was performed in which confounding by age and gender was adjusted for. For categorical variables, odds ratios (OR) were calculated as a weighted average over the six strata for age and gender, using the Mantel-Haenszel method with the test-based 95% confidence interval (CI) fol-

lowing the method of Miettinen (19). The second stage of data analysis concerned a more complete control for confounding and first-order interaction. For this purpose, a logistic model (19) was fitted. In the final model, 20 variables remained and 12 interaction terms were concluded. From the logistic regression coefficients in this model, adjusted odds ratios with their approximate 95% confidence intervals were calculated (19).

Results

Response

Response was well over 80% and about the same for cases (84%) and controls (82%). Data on 1148 downhill skiers were analyzed consisting of 572 cases and 576 controls. Between cases and controls slight differences in age and a rather strong difference in gender distribution were found. Mean age for the cases was 32.0 years and for the controls 32.6 years. This is similar to the mean age (32.1 years) of active skiers among a representative sample of the Dutch population (11). Of all the cases 46% were males compared with 67% of the controls. Among a representative sample of the Dutch population females appeared to participate in winter sports as often as males (11). In our opinion, these figures reflect selection bias due to the way the controls were chosen. The consequence is that the risks associated with age and gender cannot be estimated from our study. For the same reason every odds ratio presented is adjusted for confounding by age and gender.

Circumstances

During their holiday, the cases in our study had been skiing on average for 4 days prior to the day of the accident leading to injury. The data show a similar distribution for males and females. Females skied on the average 2.4 h and males 2.7 h prior to the accident on the same day. The majority (about 84%) of the accidents happened on the pistes. Ski lifts were involved in 4% of the male and 7% of the female cases of injury. About one-third of the cases mentioned a high or a very high velocity directly prior to the accident leading to injury, while about 7% were standing still at that moment. The injury originated during a ski lesson for 10% of the males and 17% of the females. Half of the cases was descending (free skiing), while 24% of the males and 16% of the females was going straight downhill (schuss) directly prior to the accident leading to injury.

A quarter of the female and one-third of the male cases of injury attributed their accident to the bad condition of the ski run. Another quarter of the cases mentioned loss of balance as a direct cause, while some 10% got stuck in a snow wall. Only 2% reported a collision with an object, but 4% of the males and 8% of the females collided with another skier. Premature release of binding was mentioned as a direct cause by almost no one.

Personal Factors

The skiers in our study were on the average 175 cm tall and weighed about 70 kg. Cases were slightly smaller and lighter. Although no differences were found in mean Quetelet index (24.2), underweight skiers ($QI \leq 20$) appeared to have an elevated risk ($OR = 1.8$; $CI = 1.2-2.7$) compared

Fig. 1 Odds ratios from the logistic model with 95% confidence interval bounds for planned number of hours of skiing during holiday.

with the other skiers. Although cases skied daily on average 12 min shorter than the controls, their planned number of hours skiing during the holiday was slightly higher (53 vs 51 h). This was due to the fact that the planned duration of the holiday of the cases was on the average a half day longer. This does not imply that the relative risk of injury is uniform for all levels of duration of exposure. Fig. 1 shows the odds ratios at different levels calculated from the logistic model. As expected, relative risk rises with increasing duration of exposure, although not monotonically. The higher risk for a short duration of exposure is much more pronounced when unadjusted data are taken, probably because beginners (who have a higher risk) ski less.

Some 90% of the skiers usually felt rested. Surprisingly, the risk of injury was lower among those who reported to be only moderately rested (Table 1). The same effect appeared in the logistic model. This agrees with the fact that cases slept on the average 9.5 h prior to the day of the accident, while controls slept on the average 8.6 h prior to the penultimate day on which one skied.

No clear effect of menstruation on injury risk could be detected (Table 1). Respondents who admitted to having been slightly afraid of an accident before their holiday appeared to have a lower injury risk compared with those who said they were not afraid (Table 1). This effect is also shown in the logistic model. More highly educated skiers tended to have lower injury risk, while smokers (on the average 13 cigarettes a day) appeared to have higher injury risk (Table 1). The latter effect was even more pronounced in the logistic model ($OR = 1.7$; $CI = 1.2-2.6$).

Environmental Factors

Most skiers (86%) had the opinion that the pistes were well marked (Table 2). Items concerning the environmental conditions deal with the day of the accident leading to injury for the cases and with the penultimate day on which one skied for the controls. The presence of icy spots was associated with an elevated injury risk. This association also

Table 1 Some personal risk factors for cases and controls

	Cases ^f	Controls ^f	OR ^g	CI ^h
Feeling rested ^a				
Good	94 %	86 %	1.0	
Moderate	6 %	12 %	0.4	0.3–0.7
During menstruation ^b				
No	85 %	87 %	1.0	
Yes	15 %	13 %	1.2	0.6–2.5
Afraid of an accident ^c				
Not afraid	87 %	80 %	1.0	
Slightly afraid	13 %	19 %	0.6	0.4–0.8
Very afraid	0 %	1 %		
Education ^d				
University or higher professional education	28 %	35 %	1.0	
Other education	72 %	65 %	1.4	1.1–1.8
Smoking ^e				
Nonsmoker	56 %	63 %	1.0	
Smoker	44 %	37 %	1.4	1.1–1.8

