Recorded Speed on Alpine Slopes: How to Interpret Skier's Perception of Their Speed?

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Abstract The speed before the accident is a necessary data to understand the injury mechanisms and to evaluate means of protection. In order to interpret the reported speed of a skier in an accident survey, this study aims to identify the governing factors of skiing speed and to propose ranges of speed combining the identified factors and the skiers' perception of their speed. Travelling speed of 1399 skiers and snowboarders was measured with a radar speed gun. Gender, sport, helmet use, skill level, difficulty, and preparation of the slope were recorded. 170 recorded skiers were interviewed about their age, their skill level, their perceived speed ("slow to medium," "high," or "too high"), and their estimated speed (km/h). Linear regression models were used to evaluate the effect of each factor on skiing speed. The mean recorded speed was 43.4 (±15.2) km/h. It was 37.5 (±9.8) km/h when the perceived speed was "low to medium" and 49.0 (±14.6) km/h when the perceived speed was "high." The factors best explaining skiing speed were the skill level ($\eta^2 = 0.26$) and the slope difficulty ($\eta^2 = 0.19$). Gender, age, sport, and slope preparation were found to have a small but significant effect ($\eta^2 < 0.1$; $p < 0.05$). Those factors also influenced the speed perception: for the same perceived speed, "less skilled" skiers and skiers on easy slope tended to go on average 6 km/h and 8 km/h slower than the "more skilled" and those on medium slope, respectively. Finally, skiers estimated their measured speed fairly (*r*: 0.53). They tended to overestimate the speed when they went slower than 35 km/h but underestimated it at higher speed. Ranges of speed were obtained regarding perceived speed, skill level, and difficulty of the slope. This should be considered when interpreting skiers' evaluation of their speed in accidents reports.

Keywords Ski • Snowboard • Speed • Speed perception

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1 Introduction

Each year approximately 150,000 ski and snowboard-related injuries are treated in a French medical centers [1]. One of the main factors affecting the kinematic of the accident and the injury severity is the speed of the participant prior to the accident [2, 3]. Indeed, the energy involved in the accident and the kinematic of the fall are related to the speed of the participant before the accident. In order to investigate these injury mechanisms, it is necessary to develop a robust understanding of skiing speed just before the crash. That understanding is also useful to evaluate means of protection such as ski helmets and protection mats whose effectiveness depends on the impact speed and the energy involved in the accident. In epidemiological study, the only available data on skiing speed before the accident, is the victims' perception of their own speed [1, 3]. To access skiing speed before the crash, a translation between the perceived speed and the measured speed is therefore necessary.

In order to propose such a translation, understanding the factors influencing skiing speed and its perception is crucial. Shealy et al. [4] and later Rueld et al. [5] showed that sport, gender, skill level, age, and risk-taking behavior might affect both skiing speed and the ability of the skiers to estimate their speed. Recently, Brunner et al. [6] also revealed that the skier's perception of their speed might also depend on those factors. However, those studies were conducted on the same kind of slopes (medium difficulty); therefore, the difficulty and preparation of ski slope were never considered as factors influencing skiing speed.

2 Objective

This study investigates the measured speed on alpines slope and its perception. The first objective is to identify the factors having the greatest effect on skiing speed. The second objective is to obtain the range of speed regarding those identified factors and skier's perception of their speed.

3 Materials/Methods

3.1 First Investigation: Evaluation of the Factors Not Related to the Perception of the User

The objective of this first investigation is to identify the factors best explaining the skiing speed. Using a discreet radar speed gun with an accuracy of ±2 km/h (Pocket radar, Pocket Radar, Inc., Santa Rosa, California), speed measurements were performed in three different French ski resorts [Grand Bornand (n = 158), La Clusaz (n = 747), and Courchevelle (n = 494)], during five full days of the 2013/2014

French winter holidays. A trained observer standing in the skier's way measured the skiing speed during their approach. The radar we used only measured subjects moving in line with the radar beam which was not always the case of the skier because of the turn performed. This might lead to an underestimation of the actual speed. In order to limit that underestimation, the speed of the skier was measured during an observation period of three or four turns, and only the maximum speed was recorded. The observer also recorded helmet use and estimated the gender, and the skill level of the skier. The evaluation of the skill level was performed by the same trained observer according to criteria defined by Sulheim et al. [7]. The speed of 1399 skiers and snowboarders was recorded on wide slopes of different difficulties rated according to the European classification of ski slopes: green (very easy), *blue* (easy), *red* (medium), and *black* (hard) and of different preparations (well-groomed or bumpy). The "bumpy" slopes were slopes left ungroomed during several days, where some small moguls had appeared. The bumpy slopes selected in this study were *blue* (84 recorded users) and *black* (62 recorded users). Those slopes were busy because it was the middle of the peak season and the weather was sunny. As much as possible, the speed measurement was performed on consecutive skiers and snowboarders.

3.2 Second Investigation: Combining the Identified Factors with Perception of the User

Based on the identification of the most important factors influencing skiing speed, a second investigation was conducted. The aim was to combine those identified factors with the users' perception of their speed. 200 randomly selected measured skiers and snowboarders were stopped and interviewed by a research assistant at the bottom of the ski slope. The assistant recorded the gender, age, helmet use, sport, as well as the skiers' self-estimation of their skill level (beginner, intermediate, or advanced). Users were then showed the observation area where they had been measured and were asked to estimate their perceived speed (low to medium, high, or too high) and their measured speed (km/h). The measured speed was transmitted to the research assistant by walkie-talkie and was also recorded. This method is very similar to the one described on medium slopes by Shealy et al. [4] and Rueld et al. [5]. In our second investigation, the slopes selected were large red (medium) and *blue* (easy) because the first investigation had showed that red and *blue* slopes differ in typologies of skill level and speed of the participants and because those are the slopes where most accident occur [8].

Due to the small number of interviewed snowboarders ($n = 24$), only skiers were included in the statistical analysis. In the same way, the speed categories "high" and "too high" were grouped as well as the skill level "beginner" and "intermediate" because only 10 skiers estimated their speed as "too high" and only three declared being a beginner.

3.3 Data Analysis

In order to evaluate the effect of each factor (i.e., whether the mean speed is significantly different between groups and by how much), we used the factorial ANOVA of a Generalized Linear Model (GLM). This choice was made because the GLM enables us to test the effect of each factor regardless of the other factors tested. Two-tailed p-values <0.05 were considered for statistical significance. All variables with a significant effect (significant difference of mean speed between the categories) were used in the final model. The variances explained by the models were assessed with the coefficient of determination (R^2). Effect size was evaluated using partial η^2 measuring the variance explained by each factor with 0.01, 0.1, and 0.25 for small, medium, and large effects. We analyzed the measured speed according to the perceived speed and the other factors best explaining skiing speed. Additionally, we investigated the measured speed regarding the self-estimated speed (in km/h).

4 Results

4.1 First Investigation: Evaluation of the Factors Not Related to User's Perception

1246 skiers and 153 snowboarders were measured in 3 different ski resorts, and on 10 ski slopes of different difficulties (from very easy to very hard) and different preparation (groomed or bumby). The mean skiing speed recorded was 43.4 (±15.2) km/h. The mean recorded speeds regarding slope difficulty, slope preparation, skill level, sport, gender, and helmet use are presented in Table 1. The results of the linear regression model are presented in Table 1. Table 2 summarizes the effects of each factor on the measured speed. Skill level ($\eta^2 = 0.26$; $P < 0.001$) and slope difficulty ($\eta^2 = 0.19$; $P < 0.001$) were the factors best explaining the variance of the skiing speed. Gender ($\eta^2 = 0.06$; $P < 0.001$), sport ($\eta^2 = 0.03$; $P < 0.001$), and slope preparation ($\eta^2 = 0.01$; $P < 0.001$) had a small but significant effect on skiing speed (Table 2). However, the effect of the use of helmet was not significant and was not included in the final model.

The linear regression model, presented on Table 1, explained 47% of speed variance. According to this model, intermediate skiers tended to go 11.7 km/h faster than beginner and 11.5 km/h slower than advanced skier. Speed of males was higher than the speed of females, by a mean of 3.1 km/h. Skiers were 2.8 km/h faster than snowboarders. Finally, the slope difficulty and preparation had a great influence on skiing speed. Skiers went faster on red and green slopes than on blue slopes by a mean of 7.2 km/h and 5 km/h, respectively. However, they travelled 9.0 km/h slower on black slope than on blue slope. Users went on average 1.7 km/h faster on a well-groomed ski slope than on a bumpy slope.

Table 1 Speed characteristics (on the left) and results of the multiple linear regression analysis of skiing speed considering skill level, gender, sport, helmet use, slope difficulty, and slope preparation (on the right)

		Measured speed (km/h)	Multiple linear regression analysis		
		Mean (SD), range	*B* (SD)	*T*	*p*
All groups (*n* = 1399)		43.4 (±15.2), 13–98			
Regression constant			31.9 (±0.8)	42.4	<0.001
Skill level	Advanced (*n* = 729)	50.0 (±14.8), 21–98	11.54 (±0.6)	20.5	<0.001
	Intermediate (*n* = 603)	37.7 (±11.5), 15–80	Ref*	–	–
	Beginner (*n* = 67)	23.3 (±8.5), 13–61	−11.7 (±0.9)	−12.4	<0.001
Slope level	Green (*n* = 204)	48.4 (±15.4), 19–90	5.0 (±0.7)	7.5	<0.001
	Blue (*n* = 499)	37.8 (±12.3), 13–89	Ref*	–	–
	Red (*n* = 537)	49.9 (±15.2), 15–98	7.2 (±0.5)	14.4	<0.001
	Black (*n* = 159)	32.7 (±9.2), 15–61	−9.0 (±0.8)	−11.8	<0.001
Gender	Female (*n* = 435)	37.0 (±12.2), 13–74	−3.1 (±0.3)	−9.4	<0.001
	Male (*n* = 964)	46.3 (±15.5), 13–98	Ref*	–	–
Sport	Snowboard (*n* = 153)	38.3 (±13.3), 15–80	−2.8 (±0.8)	−5.9	<0.001
	Ski (*n* = 1246)	44.0 (±15.3), 13–98	Ref*	–	–
Grooming	Bumpy (*n* = 146)	33.7 (±10.4), 16–89	−1.71 (±0.5)	−3.2	0.001
	Groomed (*n* = 1253)	44.5 (±15.3), 13–98	Ref*	–	–
Helmet	Yes (*n* = 756)	44.5 (±15.7), 13–93	**	–	0.19
	No (*n* = 643)	42.1 (±14.5), 14–98	Ref*	–	–

B unstandardized coefficient, *SD* Standard deviation
*The model's reference was: an unhelmeted male skier with intermediate skiing ability travelling on a well-groomed blue slope
**The effect of helmet use was not significant and it was not considered in the final model

Table 2 Results of the two linear regression models: the first model refers to the first investigation; it evaluates the effect of helmet use, slope difficulty, slope preparation, type of sport, gender, and skill level on the measured speed. The second model refers to the second investigation; it evaluates the effect of slope difficulty, gender, age, helmet use, reported skill level, and perceived speed on the measured speed

Factors	df	*F*	*p*	η^2	R^2
Model 1: Observer perception (*N* = 1399)					0.47
Evaluated skill level	2	241.90	<0.001	0.258	
Slope difficulty	3	110.21	<0.001	0.192	
Gender	1	88.22	<0.001	0.060	
Sport	1	34.97	<0.001	0.025	
Slope preparation (grooming)	1	10.34	0.001	0.007	
Helmet	1	1.71	0.191	0.001	
Model 2: User's perception (*N* = 176)					0.39
Reported skill level	2	24.43	<0.001	0.127	
Perceived speed	1	14.68	<0.001	0.080	
Slope difficulty	1	13.24	<0.001	0.073	
Age	3	3.32	0.021	0.056	
Gender	1	5.34	0.022	0.031	
Helmet	1	12.98	0.023	0.030	

Df degree of freedom, *F F*-statistics, η^2 effect size (amount of speed variance explained by the factor), R^2 coefficient of determination (amount of speed variance explained by the model)

4.2 Second Investigation: Interpretation of the Skiers' Estimation of Their Own Speed

176 skiers were stopped and interviewed. Their mean speed was 43.2 km/h, which was slightly lower than the mean speed of the skiers in the previous experiment (44.0 km/h). Most of the "less skilled" skiers perceived their speed as "low to medium"(64%), while among the "more skilled" group (n = 110), 48% declared travelling at "high" speed and 9% at a "too high" speed. The mean recorded speeds, regarding the reported skill level, skier's perceived speed, age, gender, helmet use, and slope difficulty, are presented in Table 3.

The results of the linear regression model are presented in Table 3. Table 2 summarizes the effects of each factor on the measured speed. The qualitative factor best explaining the measured speed was the self-reported skill level ($\eta^2 = 0.13$; $P < 0.001$) followed by the perceived speed ($\eta^2 = 0.08$; $P < 0.001$) and the slope difficulty ($\eta^2 = 0.07$; $P < 0.001$). Age, gender, and helmet use had also a small but significant effect on user's speed ($\eta^2 < 0.06$; $P = 0.02$). The effect of age was also significant ($\eta^2 = 0.06$; $P = 0.02$). Participants older than 40 years old were 4.2 (±1.4) km/h slower than the younger skier. Figure 1 presents the repartition of measured skiing speed regarding the qualitative perception of the speed and the two factors best

Table 3 Second investigation: Speed characteristics (on the left) and result of the multiple linear regression analysis (GLM) of skiing speed considering perceived speed, perceived skill level, slope difficulty, gender, age, and helmet use (on the right)

		Measured speed (km/h)	Multiple linear regression analysis		
		Mean (SD), range	*B* (SD)	*t*	*p*
All groups (n = 176)		43.2 (±13.7), 18–79			
Regression constant			42.3 (±1.0)	44.1	31.9 (±0.8)
Perceived speed	Low to medium (n = 89)	37.5 (±9.8), 18–63	Ref*	–	–
	High (n = 87)	49.0 (±14.6), 20–79	3.3 (±0.9)	3.83	<0.001
Reported skill level	Less skilled (n = 66)	37.1 (±12.2), 18–66	Ref*	–	–
	More skilled (n = 110)	46.8 (±13.2), 22–79	4.3 (±0.9)	4.94	<0.001
Slope difficulty	Blue–easy (n = 113)	40.1 (±13.2), 18–79	−3.1 (±0.9)	−3.64	<0.001
	Red–medium (n = 63)	48.7 (±12.8), 23–76	Ref*	–	–
Gender	Female (n = 50)	37.6 (±9.9), 18–69	−2.1 (±0.9)	−2.31	0.02
	Male (n = 126)	45.4 (±14.3), 20–79	Ref*	–	–
Helmet	No (n = 84)	39.4 (±11.7), 20–74	−2.1 (±0.9)	-2.29	0.02
	Yes (n = 92)	46.6 (±14.4), 18–79	Ref*	–	–
Age	<20 (n = 42)	48.4 (±14.5), 20–79	**	–	0.052
	20–30 (n = 32)	45.1 (±15.1), 18–76	**	–	0.25
	30–40 (n = 52)	43.5 (±12.3), 20–72	Ref*	–	–
	>40 (n = 50)	37.2 (±11.2), 20–72	−4.2 (±1.4)	−2.94	0.004

B unstandardized coefficient, *SD* standard deviation
*The model's reference was: an helmeted male skier age between 30 and 40 years declaring a low-to-medium speed and a beginner or intermediate skill level and travelling on well-groomed red slope
**The difference with the reference was not significative

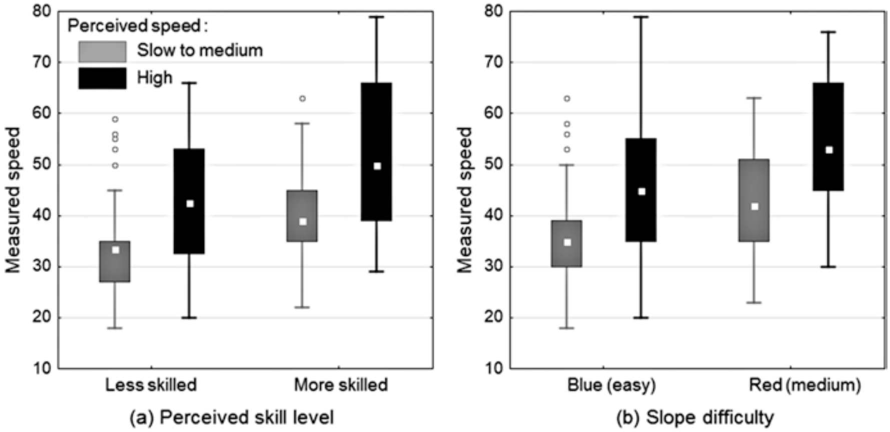

Fig. 1 Measured speed (**a**) regarding the perceived speed and the perceived skill level and (**b**) regarding the perceived speed and the slope difficulty. The boxplots presents the minimum, the first quartile, the median (small white square), the third quartile and the maximum speed for each category. The outliers are presented with small grey circle

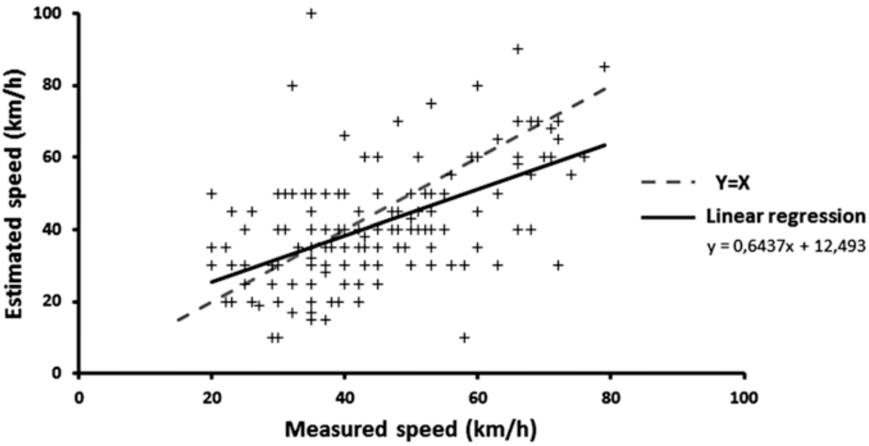

Fig. 2 Users' quantitative estimation of their own speed with regard to the measured speed

explaining the skiing speed, namely, the skill level (a) and the slope difficulty (b). The linear regression model including the perceived speed and the reported skill level explained 24% of the speed variance. 25% of speed variance was explained by the model including the perceived speed and slope difficulty.

Among the 176 skiers interviewed, 166 accepted to give a quantitative estimation of their measured speed. Figure 2 presents the measured speed as a function of that estimation. The mean estimated speed was 40.6 (±16.5) km/h, while the mean measured speed was 43.7 (±13.7) km/h. Pearson correlation coefficient between evaluated and measured speed was 0.56 ($P < 0.001$) and the absolute difference between the two speeds was 11 km/h. Finally, the linear regression ($R^2 = 0.31$) revealed that users travelling at a speed higher than 35 km/h tended to overestimate their speed, whereas faster users tended to underestimate their speed.

5 Discussion

The main finding of this work was the identification of the skill level and the difficulty of the slopes as two governing factors of skiing speed. These two factors also influence the perception of skiing speed. In order to propose an interpretation of the perceived speed registered in an accident report, the ranges of speed were obtained considering skill level, sloped difficulty, and perceived speed.

5.1 Factor Best Explaining Skiing Speed

In the first investigation, the mean speed of the 1399 users measured on ski slopes of different difficulty was 43.4 (±15.2) km/h. It was 49.9 (±15.2) km/h on medium slopes. This result is consistent with the speed measured on ski slopes of medium difficulty by Shealy et al. [4] (43.0 (±11.2) km/h) and Rueld et al. [5] (48.2 (±14.3) km/h). As in both these studies, we found that skill level, gender, and sport had a significant effect on skiing speed. In the second experiment based on 170 skiers interviewed, we also found that age had a significant effect on skiing speed according to Rueld et al. [5] as well as perceived speed in agreement with Brunner et al. [6]. Moreover, we found that the difficulty of slopes and their preparation had a significant influence on skiing speed which had not been previously investigated.

The contribution of each factor on the variation of skiing speed was evaluated. In the first investigation, evaluating factors not related to user's perception, we found that the two factors best explaining the speed variation was first the skill level ($\eta^2 = 0.26$; $P < 0.001$) and secondly the difficulty of the slopes ($\eta^2 = 0.19$; $P < 0.001$). In the second experiment, taking into account perception of skiing speed and of skill level, we obtained similar results. The factors accounting for the highest variation of speed were the self-reported skill level ($\eta^2 = 0.13$; $P < 0.001$), the self-estimated speed ($\eta^2 = 0.08$; $P < 0.001$) and the slope difficulty ($\eta^2 = 0.07$; $P < 0.001$). Gender, sport, and age had a small but significant effect ($\eta^2 < 0.1$; $p < 0.05$).

The evaluated contribution of each factor was not quite consistent with the work of Brunner et al. [6]. In their study, they interviewed and measured the speed of 416 adult skiers on medium slopes. They found that it was the gender which had the highest effect on skiing speed ($\eta^2 = 0.07$; $P < 0.001$). The effect of gender was more than twice higher than both the effect of perceived speed ($\eta^2 = 0.025$; $P = 0.007$) and the effect of reported skill level ($\eta^2 = 0.01$; $P = 0.05$). These differences are surprising but might be partly explained by differences in the methodology of the two studies. First, the two studies did not evaluate the same factors: contrary to Brunner et al., we included in our study the difficulty of the slope but we did not include the perception of risk taking behavior. Secondly, there was a difference in the categories used during the interview to define each factor. For example three categories were used in our study to describe the skill level (beginner, intermediate, and advanced) while four categories were used by Brunner et al. (beginner, intermediate, advanced, and expert). These categories might have influenced differently the answer of the skier. Another explanation might be that skiers did not estimate their skill level correctly. In an investigation in which skiers were observed while skiing to their best ability, Sulheim et al. [7] found that "the correlation between observed and self-reported skiing ability was low to fair." That explanation is supported by the fact that when the skill level was evaluated by an observer (first investigation) its effect on skiing speed was larger than when evaluated by the skier themselves (second investigation) ($\eta^2 = 0.26$ and $\eta^2 = 0.10$, respectively). Finally, these differences in the effect of each factor on skiing speed might be explained by differences in the locations, the types of ski resort and the periods in which the studies were performed. The data set of Brunner et al. was obtained in 2008–2009 in Austria, while our study was conducted in the French Alps, 5 years later.

Users' skill level, first evaluated by a trained observer and then estimated by the users themselves, was among the best explaining factors of speed ($\eta^2 = 0.26$ and $\eta^2 = 0.10$, respectively). In the first investigation, the skiers evaluated by the observer as advanced were on average 11.5 km/h faster than intermediate and 23.2 km/h faster than beginner. The effect of the skier's level had already been identified in every studies related to skiing speed [4, 5, 9, 10]. This difference in speed might partly explain that advance skiers' injuries are more likely to be severe [11].