^a On the day of the accident for cases and on the penultimate day on which one skied for controls

^b Among women having menstrual periods

^c Before the ski holiday

^d Highest education successfully concluded

^e During the year before the ski holiday

^f Percentage based on direct standardization (6 strata) for age and gender

^g Odds ratio as weighted average over 6 strata for age and gender (Mantel-Haenszel)

^h Test-based 95 % confidence interval (Miettinen)

shows within the logistic model. No influence of the thickness of snow could be detected. The risk of injury appeared to be higher on cloudless days (Table 2). This agrees with the observation that good visibility was associated with a higher injury risk. More than 30 % of the cases called the day of the injury a (slightly) cold day, while almost half of the controls thought the same of the arbitrarily chosen day. The preventive effect of perceived coldness appeared also in the logistic model.

Discussion

The circumstances of the accident leading to injury mentioned by our cases are in reasonable agreement with earlier studies. Our data confirm that most accidents (84 %) happen on the pistes (3, 30) and that ski lifts are involved in about 6 % of the accidents leading to injury (13, 18, 23–25, 28). In our study collisions with an object (2 %) were mentioned less often than in other studies (14, 17, 21, 24, 25, 27, 29). Premature release of binding was hardly mentioned by our respondents as a direct cause of injury. Compared with Shealy's (26) study, many more skiers were taking a ski lesson at the moment of the accident. This does not mean that ski lessons are dangerous. On the contrary, elsewhere (8) it is suggested from our data that ski lessons have an important protective effect among beginners. Our data on the moment of the accident leading to injury seems consistent with the hypothesis that the risk is constant over time (14, 16, 31).

The observation that injury risk generally rose the greater number of hours of skiing planned during the holiday is certainly not implausible. The elevated risk among those who planned to ski only for a very short period can be ex-

Table 2 Some environmental risk factors for cases and controls

	Cases ^c	Controls ^c	OR ^d	CI ^e
Marking of pistes ^a				
Good	87 %	86 %	1.0	
Moderate	11 %	12 %	0.9	0.6–1.4
Bad	1 %	2 %		
Snow quality ^b				
Fresh snow	26 %	30 %	1.0	
Old snow	33 %	33 %	1.2	0.9–1.7
Icy Spots	39 %	34 %	1.4	1.0–1.9
Wet snow	1 %	3 %		
Thickness of snow ^b				
Sufficient	45 %	40 %	1.0	
Ground or rocks at some places	55 %	60 %	0.8	0.6–1.1
Visibility ^b				
Good	85 %	68 %	1.0	
Poor	15 %	32 %	0.4	0.3–0.7
Cloudiness ^b				
Cloudless	63 %	48 %	1.0	
Partly cloudy	20 %	25 %	0.7	0.5–0.7
Cloudy	17 %	27 %	0.5	0.4–0.7
Temperature ^b				
Not cold	68 %	51 %	1.0	
Slightly cold	19 %	29 %	0.5	0.4–0.7
Cold	13 %	19 %	0.6	0.4–0.7

^a In general during the ski holiday

^b On the day of the accident for cases and on the penultimate day on which one skied for the controls

^c Percentage based on direct standardization (6 strata) for age and gender

^d Odds ratios as weighted averages over 6 strata for age and gender (Mantel-Haenszel)

^e Test-based 95 % confidence interval (Miettinen)

plained by assuming a somewhat higher risk during the first hours due to the fact that the skier has to get used to skiing again. Dutch skiers are holidays skiers usually skiing only once a year. Our data confirm the opinion (4) that skiers sleep more than enough. The preventive effect of feeling only moderately rested has not been reported before and is difficult to interpret. This could be thought to concur with the hypothesis that relaxed skiers tend to underestimate the risks. The observation that being afraid of an accident before the holiday has a preventive effect could also be due to risk underestimation by fearless skiers. Something analog can be hypothesized to explain the finding that smokers and less highly educated skiers had an higher injury risk.

Our data confirm the elevated injury risk reported by Lamont (22) when icy spots were present. We could also confirm the relatively high accident risk during good skiing weather (cloudless, not cold, and good visibility) described by others (2, 4, 5, 22). Because our study lacks objective meteorological information, we must be careful in drawing conclusions from this. The way these questions were put guaranteed that both cases and controls skied on the day to which these answers refer, but it cannot be excluded that skiers skied fewer hours and/or took less difficult ski runs on days of less favorable weather. Another alternative explanation would be that skiers are more careful under suboptimal weather conditions.

Taken together the results presented in this article do not lead to firm recommendations with respect to prevention of ski injury. This is primarily due to the fact that by their own nature most of the personal and environmental risk factors discussed are not open to manipulation. Furthermore, it appears that the existing small empirical basis for the risks associated with some of these factors could not be confirmed by our data. Further studies should have a prospective design (for the personal factors especially) and/or should use independent objective information (for the environmental factors especially).

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