A second important factor was the difficulty of the slope accounting for, respectively, 19.2% and 7.3% of the speed variance in the first and the second investigations (Table 2). This effect had, to our knowledge, not been evaluated in skiers previously. However, it is consistent with the work of Scher et al. [12] showing that intermediate snowboarders went faster on medium slopes than on easy slopes. According to the first investigation, skiers tended to go 14.4 km/h faster on red (medium) slopes than on blue (easy) slopes, probably due to a steeper slopes. On the contrary, users tended to go on average 9 km/h slower on black slopes than on blue ones. It might be because the increased technicality restricts the maximum speed to remain in control as discussed by Dickson et al. [10]. However, the measured speed in green slopes was surprisingly high (on average 5 km/h higher than in blue slopes). It was observed that the low steepness of the slope might encourage users to go straight in order to maintain a high speed rather than to perform turns. Green slopes are supposed to be the best areas for beginner. The measured high speed might explain that it is on easy slopes that most collisions leading to head injuries occur [13]. The preparation of the slope also had a significant effect on the measured speed, even if that effect was smaller than that of the difficulty of the slope. Indeed, users tended to go significantly slower (1.7 km/h on average, p-value = 0.001) on bumpy slopes than on well-groomed slopes (Table 1). According to this finding, the preparation of the ski slopes could be used as preventing measures to reduce skier's speed in areas identified as dangerous, such as intersections, low visibility areas, and slow zones [10, 14, 15]. More generally those results confirm that the typology of the slopes has a great effect on the users' speed. To better target prevention strategies on the slopes, further work should focus on the understanding of skiing speed regarding the slope typologies. GPS data-logging devices seem to be a promising technology to improve knowledge in that direction [16, 17].

The effect of the helmet on skiing speed is a controversial issue. According to Rueld et al. (2013a), that effect was nonsignificant whereas for Shealy et al. [4], helmet users were significantly faster than non-helmet users. In our first experiment, we did not find a significant effect between helmet use and the measured speed (Table 1, multiple linear regressions). However, in our second experiment, we found that there was a significant effect of helmet use on skiing speed, but it was the factor which had the smallest effect on skiing speed ($\eta^2 = 0.03$; $P = 0.023$). Therefore, according to our results helmet use might have an effect on the skiing speed but that effect is very small.

5.2 *Interpretation of the Skier's Estimation of Their Own Speed*

The results of the second investigation demonstrate that the perception of skiing speed depends on various factors such as skill level, slope difficulty, age, gender, and helmet use. For example, when perceiving their speed as "high," "less skilled" skiers were on average 9 km/h slower than the "more skilled" (42.5 (±14.1) km/h and 51.5 (±14.1) km/h, respectively). In order to better interpret the skiers' estimation of their own speed, we combined their perception of skiing speed with the best explaining factors, namely, the skill level and the difficulty of the slope (Fig. 1). To combine those information, enable a better prediction of the measured speed. Indeed, the regression model including the perception of speed and the reported skill level explained 24% of the speed variance. This is 7% higher than the regression model including the speed perception only (17%). However, we recorded a high variability of the measured speed among the defined categories of skiers as mentioned by Brunner et al. [6]: there was almost 50 km/h between the slowest and the fastest "less skilled" skiers who estimated their speed as "high." It shows that skiers' perception of their own skill level and their speed is not very precise nor very reliable and has to be taken carefully. We argue that it might be relevant to choose range of speed over mean speed in order to describe the speed of a category of skiers.

The quantitative estimation of the measured speed was also studied (Fig. 2). The Pearson correlation coefficient between estimated and measured speed was 0.53 which is consistent with the study of Shealy et al. [4] and Rueld et al. [5] (0.56). And the mean absolute difference between measured and estimated speed was 11.3 km/h. Interestingly, we found that skiers tended to overestimate their speed when travelling at a speed of under 35 km/h and underestimate their speed when travelling faster. Previously, Rueld et al. (2013a) had found a similar result but for a speed of 40 km/h. Based on those results, speed quantitative estimation should be included in an accident survey. However, the interpretation of such data is difficult, indeed, as reported in Rueld et al. [5], because a few users were incompetent in the evaluation of their speed: one skier claimed a speed of 30 km/h when, actually, he travelled at 72 km/h, or at the contrary one claimed a 80 km/h speed when he travelled at 32 km/h. Moreover, users were very reluctant to estimate quantitatively their speed and we doubt that many would accept to give such an interpretation in an accident survey.

5.3 Limitations

The second experiment was performed in order to interpret the reported speed of a skier in an accident survey. Even if there was a large variability in speed among each category of users, the study provides approximate speed ranges of these categories. For example, the advance skiers who perceived their speed as "low to medium" were at a speed of between 18 and 59 km/h, and a majority of them was at a speed of between 27 and 35 km/h. However, it is possible that in the medical center, due to the traumatic event, the users do not perceive their speed and their skill level the same way they would at the bottom of a ski slope.

The radar used in this study was designed to measure the speed of objects of various size from tennis ball to car at a speed from 11 to 600 km/h and could operate at a temperature as low as −7 °C. It was hence appropriate to measure skiers. Also the speed measurements were done in 1/50 s and were hence not affected by the slow movement made by the observer to track the skier. However, the radar measured the speed only in the direction in which it was pointing. To measure the speed accurately, the observer had to be in the skier's way which was not the case during the skier's turn. To tackle that issue, we chose to measure the skier during several turns and to record the highest measured speed during that observation period. However, the speed might still be slightly underestimated by the radar.

The gender and the skill level were evaluated by the observer during the observation period. The skier was included in the study when the observer was positive about their gender. Yet it is worth noticing that in the literature, there is reported bias associated with higher skill skiers more easily perceived as male [18].

6 Conclusion

In conclusion, we found that among the evaluated factors, the skiers' perception, the skill level, and the slope difficulty were the most influencing factors of skiing speed. These results should be considered in order to improve the prevention strategies on the slopes. We also provided ranges of speed associated with the skier's perception of their speed and considering skill level and the slope difficulty. This result provides insights to interpret the skiers' assessment of their own speed in an accident report. This is, therefore, a first step toward a precise accident reconstruction, leading to a better understanding of the accident mechanisms and a better evaluation of the means of protection.

References

1. Laporte J-D, Bajolle L, Lamy D, Delay J-B (2012) Winter sports injuries in France over two decades. In: Skiing trauma and safety, vol 19. ASTM International, pp 201–215
2. Bailly, N., Llari, M., Donnadieu, T., Masson, C. and Arnoux, P. J. (2016), Head impact in a snowboarding accident. Scand J Med Sci Sports.

3. Takakuwa T, Endo S (1997) Factors determining the severity of ski injuries. J Orthop Sci 2(6):367–371
4. Shealy JE, Ettlinger CF, Johnson RJ (2005) How fast do winter sports participants travel on alpine slopes? J ASTM Int 2(7):JAI12092
5. Ruedl G, Brunner F, Woldrich T, Faulhaber M, Kopp M, Nachbauer W, Burtscher M (2013) Factors associated with the ability to estimate actual speeds in recreational alpine skiers. Wilderness Environ Med 24(2):118–123
6. Brunner F, Ruedl G, Kopp M, Burtscher M (2015) Factors associated with the perception of speed among recreational skiers. PLoS One 10(6):e0132002
7. Sulheim S, Ekeland A, Bahr R (2007) Self-estimation of ability among skiers and snowboarders in alpine skiing resorts. Knee Surg Sports Traumatol Arthrosc Off J ESSKA 15(5):665–670
8. Fukuda O, Takaba M, Saito T, Endo S (2001) Head injuries in snowboarders compared with head injuries in skiers a prospective analysis of 1076 patients from 1994 to 1999 in Niigata, Japan. Am J Sports Med 29(4):437–440
9. Williams R, Delaney T, Nelson E, Gratton J, Laurent J, Heath B (2007) Speeds associated with skiing and snowboarding. Wilderness Environ Med 18(2):102–105
10. Dickson T, Terwiel F, Waddington G, Trathen S (2012) Easiest routes and slow zones: How fast do I go?: speeds and distances of recreational and expert snowsport participants. In: Skiing trauma and safety, vol 19. ASTM International, pp 184–197
11. Goulet C, Hagel BE, Hamel D, Légaré G (2010) Self-reported skill level and injury severity in skiers and snowboarders. J Sci Med Sport Sports Med Aust 13(1):39–41
12. Scher I, Richards D, Carhart M (2006) Head injury in snowboarding: Evaluating the protective role of helmets. J ASTM Int 3(4)
13. Bailly N, Afquir S, Laporte J-D, Melot A, Savary D, Seigneuret E, Delay J-B, Donnadieu T, Masson C, Arnoux P-J (2017) Analysis of Injury Mechanisms in Head Injuries in Skiers and Snowboarders. Med Sci Sports Exerc. 49:1–10
14. Ruedl G, Kopp M, Sommersacher R, Woldrich T, Burtscher M (2013) Factors associated with injuries occurred on slope intersections and in snow parks compared to on-slope injuries. Accid Anal Prev 50:1221–1225
15. Bergstrøm KA, Ekeland A (2004) Effect of trail design and grooming on the incidence of injuries at alpine ski areas. Br J Sports Med 38(3):264–268
16. Dickson TJ, Terwiel FA, Waddington G, Trathen S (2011) Evaluation of the use of a GPS data-logging device in a snowsport environment. Procedia Eng 13:470–475
17. Dickson TJ, Trathen S, Waddington GS (2014) Speeds of pediatric snowsport participants: insights for injury prevention strategies. In: Skiing trauma and safety, vol 19. ASTM International, pp 141–149
18. Dickson TJ, Laneyrie F, Pritchard A (2006) Australian snowsports: gendered and contested spaces? Tour 54(1):17–32

Snowsport Instructors: Their Actual Maximum Speeds, Their Estimation of Maximum Speed and Speed in Slow Zones, and Their Knowledge of Helmet Effectiveness

Tracey J. Dickson and F. Anne Terwiel

Abstract Snowsport safety strategies include resort and equipment design, trail management, emergency response, and public education. Snowsport instructors are well placed to inform their students about snowsport safety both in the behavior they model and the information they provide. To contribute to the evidence-base of snowsport safety and helmet awareness, this research explores the actual and estimated maximal speeds of ski and snowboard instructors across a normal work-day as well as their knowledge of helmet effectiveness. During winter 2012/13, a convenience sample of 109 instructors was recruited across six resorts in Western Canada and were issued with iPhone 3 s loaded with the Ski Tracks app. An anonymous questionnaire investigated their prior snowsport experiences, their knowledge of snowsport safety, and their understanding of helmet effectiveness. Results indicated that snowsport instructors: (1) underestimated their maximal speeds by 12 km/h on average; (2) overestimated the overall snowsport injury rate as well as the proportion of head injuries; and (3) overestimated the effectiveness of helmets. Based upon these results, if snowsport instructors are to contribute to the knowledge and understanding of the snowsport safety of their students then their own knowledge needs to be developed with regard to helmet effectiveness.

Keywords Skiing • Snowboarding • Speed • Slow zones • Helmet effectiveness

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1 Introduction

Snowsport safety is a multidisciplinary activity [1] incorporating resort and equipment design [2], trail management [3], emergency response through ski patrol [4], industry codes such as the Alpine Responsibility Code [5], and public education [6]. Snowsport instructors are well placed to contribute to a public education program that addresses key snowsport safety issues. However, in order to capitalize upon their ability to inform the public, snowsport instructors must be knowledgeable about safety-related issues and aware of their own behavior. This research focuses on the knowledge that snowsport instructors have with regard to helmets, their awareness of the speeds at which they travel, and recommendations regarding designated slow zones.

In an effort to enhance snowsport safety, helmets have been promoted as an effective measure to protect against head injuries (e.g., [7–11]). However, recent research has demonstrated that even with increased helmet usage in a non-mandatory environment, head injuries have not been reduced in proportion to the increased usage [12]. It was suggested that this may, in part, be due to an overestimation of the effectiveness of a helmet's protection [13]. Thus, there is debate as to whether helmets should be mandatory [14–16] with evidence that public education may be a more effective safety strategy than mandatory usage [17]. However, for risk or injury prevention communication to be effective it must empower the user to make informed decisions [18].

Further, speed has been associated with the enjoyment of snowsports such as skiing and snowboarding (e.g., [19–21]), but also as a contributing factor to injury (e.g., [22–24]); yet there are only a few studies that have explored actual speeds in snowsport resorts (e.g., [1, 2, 25–31]). Most of this research, as summarized in Table 1, has focused on recreational participants with speeds typically recorded on limited terrain, or a single run, using static radar guns or speed cameras [25, 29–31]. There has been limited work utilizing emerging and more flexible GPS-technology to cover whole-resort behaviors where adults have demonstrated higher speeds [2,

Table 1 Previous English language snowsport speeds research

Study	Data collection	Participants (n)	Resorts (n) and country	Terrain covered	Method	Range (km/h)	Mean (km/h)
Shealy et al. [30]	2002–03	650	3 USA	Open run	Radar	Not indicated	43.0
Williams et al. [31]	Not indicated	113	2 USA	Terrain parks and gladed areas	Radar	<18–42	Not indicated
Brunner et al. [25]	2008–09	416	4 Austria	Medium slope	Radar	Not indicated	48.2
Dickson et al. [2]	2009 and 2010	158 pediatric	2 Australia	Whole resort	GPS	6.3–82.2 km/h	44.1
Dickson et al. [26]	2010–11	102	1 Canada	Whole resort	GPS	20.2–108.5	62.1

26], nor has there been a specific focus on instructors who may act as safety role models and educators.

A common finding from all of this speeds research (Table 1) that is relevant for snowsport safety is that most participants, young and old, beginner through expert, regularly exceed the flat impact test standards for snowsport helmets which are in the range of 20–23 km/h [2, 32–35]. It has been demonstrated that people regularly exceed their own recommended speeds for slow zones [26]. Slow zones are typically identified by prominent signs on slopes and markings on trail maps, and include learning areas, areas reserved for children, trail junctions, and busier runs. Those signs, according to the Alpine Responsibility Code, should be obeyed [5], but there is lack of understanding as to what "slow" means [26]. From a risk management or snowsport safety perspective together these may be problematic when arguing for slow zone regulation and mandatory helmet usage and may explain research that refers to mitigation of injury rather than prevention [36–39].

To contribute to the evidence-base of snowsport safety, speed regulation, and helmet awareness, with respect to professional snowsport instructors, this research explores:

1. The actual and estimated maximum on-snow speeds of professional snowsport instructors in six mid-sized Western Canada resorts during a normal work-day
2. Recommendations for speeds in designated slow zones
3. Their knowledge and understanding of snowsport helmet effectiveness
4. The differences that exist between the characteristics of helmet wearers and non-helmet wearers and their on-snow behaviors

The broader context of this research is Western Canadian snowsport where the governing bodies of ski and snowboard instructors are the Canadian Ski Instructors Alliance (CSIA), and the Canadian Association of Snowboard Instructors (CASI). They are responsible for instructor training, certification, and ongoing education, with education committees responsible for developing content and materials that enable and support instructor training, certification, and teaching ([40], Sec 1.3).

The mission statement of the CSIA is that the CSIA "sets the standard for the profession of ski teaching" ([40], 1.2). Their manual provides a detailed Code of Ethics to be followed, and under the heading Responsible Teaching, demands that the activities of members will be done safely and with the best interests of all participants in mind ([40], 1.4). The manual reinforces the concept of Duty of Care, taught to all instructors in every certification course, encouraging them to act as a prudent parent would act, and to conduct themselves as knowledgeable, responsible, and vigilant guides, acting with strict adherence to the Alpine Responsibility Code ([40], 1.10).

Regarding helmet use, "The CSIA supports its members, staff and partners and their choices on helmet use while skiing … The CSIA encourages informed helmet use" ([40], 1.10). Currently, all CSIA Course Conductors wear helmets while conducting certification courses; however, course participants are not mandated to wear helmets. At the time of this research, helmet wearing was not mandatory for snowsport instructors in western Canada

With respect to speed, the CSIA does not have a stated public position. In instructor certification courses, participants are taught to use "appropriate" speed and terrain, suitable to the skill of the guest and the goals of the lesson [41]. The CSIA promotes the Alpine Responsibility Code [5] where the first item relates to speed: "Always stay in control. You must be able to stop, or avoid other people or objects."

2 Method

In order to explore the on-snow work-day behavior of snowsport instructors and their knowledge and understanding of key snowsport safety issues, a convenience sample of snowsport instructors was recruited across six resorts in Western Canada during the 2012/13 season. Data was collected at each resort over two consecutive days. Instructors were approached at their morning meetings and briefed on the research; up to ten instructors volunteered each day to participate. Speed, distance, and duration over the day were recorded using the "Ski Tracks" app (http://www.corecoders.com/applications/ski-tracks/) on ten iPhone 3 s. Ski Tracks is a GPS-based application that does not require WiFi or Phone connections. This smartphone application was chosen to apply a more affordable and publically accessible GPS-based technology than in previous research [1, 42]. At the time of this research, Ski Tracks was the world's most downloaded ski application. Ski Tracks is battery efficient (up to 14 h of track recording), runs in the background, is simple to operate, does not require a SIM card and is ski/snowboard specific. Readouts include maximum speed, average speed, ski distance (ascent and descent), accumulated vertical distance, number of runs, slope angle, and time duration.

Participants completed an anonymous questionnaire exploring: demographic information including age range, previous snowsport experience across four snowsport disciplines: snowboarding, alpine skiing, telemarking, and cross-country skiing (no experience, 1 day, 2–6 days, 7–13 days, 14–27 days, 4–8 weeks, >8 weeks); history of serious snowsport injury (i.e., concussion, fracture, dislocation) in each snowsport discipline (no injury, 1, 2, 3, 4, 5, 6, or more); how fast they believe that skiers should ski in slow zones (open question); perception of their own maximum speed (open question) and distance travelled that day (open question); and they were asked to estimate the maximum speed at which a snowsport helmet is effective (open question). To explore knowledge of snowsport risks, participants were asked, 'If there are 1000 people on the slopes today, how many people do you think will be injured? (<1, 1–5, 6–10, 11–15, 16–20, more than 20); and 'Of all snowsport injuries, what percentage do you think are head injuries? (open question). Current GPS use was also explored to track awareness and changes in uptake.

With the initial part of the questionnaire completed, and data-recording devices fitted, instructors undertook their normal day's instructional activity. The full variety of lesson types were represented, with guests ranging from beginner through advanced and from very young children through to older adults. Instructors completed the reflective portion of the questionnaire at the end of their work-day. No data was collected on client profiles.

Data was entered into SPSS v21 for analysis and included descriptive statistics to summarize the data (e.g., mean and standard deviation, as well as mode for speeds in slow zones) and between group differences. Chi-squared tests were used to assess differences between groups (gender, age, and activity) regarding GPS use and helmet use; a paired sample *t*-test was used to compare instructors' estimated and actual maximum speeds and independent-samples *t*-tests assessed differences between groups (gender, age, and helmet use) regarding actual maximum speeds, where ages were recoded into groups for further analysis. A *p*-value of 0.05 was used to determine significance.

3 Results

In the following results, the resorts have been de-identified to protect their anonymity, as was agreed to at the outset of the study.

3.1 Respondents: Demographics, Serious Injuries, and Risk Awareness

There were 109 participants from the six resorts over 12 days of data collection, 36% were females, and 96% had self-reported skill levels of advanced/expert; 78% were ski instructors and 22% snowboard instructors, with 75% wearing helmets.

The age range was 19–67 years ($\bar{x}$ = 32.5 years, SD = 11.7), with the largest group being 25–34 years (Table 2). The older age groups (45 years and over) had the lowest rate of helmet use (67%), while the youngest (15–24 years) had the highest rate of helmet use (84%).

Outside this study, GPS-enabled equipment such as watches and Smartphone apps was used by 31% of respondents. Pearson Chi-squared analyses demonstrated

Table 2 A comparison of snowsport helmet use according to age groups

	No helmet	Helmet worn	Total
15–24 years	5 (16%)	27 (84%)	32 (30%)
25–34 years	12 (29%)	29 (71%)	41 (38%)
35–44 years	3 (23%)	10 (77%)	13 (12%)
45–54 years	5 (33%)	10 (67%)	15 (14%)
55 and over	2 (33%)	4 (67%)	6 (6%)
	27 (25%)	80 (75%)	107
Missing			2

that there was no significant difference between GPS use by females and males (p = 0.81), younger and older instructors (p = 0.96), nor between skiers and snowboarders (p = 0.32).

To consider risk-awareness participants were asked if they had experienced a serious snowsport injury, defined as being a concussion, fracture, or dislocation. Most alpine ski instructors had experienced a serious injury while skiing (67%), which was the same for snowboard instructors who had experienced a serious injury while snowboarding. When estimating snowsport injury rates and proportion of head injuries, just 32.7% of instructors correctly estimated the injury rate at between 1–5 injuries per 1000 skier-days, 19.6% believed the injury rate was 16 or more per 1000 skier-days. Others indicated: 0 (0.9%), 6–10 (27.1%), 11–15 (19.6%). Estimates of the proportion of head injuries ranged from 0 to 80% ($\bar{x}$ = 22.0%, SD = 17.6), 79.4% estimated that 10% or more of injuries are to the head, the remainder indicated: nil (2.8%), 1 (0.9%), 2 (5.6%), 4 (0.9%), 5 (10.3%), and 8 (0.9%).

3.2 Duration, Distance Travelled, and Maximum Speeds

Total skiing/boarding time logged was 665 h (2:49–8:50 h, $\bar{x}$ = 6:06 h, SD = 1:24 h), covering 4389.2 km ($\bar{x}$ =6.6 km travelled per hour). The number of runs taken ranged from 1 to 25, with an average of nine runs per work-day (SD = 4.8). Maximum-recorded speeds ranged from 25.9–110.6 km/h ($\bar{x}$ = 64.7 km/h, SD = 17.4). Estimates of their maximum speeds ranged from 10 to 140 km/h ($\bar{x}$ = 53.0 km/h, SD = 25.3). A paired sample t-test of the estimated and actual maximum speeds was significant ($t(99) = 5.92$, $p < 0.001$) with instructors underestimating their maximum speeds by an average of 12 km/h.

Male instructors travelled faster and further than females, with a 13.6 km/h difference in mean maximum speeds (69.6 versus 56.0 km/h), and a 6.4 km difference in mean distance travelled (23.2 versus 16.8 km). Younger instructors (<25 years) travelled less distance and had lower mean maximum speeds than older instructors (i.e., 25 years plus). An independent sample t-test analysis was conducted to compare the actual maximum speeds for females and males, as well as younger (<25 years) and older (25 years plus) instructors. There was a significant difference in the actual maximum speeds for females ($\bar{x}$ = 56.0 km/h, SD = 15.87) and male instructors ($\bar{x}$ =69.6 km/h, SD = 16.54; $t(105) = 4.15$, p = <0.01) and also for younger ($\bar{x}$ = 59.1 km/h, SD = 18.80) and older instructors ($\bar{x}$ = 66.7 km/h, SD = 16.43; $t(105) = 2.09$, $p = 0.04$). For mean distance travelled, there was a significant difference between female ($\bar{x}$ = 28.6 km, SD = 12.2) and male ($\bar{x}$ = 46.8 km, SD = 50.4; $t(105) = 2.222$, $p = 0.03$) instructors, and between younger ($\bar{x}$ = 27.7 km, SD = 10.5) and older ($\bar{x}$ = 45.2 km, SD = 48.4; $t(105)$ = 2.0.28, $p = 0.045$) instructors. An independent-samples t-test analysis did not reveal a significant difference between helmet wearers ($\bar{x}$ = 64.8 km/h, SD = 18.3) and non-helmet wearers ($\bar{x}$ = 64.4 km/h, SD = 14.8; $t(107) = 2.115$,

p = 0.91) nor for GPS users ($\bar{x}$ =63.1 km/h, SD = 16.4) and non-users ($\bar{x}$ =65.1 km/h, SD = 18.3; t(100) = 0.53, p = 0.60).

3.3 Slow Zone Recommendations

The range in instructor-recommended maximum speed for slow zones was between 2 and 62 km/h ($\bar{x}$ =20.8 km/h, SD = 11.9, mode = 20 km/h), with an almost 5 km/h difference in the recommendations between male ($\bar{x}$ =22.6 km/h, SD = 12.8) and female ($\bar{x}$ =17.8 km/h, SD = 9.8; t(101) = 1.98, p = 0.051) instructors though not statistically significant. Though there was nearly 3 km/h difference in the recommendations of older ($\bar{x}$ =21.6 km/h, SD = 12.5) and younger instructors ($\bar{x}$ =18.8 km/h, SD = 10.6; t(101) = 1.10, p = 0.28), this was not statistically significant either. An independent-samples t-test was conducted to compare the recommended maximum speeds in slow zones between helmet wearers and non-helmet wearers. There was no significant difference in estimates for helmet wearers ($\bar{x}$ =19.9 km/h, SD = 10.7), and non-helmet wearers ($\bar{x}$ = 23.3 km/h, SD = 15.2; t(103) = 1.05, p = 0.30), nor for GPS users ($\bar{x}$ =18.1 km/h, SD = 9.3) a non-users ($\bar{x}$ = 21.5 km/h, SD = 12.9 t(96) = 1.32, p = 0.19).

3.4 Helmet Effectiveness

Helmets were worn by 75% of respondents that day, with the estimates for the maximum speed to which helmets are effective ranging from 0 to 150 km/h ($\bar{x}$ = 54.1 km/h, SD = 29.5). An independent-samples t-test was conducted to compare the estimated maximum speeds to which helmets are effective between helmet wearers and non-helmet wearers. There was no significant difference in estimates for helmet wearers ($\bar{x}$ = 54.3 km/h, SD = 27.5), and non-helmet wearers ($\bar{x}$ = 53.7 km/h, SD = 36.5; t(90) = 0.82, p = 0.94). Those with higher maximum recorded speeds believed that their helmets were effective to higher speeds.

3.5 Characteristics of Helmet Wearers Vs. Non-Helmet Wearers

The only between group difference noted between helmet wearers and non-helmet wearers was for alpine skiing vs. snowboarding (1, n = 109) = 0.04 (Table 3). Chi-squared tests indicated there was no significant difference for gender (1, n = 107) = 0.08, nor age groups (1, n = 107) = 0.14.

Table 3 Characteristics of helmet wearers and non-helmet wearers

	No helmet	Helmet worn	Total	*p**
Gender				
Female	6 (15%)	33 (85%)	39	0.08
Male	21 (31%)	47 (69%)	68	
Total	27 (25%)	80 (75%)	107	
Age groups: <25, 25+				
<25 years	5 (16%)	27 (84%)	32	0.14
25 years plus	22 (29%)	53 (71%)	75	
Total	27 (25%)	80 (75%)	107	
Main Snowsport Activity "Today"				
Alpine skiing	25 (29%)	60 (71%)	85	*0.04*
Snowboarding	2 (8%)	22 (92%)	24	
Total	27 (25%)	82 (75%)	109	

*Chi-squared

4 Discussion

This novel research was able to utilize new smartphone technology that is expanding the repertoire of data collection methods of researchers. The fact that Ski tracks is free, is purposely designed for snowsport, does not require phone coverage or network access, and is able to be used around the world, was beneficial to this project.

To be effective, a public education campaign must be based upon accurate data, conveyed by trained and knowledgeable people [43]. Snowsport instructors are one information conduit to participants who are new to snowsports, and to those looking to improve their snowsport skills. This research was undertaken in an effort to assess the knowledge and behaviors of these potential snowsport safety educators by investigating their: estimated and actual maximum on-snow; recommended speeds in designated slow zones, knowledge of snowsport helmets; and to determine if there were differences between helmet wearers and non-helmet wearers, so that we might gain some insight into the information these experts may need to accurately and effectively inform the snowsport public.

Respondents were from across the age spectrum of resort workers, with mostly male respondents. Notable is that in this non-mandatory period, 75% of participating instructors were wearing helmets.

With a range of 26–110 km/h all respondents achieved maximum speeds that exceed the test standards of snowsport helmets (e.g., [32, 34]). The lack of difference in maximum recorded speeds between helmet wearers and non-helmet wearers reflects previous research [44], but contrasts with earlier research that did see a difference [30], which may reflect normalizing of behaviors as helmet wearing becomes more common, or it could reflect cultural differences in research sites.

It is not possible to speculate on whether differences in speeds and distance travelled between males and females and older and younger instructors lie in the instructors themselves, or in the skill level of guests with whom individual instructors were working. Regarding estimation of speeds, female instructors underestimated their actual maximum speed by 16.9 km/h, while males only underestimated maximum speeds by 8 km/h. However, of the 31% of instructors who reported GPS-enabled equipment already in use, an independent-samples *t*-test indicated that there was no significant difference in their means for maximum speeds, estimated maximum speeds, or recommended speeds in slow zones. That said, Mobile Applications (apps) that measure speed, distance, vertical accumulated, etc. may be changing the on-hill behavior of snowsport instructors and the general public. Now that these apps are ubiquitous, research is needed to ascertain whether this is the case, and if so, is this a safety management problem. (http://www.banfflakelouise.com/Media-Relations/News-Releases/RockiesReplay-Allows-Skiers-and-Snowboarders-to-Shred-with-Cred-at-Banff--National-Park-Ski-Resorts).

Previous research on slow zone recommendations in a study of a single resort [26] revealed a range of 5–60 km/h with a slightly higher mean of 23.8 km/h and a higher mode of 30 km/h. Experts in this previous research had a range of 10–50 km.h and much higher mean of 33.4 m/h. This survey of instructors across six resorts reveals a much more conservative recommendation for slow zones than the broader public at just one resort.

With regard to estimates of the speeds to which helmets are effective, there was a remarkable 150 km/h range, an indication that, at the time of this research, information about the speed to which helmets are tested to meet the helmet's limited performance requirements had failed to reach this group of instructors. The mean of 54 km/h across the six resorts is the same as previous research with instructors at a single resort [13]. When considering speed and helmet effectiveness it is worth noting that the kinetic energy at 65 km/h is nearly eight times higher than at 23 km/h [30] which will impact the ability of a helmet to reduce head accelerations as per the standards. The wide range regarding speeds to which helmets are expected to be effective indicates a knowledge gap between snowsport instructors and the helmet industry. Commensurate with a risk communication approach it is necessary for instructors to be educated about the design and use of helmets relative to the speeds achieved in normal snowsport behaviors, in order to be able to provide accurate information to their students as part of a broader snowsport safety strategy. The current mandate to wear helmets while working points to further research to ensure that helmets are being used effectively such as looking at how instructors purchase their helmets (used versus new), how the helmets fit, how they are worn, and in particular, how they are cared for [45].

The higher than average rate of serious injury reported may reflect the higher exposure levels of instructors compared to the average participant who only participates in snowsports 10 days a year [46]. Some instructors are working back-to-back winters (teaching in the northern hemisphere December through April and in the southern hemisphere June through September), effectively doubling their yearly exposure. Having been exposed to or perceiving more serious injuries than the norm may have contributed to their overestimation of the risk of injury in the broader public, but does not appear to have impacted their behaviors such as maximum recorded speeds. Nearly one-third correctly estimated snowsport injuries to be in the range of 1–5 injuries per 1000 skier visits, at the time of the research it was closer to 2 per 1000 skier visits in Western Canada [12]; most overestimated the head injury rate which was close to 9% of reported injuries at the time [12]. This may be a result of the increased interest in head injuries, particularly concussions, across a range of sports.

While snowsport instructors are well positioned to support a public education campaign, this research has demonstrated that neither the CSIA nor CASI provide information through their manuals to their members upon which they can make an informed decision about helmet use or the effectiveness of helmets. This raises a further question as to who could, or should, help provide relevant information about helmet effectiveness. Further, the research has shown that for the sample here, their knowledge of snowsport risks, helmet effectiveness, expectations about behaviors in slow zones, and their ability to estimate their speeds is problematic if they are to be central to a public education campaign that will clarify snowsport safety for the broader public.

5 Limitations

Instructors were fitted with the GPS-logging device at the beginning of their work-day and turned the devices in at the end of the day. We are unable to determine whether instructors were working with guests every minute that the devices were recording, or whether they may have gone skiing or boarding on their own between or after lessons. The research was conducted during the height of the Western Canadian snowsport season, during which time most instructors are fully utilized, however there is no way to confirm that all data collected represented time with students. All instructors were in uniform for the duration of the recording time, so whether with students or not, as they were still in uniform they were in the public eye.

While this research was undertaken to try to understand the knowledge levels of ski and snowboard instructors in general, the relatively small sample size and the convenience sample limits the generalizability to a larger population.

Speed analysis, in the form of maximum speed rather that mean speed, was the unit of analysis in this research. This is because the Ski Tracks application measures speed from the time it begins recording until it is shut off. That means Ski Tracks measures speed while standing still, walking, riding the chair lift, etc. With Ski Tracks the only reliable measure of speed while sliding downhill is maximum speed, as maximum speed cannot occur in situations other than skiing or snowboarding while on-hill during the work-day.

Finally, while the focus on speeds was downplayed it was possible that instructors were aware that speed data was being collected, and as such, may have modified their behavior, as per the Hawthorne Effect [47].

6 Conclusion

Consistent with previous research on recreational participants, during this novel research that utilized a smartphone application, snowsport instructors: (1) underestimated the speeds they travelled by an average of 12 km/h, (2) recommended lower slow zone speeds than recreational participants, (3) overestimated the speeds at which helmets may be effective, as indicated by industry standards, and (4) overestimated the injury risk in snowsports.

Finally, it has been proposed that education programs are the best way to inform both instructors and the general public about safe behavior within resorts, involving both the use of personal protective equipment and personal and group behavior. Research is necessary to determine if this is, in fact, the case in a snowsport environment.

References

1. Dickson TJ, Trathen S, Waddington G, Terwiel FA, Baltis D (2016b) A human factors approach to snowsport safety: novel research on pediatric participants' behaviors and head injury risk. Appl Ergon 53(Part A):79–86. doi:10.1016/j.apergo.2015.08.006
2. Dickson TJ, Trathen S, Waddington GS (2015) Speeds of pediatric snowsport participants: insights for injury prevention strategies. In: Johnson RJ, Shealy JE, Greenwald RM (eds) Skiing trauma and safety: 20th volume, STP1582 ASTM international, West Conshohocken, PA, pp 141–149
3. Bergstrom KA, Ekeland A (2004) Effect of trail design and grooming on the incidence of injuries at alpine ski areas. Br J Sports Med 38(3):264–268
4. Kuepper T, Steffgen J, Gore C, Perren B, Zahnd P, Gore R (2002) Qualified rescue by ski patrols–safety for the skier. Int J Sports Med 23(7):524–529
5. Canada West Ski Areas Association (2016) Policy–Alpine Responsibility Code. http://www.cwsaa.org/policy/alpine-responsibility-code.html. Accessed 19 Jan 2016
6. Levy AS, Hawkes AP, Rossie GV (2007) Helmets for skiers and snowboarders: an injury prevention program. Health Promot Pract 8(3):257–265
7. Cusimano MD, Kwok J (2010) The effectiveness of helmet wear in skiers and snowboarders: a systematic review. Br J Sports Med 44:781–786. doi:10.1136/bjsm.2009.070573
8. Hagel BE, Pless IB, Goulet C, Platt RW, Robitaille Y (2005) Effectiveness of helmets in skiers and snowboarders: case-control and case crossover study. Br Med J 330(7486):281. doi:10.1136/bmj.38314.480035.7C
9. Haider AH, Saleem T, Bilaniuk JW, Barraco RD, Committee obotEAftSoTICP (2012) An evidence-based review: efficacy of safety helmets in the reduction of head injuries in recreational skiers and snowboarders. J Trauma Acute Care Surg 73(5):1340–1347. 1310.1097/TA.1340b1013e318270bbca
10. Jung C, Zweckberger K, Schick U, Unterberg A (2011) Helmet use in winter sport activities—attitude and opinion of neurosurgeons and non-traumatic-brain-injury-educated persons. Acta Neurochir 153(1):101–106. doi:10.1007/s00701-010-0704-8
11. Russell K, Christie J, Hagel BE (2010) The effect of helmets on the risk of head and neck injuries among skiers and snowboarders: a meta-analysis. Can Med Assoc J 182(4):333–340
12. Dickson TJ, Trathen S, Terwiel FA, Waddington G, Adams R (2016a) Head injury trends and helmet use in skiers and snowboarders in Western Canada, 2008–09 to 2012–13: an ecological study. Scand J Med Sci Sport. Doi:10.1111/sms.12642

13. Terwiel FA, Dickson TJ (2015) Helmets: what do snowsport instructors and guests know and expect? In: Johnson RJ, Shealy JE, Greenwald RM (eds) Skiing trauma and safety: 20th volume, STP 1582. ASTM International, West Conshohocken, PA, pp 3–21. doi:10.1520/STP158220140008
14. Bussewitz C (2010) California considers mandatory ski helmet laws. USA Today
15. CBC News (2012) Ski helmets lack mandatory Canadian safety rules: Canadian Standards Association alpine helmet guidelines. Under review
16. Ruedl G, Kopp M, Burtscher M (2010a) Editorial: mandatory ski helmets? Can Med Assoc J 182(9):942
17. Ruedl G, Kopp M, Burtscher M (2012b) Editorial: is ski helmet legislation more effective than education? Br J Sports Med 46(16):1091–1092. doi:10.1136/bjsports-2012-091374
18. Covello V, Sandman PM (2001) Risk communication: evolution and revolution. In: Wolbarst A (ed) Solutions to an environment in peril. John Hopkins University Press, Baltimore, pp 164–178
19. Brandauer T, Senner V, Woitschell J (2010) Speed and ability as modulating factors of the flow experience while skiing on prepared slopes. In: Müller E, Lindinger S, Stöggl T, Pfusterschmeid J (eds) Science and skiing V. Meyer & Meyer Sport, Maidenhead, pp 85–93
20. Dickson TJ, Terwiel FA (2013) Supervising snowsport activities: a reflection upon legislation, policies, guidelines and practice. Aust J Outdoor Educ 16(2):24–41
21. Ruedl G, Abart M, Ledochowski L, Burtscher M, Kopp M (2012a) Self reported risk taking and risk compensation in skiers and snowboarders are associated with sensation seeking. Accid Anal Prev 48(0):292–296. doi:10.1016/j.aap.2012.01.031
22. Chaze B, McDonald P (2009) Head injuries in winter sports: Downhill skiing, snowboarding, sledding, snowmobiling, ice skating and ice hockey. Phys Med Rehabil Clin N Am 20(1):287–293
23. Franz T, Hasler RM, Benneker L, Zimmermann H, Siebenrock KA, Exadaktylos AK (2008) Severe spinal injuries in alpine skiing and snowboarding: a 6-year review of a tertiary trauma centre for the Bernese Alps ski resorts, Switzerland. Br J Sports Med 42(1):55–58. doi:10.1136/bjsm.2007.038166
24. Spörri J, Kröll J, Amesberger G, Blake OM, Müller E (2012) Perceived key injury risk factors in World Cup alpine ski racing—an explorative qualitative study with expert stakeholders. Br J Sports Med. bjsports-2012-091048
25. Brunner F, Ruedl G, Kopp M, Burtscher M (2015) Factors associated with the perception of speed among recreational skiers. PLoS One 10(6):e0132002
26. Dickson TJ, Terwiel FA, Waddington GS, Trathen S (2012) Easiest routes and slow zones: how fast do I go?: speeds and distances of recreational and expert snowsport participants. In: Johnson RJ, Shealy JE, Greenwald RM, Scher I (eds) STP 1553 skiing trauma and safety: 19th volume. ASTM International, West Conshohocken, PA, pp 184–197. doi:10.1520/STP104413
27. Dickson TJ, Waddington G, Trathen S, Baltis D, Adams R (2013) Technology applications to enhance understanding of real-time snowsport head accelerations. Procedia Eng 60(0):220–225. doi:10.1016/j.proeng.2013.07.079
28. Ruedl G, Brunner F, Woldrich T, Faulhaber M, Kopp M, Nachbauer W, Burtscher M (2013) Factors associated with the ability to estimate actual speeds in recreational alpine skiers. Wilderness Environ Med 24(2):118–123. doi:10.1016/j.wem.2012.11.021
29. Scher I, Richards D, Carhart M, Thomas R, Hurlen N, Lam T (2008) Pediatric head and neck injuries in snow sports: evaluating the influence of helmets. J ASTM Int 5(4):91–100
30. Shealy JE, Ettlinger CF, Johnson RJ (2005) How fast do winter sports participants travel on alpine slopes? J ASTM Int 2(7):12092–12098
31. Williams R, Delaney T, Nelson E, Gratton J, Laurent J, Heath B (2007) Speeds associated with skiing and snowboarding. Wilderness Environ Med 18(2):102–105
32. ASTM International (2000) F2040 Standard specification for helmets used for recreational snow sports. ASTM International, West Conshohocken, PA
33. Canadian Standards Association (2009) CSA Z263.1–08 Recreational alpine skiing and snowboarding helmets. Ontario

34. European Committee for Standardization (1996) EN 1077:1996 Helmets for alpine skiers. European Committee for Standardization, Brussels.
35. Snell Memorial Foundation (1998) 1998 Standard for Protective Headgear RS-98 For Recreational Skiing and Snowboarding. http://www.smf.org/standards/ski/rs98std.html. Accessed 18th May 2009
36. Editor (2014) Families approve of increased slow zone safety. The Whistler News
37. Fidel S (2010) Reckless skier hurts 6-year-old girl. Deseret News
38. Scher I, Richards D, Carhart M (2006) Head injury in snowboarding: Evaluating the protective role of helmets. J ASTM Int 3(4):14203–14209
39. Shealy JE, Johnson RJ, Ettlinger CF, Scher I (2015) Role of helmets in mitigation of head injuries: epidemiologic study of head injuries to skiers. In: Johnson RJ, Shealy JE, Greenwald RM (eds) Skiing trauma and safety: 20th volume, STP1582 ASTM international, West Conshohocken, PA, pp 22–36
40. Canadian Ski Instructor's Alliance (2011) Canadian Ski teaching. Canadian Ski Instructor's Alliance, Montreal, QB
41. Canadian Ski Instructor's Alliance (2013) Canadian Ski teaching
42. Dickson TJ, Terwiel FA, Waddington G, Trathen S (2011) Evaluation of the use of a GPS data-logging device in a snowsport environment. Procedia Eng 13:470–475. doi:10.1016/j.proeng.2011.05.116
43. Poulos R, Donaldson A, Finch C (2010) Towards evidence-informed sports safety policy for New South Wales, Australia: assessing the readiness of the sector. Inj Prev 16(2):127–131
44. Ruedl G, Pocecco E, Sommersacher R, Gatterer H, Kopp M, Nachbauer W, Burtscher M (2010b) Factors associated with self-reported risk-taking behaviour on ski slopes. Br J Sports Med 44(3):204–206. doi:10.1136/bjsm.2009.066779
45. Shealy JE, Stepan L (2013) Head Injury and Helmets in Skiing & Boarding. Paper presented at the Can West Ski Areas Association Spring Meeting, 6th–9th May, Kelowna, BC, Canada
46. Canadian Ski Council (2011) 2010–2011 Canadian Skier and Snowboarder Facts and Stats
47. Landsberger HA (1958) Hawthorne revisited: Management and the worker: its critics, and developments in human relations in industry. Cornell Studies Series, vol 9. Cornell University, New York

Factors Associated with Alcohol Intake in Mountain Top Huts Among Slope Tourers

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Abstract Introduction: Ski touring along ski slopes (slope touring) has increased in recent years on Austrian ski slopes. Alcohol consumption is proposed to be a risk factor in winter sports-related accidents. The aim of this study was to evaluate factors associated with alcohol intake among uninjured slope tourers.

Methods: A total of 328 slope tourers (45% females) with a mean age of 43.8 ± 11.8 years were questioned in February and March 2014 in two huts at the top of two Austrian ski areas. Questionnaires were conducted during daytime (9.00 a.m.–4.00 p.m.) and nighttime hours (5.00 p.m.–9.45 p.m.) with a following breath alcohol test. Slope tourers filled in on demographics, skill level, risk-taking behavior, ski helmet use, and alcohol consumption. In addition, slope tourers who had consumed alcohol were asked to estimate their individual breath alcohol level.

Results: In total, 187 (57%) of the slope tourers reported that they had consumed alcohol at the hut. Male sex, a higher BMI, more ski touring experience, and less ski helmet use were significantly associated with alcohol intake among slope tourers. Mean-tested breath alcohol level was 0.24 ± 0.17‰; this significantly differed from the mean estimated breath alcohol level of 0.18 ± 0.12‰. Male slope tourers had a significantly higher breath alcohol level than female slope tourers (0.26 ± 0.17 vs. 0.22 ± 0.15‰, $p = 0.014$).

Conclusion: Approximately 60% of interviewed slope tourers, predominantly males, consumed alcohol in the huts. In addition, male slope tourers had a significantly higher breath alcohol level compared to female slope tourers and mean-tested breath alcohol level was underestimated by approximately 25% on average.

Keywords Ski touring • Slope touring • Alcohol consumption • Risk factors

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1 Introduction

In the Austrian mountainous regions alone, there is an estimated number of eight million ski visitors per year [1]. Slope touring (= the ascending of a ski slope with ski touring equipment and following downhill skiing on the slope) has increased throughout the years with an estimated number of 80,000 slope tourers on Austrian ski slopes per year [2]. The region around the city of Innsbruck hosts approximately 30,000 slope tourers per year [3]. Reasons given for the growing number of slope tourers include the easy ascent, physical activity-related health promotion, no risk of avalanches on slopes, and social aspects [3]. This progress, however, often causes troubles with the lift companies because of safety risks through ascending slope tourers during daytime hours and descending slope tourers during nighttime hours [2]. Overall, little is known about injuries and risk factors in slope touring. In a preliminary study, Ruedl et al. investigated potential factors associated with injuries in slope touring [2]. More than 450 slope tourers (60.1% males) with a mean age of 39.3 ± 14.4 years reported that they perform about 20.6 ± 16.0 slope tours per season mainly with a partner (48%) and during the day (51%) [2]. A total of 57 persons (12.6%) reported that they have suffered at least one injury during slope touring that required medical care; this corresponds to a rate of six injuries per 1000 slope tours. Main causes of injury were falls (78%) and collisions with another person (15%), and the main injured body part was the knee (36%) [2]. Slope tourers with an injury history were more likely to report wearing back protectors and to have experienced more falls during downhill skiing [2]. They were also more likely to report listening to music more often during downhill skiing and to consume alcohol more frequently in the hut compared to slope tourers without an injury history [2]. In a survey among slope tourers, participants reported to fear an injury mostly through a collision with intoxicated, descending skiers while ascending the mountain uphill or an accident with the cable winch of a snow groomer while skiing downhill on the slope during night [4]. As alcohol consumption is often associated with winter sports-related injuries [5], the aim of this study was to evaluate factors associated with alcohol intake among uninjured slope tourers.

2 Methods

Slope tourers were assessed at two different skiing huts (>750 m of ascent) in Tyrol, Austria. Assessments took place during daytime (9.00 a.m.–4.00 p.m.) and nighttime hours (5.30 p.m.–9.45 p.m.) in February and March 2014. The mean duration of completing the questionnaires was about 15–25 min. Inclusion criterion was the ascent of the person with skis. Eight persons cancelled the participation at an early stage and were therefore excluded. Before leaving the hut, participants were asked to perform an alcohol breath test with the LION FUEL CELL SENSOR 500 to measure their breath alcohol concentration; to avoid false-positive results, a time interval of at least 15 min after the last drink was assured before breathalyzing.

Besides sociodemographic data (age, sex, BMI, education degree), participants were asked about their subjective skill level (beginner/intermediate, advanced, expert) according to Sulheim et al. [6] and risk-taking behavior (more cautious vs. more risky) according to Sulheim et al. [7] and Ruedl et al. [8], years of experience in ski touring, weekly frequency of ski touring (regularly = minimum one tour per week vs. irregularly), amount of persons in the group (alone vs. two persons vs. three and more persons), and ski helmet use. Additionally, participants had to answer questions about how frequently they consumed alcohol during the last five ski tours (never vs. once vs. several times vs. always), their perceived alcohol intake (Do you feel intoxicated?—not at all vs. little vs. moderate vs. strongly), and their estimated alcohol level (in ‰).

3 Statistical Analysis

Data are presented as means and standard deviations and as absolute and relative frequencies. Chi-square tests were used to compare the groups of slope tourers with and without alcohol intake regarding sex, education degree, time of the day (day vs. night), skill level, risk-taking behavior, helmet use, group size, and ski touring frequency. Mann-Whitney-U Tests were used to compare both groups (alcohol vs. no alcohol intake) regarding age, BMI, and years of experience. In addition, Mann-Whitney-U Tests were used to compare mean breath alcohol level between male and female slope tourers. One-way ANOVAs were used to calculate differences between mean alcohol level and perceived alcohol intake, and between mean breath alcohol level and alcohol consumption during the last five ski tours. Spearman correlation analyses were used to show relationships between estimated and measured breath alcohol level. All p-values were two-tailed and values of $p < 0.05$ were considered to indicate statistical significance.

4 Results

A total of 328 slope tourers (45% females) with a mean age of 43.8 ± 11.8 years and a mean BMI of 23.0 ± 2.9 participated in this study. The majority of the slope tourers were advanced skiers (55%) and performed their sport in a favored group size of two people (75%).

In total, 187 (57%) of slope tourers stated that they consumed alcohol in the hut. Mean-tested breath alcohol level was 0.24 ± 0.17‰ (range: 0–1.32‰) which significantly differed from the mean estimated breath alcohol level of 0.18 ± 0.12‰ (range: 0–0.5‰) ($p < 0.001$). Male slope tourers had a significantly higher breath alcohol level than female slope tourers (0.26 ± 0.17 vs. 0.22 ± 0.15‰, $p = 0.014$).

None of the slope tourers with alcohol intake felt strongly intoxicated. In total, 11 (6%) participants felt moderately intoxicated with a tested mean alcohol level of

0.45 ± 0.35‰, 50 (27%) participants felt little intoxicated with a tested mean alcohol level of 0.29 ± 0.17‰, and 126 (67%) participants did not feel intoxicated at all with a tested mean alcohol level of 0.21 ± 0.12‰. The subjective feeling of intoxication showed a significant difference between the three groups in terms of the tested breath alcohol level ($p < 0.001$). There was a strong, significant correlation between estimated and measured breath alcohol level ($r = 0.854$; $p < 0.001$).

Regarding the alcohol consumption during the last five ski tours, one-way ANOVA showed that those participants who drank always ($N = 44$; mean alcohol level of 0.32 ± 0.22‰) or several times ($N = 83$; mean alcohol level of 0.24 ± 0.14‰) had significantly higher mean alcohol levels than those who drank just once ($N = 46$; mean alcohol level of 0.18 ± 0.11‰) or never ($N = 12$; mean alcohol level of 0.20 ± 0.12‰) ($p < 0.001$).

Table 1 shows two groups of slope tourers divided into an Alcohol Intake Group (AIG) and a No-Alcohol Intake Group (NAIG). AIG significantly differed from NAIG regarding sex, BMI, ski touring experience, and ski helmet use (see Table 1).

5 Discussion

The aim of this study was to evaluate factors associated with alcohol intake among slope tourers who visited mountain top huts in Austria in the winter of 2014. In total, 57% of the slope tourers stated that they consumed alcohol in the hut. Based on data collected from self-report questionnaires, male sex, higher BMI, more ski touring experience, and less ski helmet use were significantly associated with alcohol intake among slope tourers. In addition, male slope tourers had a significantly higher breath alcohol level than female slope tourers and mean-tested breath alcohol level was significantly higher (about 25%) compared to the mean estimated breath alcohol level.

The cohort of slope tourers in the current study with a mean age of about 44 years consisted primarily of males (55%). In comparison, in the study on slope tourers by Ruedl et al. 60% were males and mean age was about 39 years [2]. Furthermore, the high number of slope tourers with a self-estimated advanced or expert skiing skill level and the favored group size of two persons remain comparable throughout various studies [2, 4, 9].

The high number of slope tourers with alcohol consumption in this study must be viewed with caution as it needs to be taken into account that assessments were conducted in the huts. Since not all slope tourers visit the huts, a much lower proportion of alcohol consumption may be observed if tests were conducted of slope tourers in the parking area.

In the current study, 66% of slope tourers who consumed alcohol were males and the mean breath alcohol level was significantly higher among male compared to female slope tourers. Those sex differences regarding alcohol consumption are widely known [10, 11] and occur even in adolescence [12]. Schmid stated that in young adults aged 19–20 years, 62% of males and 32% of females consume alcohol

Table 1 Characteristics of factors associated with alcohol intake among slope tourers

		AIG	NAIG	*p*
Sex, N^a (%)	Female	63 (34)	86 (61)	<0.001**
	Male	124 (66)	54 (39)	
BMI (mean ± SD)		23.3 ± 2.9	22.6 ± 2.8	0.007**
Age (mean ± SD)		44.5 ± 11.3	42.8 ± 12.4	0.172
Education/degree, N^a (%)	Compulsory school graduation/apprenticeship	55 (29)	40 (28)	0.152
	A level	50 (27)	24 (17)	
	University	66 (35)	50 (43)	
	Other education	16 (9)	17 (12)	
Ski touring frequency, *N* (%)	Regularly: min 1/week	129 (69)	61 (43)	0.116
	Unregularly	58 (31)	80 (57)	
Group size[a], *N* (%)	Alone	34 (18)	27 (19)	0.561
	Two people	100 (54)	82 (59)	
	Three or more	52 (28)	30 (22)	
Skill level, *N* (%)	Beginner/intermediate	24 (13)	27 (19)	0.306
	Advanced	142 (76)	104 (74)	
	Expert	21 (11)	10 (7)	
Ski touring experience [years] (mean ± SD)		15.8 ± 11.8	10.7 ± 9.2	<0.001**
Time of day, *N* (%)	Day	70 (37)	61 (44)	0.262
	Night	117 (63)	79 (56)	
Helmet, *N* (%)	Yes	68 (36)	70 (50)	0.019*
	No	119 (64)	71 (50)	
Risk-taking behavior[a], *N* (%)	More cautious	147 (80)	117 (84)	0.347
	More risky	38 (20)	23 (16)	

AIG alcohol intake group, *NAIG* no-alcohol intake group
*$p \leq 0.05$, **$p \leq 0.01$
[a]Due to missing data, the number of participants does not sum up to $N = 328$

[12]. In accordance, it has been reported that mean blood alcohol concentrations are significantly higher in a cohort of uninjured male skiers and snowboarders compared to uninjured female skiers and snowboarders [13].

Mean breath alcohol level of slope tourers was 0.24 ± 0.17‰ with a range from 0–1.32‰. In comparison, Li et al. stated that in biking, a blood alcohol concentration of 0.02 g/dL (≙ 0.16‰) raises the risk of a fatal or serious injury about 5.6 times and a blood alcohol concentration of 0.08 g/dL (≙ 0.65‰) increases the risk of a fatal or serious injury about 20.2 times [14]. Gaudio et al. detected in a cohort of 200 skiers and snowboarders with a major injury trauma that a high blood concentration was present in 43% of patients [5]. In addition, in the study by Ruedl et al., slope tourers with an injury history reported greater alcohol consumption in the hut compared to slope tourers without an injury history [2]. Therefore, one could assume that alcohol consumption would be a major risk factor for injuries on ski slopes. However, to evaluate the impact of alcohol consumption on injury risk among winter sport participants, a case-control study design comparing the breath or blood alcohol levels of injured to uninjured persons would be necessary. Earlier studies using such a study design, however, found no significant differences with respect to mean blood alcohol concentration between injured and uninjured winter sport participants [13, 15, 16]. In contrast, Burtscher et al. stated that alcohol consumption on the skiing day was a risk factor for falls in skiers and snowboarders [17]. This might be due to the fact that alcohol consumption impairs the central nervous system function, resulting in decrements in cognitive function and motor skills [18]. Although a fall does not imply an injury, self-inflicted falls are the major cause for injuries during skiing and snowboarding [17].

The present study found that slope tourers significantly underestimated their breath alcohol level considering that the mean-tested breath alcohol level was about 25% higher compared to the mean estimated breath alcohol level. Underestimation of alcohol intoxication might be a risk factor for a fall causing an injury on the ski slope.

Regarding participants' perceptions of alcohol consumption, none of the slope tourers with alcohol intake reported feeling strongly intoxicated, and a decreasing perception of the individual alcohol level was significantly associated with a decreasing mean-tested breath alcohol level. This result implies that many of the slope tourers may be unaware of the fact that there is sufficient alcohol in their system to potentially cause impairments. Even low doses of alcohol significantly produced more incorrect reactions during a peripheral vision test [19] and might have further impacts on athletic and cognitive performance [18, 20].

In this study, a higher frequency of alcohol consumption during the last five ski tours was significantly associated with a higher mean breath alcohol level indicating a possible association between drinking frequency during ski tours and level of alcohol intoxication. In addition, slope tourers with alcohol consumption reported significantly higher BMIs compared to those without alcohol intake. This might be due to the fact that studies reported positive findings between alcohol intake and weight gain [21, 22].

Slope tourers with and without alcohol consumption did not differ in this study with regard to age, group size, educational degree, self-reported skill level, and risk-taking behavior. Group size or peer group are likely to influence alcohol consumption as studies have shown that team athletes consume more alcohol than individual athletes [10, 23, 24]; however, this result was not reflected in the present study.

Slope tourers with alcohol intake showed a significantly higher mean ski touring experience (16 vs. 11 years) compared to those who did not drink alcohol in the hut. Although studies indicate that sport participation is associated with alcohol use [25], to our knowledge, no literature is available concerning the years of sport participation and alcohol intake.

Slope tourers with alcohol intake were significantly less likely to report wearing a ski helmet compared to tourers with no alcohol intake (36 vs. 50% helmet use). This might be the result of the duration in sport participation because AIG slope tourers have engaged in their sport over a longer period of time (16 years vs. 11 years). Since helmet use rates have increased significantly over the last decade, the NAIG might have started slope touring with helmet right from the beginning. As Ruedl et al. presented, the head was involved in 14% of injuries among slope tourers [2]. A helmet would be a meaningful safety equipment to reduce head injury risk [7].

In conclusion, about 60% of the interviewed slope tourers consumed alcohol in the hut. Male sex, a higher BMI, a longer ski touring experience, and less ski helmet use were significantly associated with alcohol intake among slope tourers. In addition, male slope tourers had a significantly higher breath alcohol level than female slope tourers and mean-tested breath alcohol level was significantly higher compared to the mean estimated breath alcohol level by about 25%.

Obtained results require preventive interventions to reduce alcohol consumption among slope tourers. The interventions should be especially addressed to the group of male slope tourers with over 10 years of experience in ski touring and an age of about 40 years.

References

1. Burtscher M, Bodner T, Burtscher J et al (2013) Life-style characteristics and cardiovascular risk factors in regular downhill skiers: an observational study. BMC Publ Health 13:788. doi:10.1186/1471-2458-13-788
2. Ruedl G, Pocecco E, Kopp M et al (2015) Verletzungshäufigkeit und unfallursachen beim pistentourengehen—eine pilotstudie. Sportverletz Sportschaden 29(01):46–50. doi:10.1055/s-0034-1399181
3. Essl J, Koch W (2011) Pistentouren im Großraum Innsbruck: 3–10
4. Pröbstl U (2012) Skitourengeher auf pisten—neue zielgruppe oder trainingsvariante? Mountainmanager (4):54–55
5. Gaudio RM, Barbieri S, Feltracco P et al (2010) Impact of alcohol consumption on winter sports-related injuries. Med Sci Law 50(3):122–125
6. Sulheim S, Ekeland A, Bahr R (2007) Self-estimation of ability among skiers and snowboarders in alpine skiing resorts. Knee Surg Sports Traumatol Arthrosc 15(5):665–670. doi:10.1007/s00167-006-0122-x
7. Sulheim S, Holme I, Ekeland A et al (2006) Helmet use and risk of head injuries in alpine skiers and snowboarders. JAMA 295(8):919–924. doi:10.1001/jama.295.8.919
8. Ruedl G, Pocecco E, Sommersacher R et al (2010) Factors associated with self-reported risk-taking behaviour on ski slopes. Br J Sports Med 44(3):204–206. doi:10.1136/bjsm.2009.066779
9. Kopp M, Wolf M, Ruedl G et al (2016) Differences in sensation seeking between alpine skiers, snowboarders and ski tourers. J Sports Sci Med 15(1):11–16
10. Watten RG (1995) Sports, physical exercise and use of alcohol. Scand J Med Sci Sports 5(6):364–368
11. Greenfield TK, Room R (1997) Situational norms for drinking and drunkenness: trends in the US adult population, 1979–1990. Addiction 92(1):33–47
12. Schmid H (2002) Sport, alkohol, tabak und illegale drogen in der entwicklung von jugendlichen zu jungen erwachsenen. Zeitschrift für Gesundheitspsychologie 10(1):36–48. doi:10.1026//0943-8149.10.1.36
13. Salminen S, Pohjola J, Saarelainen P et al (1996) Alcohol as a risk factor for downhill skiing trauma. J Trauma 40(2):284–287
14. Li G, Shahpar C, Soderstrom CA et al (2000) Alcohol use in relation to driving records among injured bicyclists. Accid Anal Prev 32(4):583–587

15. Bouter LM (ed) (1988) Alcohol consumption and injury risk in downhill skiing: Injury risk in downhill skiing. Results from an etiological case-control study conducted among Dutch skiers. In: Sportwetenschappelijke onderzoekingen, vol 14. De Vrieseborch, Haarlem, pp 89–107
16. Made C, Elmqvist L (1996) Downhill Skiing injuries in Lapland, Sweden: a survey including alcohol monitoring and one-year follow-up. In: Mote CD, Johnson RJ, Hauser W et al (eds) Skiing Trauma and Safety, vol 10. ASTM International, West Conshohocken, PA, pp 98-98-6
17. Burtscher M, Pühringer R, Werner I et al (2010) Gender-specific effects of smoking and alcohol consumption on the risk of falling in downhill skiers. J ASTM Int 7(7):102815. doi:10.1520/JAI102815
18. Shirreffs SM, Maughan RJ (2006) The effect of alcohol on athletic performance. Curr Sports Med Rep 5(4):192–196
19. Langer P, Holzner B, Magnet W et al (2005) Hands-free mobile phone conversation impairs the peripheral visual system to an extent comparable to an alcohol level of 4–5 g 100 ml. Hum Psychopharmacol 20(1):65–66. doi:10.1002/hup.654
20. Barnes MJ (2014) Alcohol: impact on sports performance and recovery in male athletes. Sports Med 44(7):909–919. doi:10.1007/s40279-014-0192-8
21. Sayon-Orea C, Martinez-Gonzalez MA, Bes-Rastrollo M (2011) Alcohol consumption and body weight: a systematic review. Nutr Rev 69(8):419–431. doi:10.1111/j.1753-4887.2011.00403.x
22. Schrieks IC, Stafleu A, Griffioen-Roose S et al (2015) Moderate alcohol consumption stimulates food intake and food reward of savoury foods. Appetite 89:77–83. doi:10.1016/j.appet.2015.01.021
23. Lorente FO, Souville M, Griffet J et al (2004) Participation in sports and alcohol consumption among French adolescents. Addict Behav 29(5):941–946. doi:10.1016/j.addbeh.2004.02.039
24. Kulesza M, Grossbard JR, Kilmer J et al (2014) Take one for the team? Influence of team and individual sport participation on high school athlete substance use patterns. J Child Adolesc Subst Abuse 23(4):217–223. doi:10.1080/1067828X.2013.786928
25. Kwan M, Bobko S, Faulkner G et al (2014) Sport participation and alcohol and illicit drug use in adolescents and young adults: a systematic review of longitudinal studies. Addict Behav 39(3):497–506. doi:10.1016/j.addbeh.2013.11.006

To What Extent Do Attitudes Regarding Ski Helmets Change After a Period of Utilization?

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Abstract Background: Common reasons reported for helmet non-use are impaired hearing and impaired vision and an increasing level of risk taking. Therefore, health communication programmes should be instituted to get non-helmeted skiers and snowboarders to try out helmets to eliminate their potential prejudices. Aim: to evaluate whether and to what extent attitudes regarding ski helmets change after a period of utilization. Methods: Subjects who wanted to borrow a ski helmet in a ski rental shop had to rate 14 attitudes about ski helmets using a 5-point Likert scale two times (1) before they borrow a helmet and (2) after the return of the helmet. Results: A total of 231 (43.7% females) subjects with a mean age of 35.2 ± 14.3 years participated. A ski helmet was used never before, one time, and more times by 21.2, 16.7, and 62.1%, respectively. There was a significant increase after borrowing in the agreement that all winter sport participants should wear a ski helmet ($p = .003$), and that a ski helmet damages the hairstyle ($p = .021$) while there was a decreasing agreement that a ski helmet looks good/is stylish ($p = .030$). According to a factor analysis, attitudes about ski helmets clustered around two major dimensions—"safety awareness/comfort" and "subjective disadvantages" explaining 42–43% of the overall variance. A significant increase in the dimension "safety awareness/comfort" from pre- 31.8 ± 5.9 to post-borrowing 32.6 ± 5.9 ($p < .001$) was found while the dimension "subjective disadvantages" did not significantly change (pre: 18.6 ± 4.3 vs. post: 19.1 ± 4.3, $p = .091$). Regarding subgroup analysis with these two dimensions, previous helmet use (never before vs. one time vs. more times) did not show significant differences in the change in attitudes. Conclusion: The ski helmet-related dimension "safety awareness/comfort" significantly increased after a period of utilization, irrespective of previous helmet use.

Keywords Ski helmet • Attitude change • Safety behaviour • Alpine skiing • Snowboarding • Head injury

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1 Introduction

In recreational alpine skiing and snowboarding, the prevalence of all injuries to the head account for up to 20% of all injuries occurred on ski slopes [1–3]. In past years, ski helmet usage rate on ski slopes increased up to 80% among recreational skiers and snowboarders [2–4]. Although there is convincing evidence of head protective effects by wearing ski helmets [1, 3, 5], about 20% of skiers and snowboarders do not wear a ski helmet yet on ski slopes [3, 4].

Common reasons reported for helmet non-use are impaired hearing, impaired vision, and an increasing level of risk taking [6–8]. In a previous study by Ruedl et al. [9], more than 900 persons scored 14 statements on a five-level Likert scale about their attitudes regarding ski helmets. While results of this study showed little disagreement on the important features of helmets that they could save lives, that they do not promote risk compensation and that adults wearing a ski helmet are positive role models, helmeted and non-helmeted skiers, and snowboarders differed in far less fundamental issues (e.g. hearing, hairstyle, costs), which might be more amenable to attitude change [9]. Therefore, health communication programmes should be instituted to get non-helmeted skiers and snowboarders to try out helmets to eliminate their potential prejudices. According to Andersen et al. [10], helmet campaigns should be based on Roger's "Trialability from Diffusion of Innovation Theory" [11] because the ability to utilize an innovation for a trial period is positively correlated with its rate of adoption [10]. From a health psychological approach there is a lack of knowledge how practicing the behaviour might influence attitudes toward the behaviour or subjective norms as most of the models neglect consequences of behaviour (i.e. theory of planned behaviour, TBP, Ajzen [12]). In interpreting the results from our earlier study [9] we used the Transtheoretical Model (TTM) and concluded that specific information in the second stage, "contemplation", might foster at least the preparation of behaviour change [13]. In a further step, it seems necessary to focus on the stage of "action" relying on this model. Therefore, the aim of the study was to evaluate whether and to what extent attitudes regarding ski helmets change after a period of utilization.

2 Methods

2.1 Study Design

Pre-/post-survey

2.2 Subjects

German-speaking skiers and snowboarders who wanted to borrow a ski helmet in one out of three ski rental shops during three consecutive winter seasons from 2012/13 to 2014/15 were randomly invited to participate. Subjects had to rate attitudes about ski helmet use two times (1) before they borrow a helmet and (2) after the return of the helmet. Subjects were asked then for how many days they borrowed the helmet and whether they wore the ski helmet (yes vs. no. vs. sometimes). More than 80% of participants filled out also the second questionnaire.

Inclusion criteria were an age >17 years and that subjects wore the helmet at least partially during the borrowing time. Informed consent was obtained from all subjects prior to participating in this research. This study was approved by the Institutional Review Board of the Department of Sport Science, University of Innsbruck.

2.3 Questionnaire

The same 14 questions about attitudes regarding ski helmet use according to our previous work [9] were used (Fig. 1, Table 1). Participants scored the 14 statements about ski helmets on a five level Likert scale (I disagree totally—I rather disagree—I disagree/agree partly—I rather agree—I agree totally). In addition, information on sex, age, nationality (Austrian vs. others), preferred winter sport (skiing vs. snowboarding vs. others), self-estimated skill level (first-day skier/snowboarder, beginner, intermediated, advanced, expert), and risk-taking behaviour (more risky vs. more cautious) according to Ruedl et al. [14] were recorded. In addition, previous helmet use (never before vs. one time vs. more often) was asked. The fill in of the questionnaire took about 5 min.

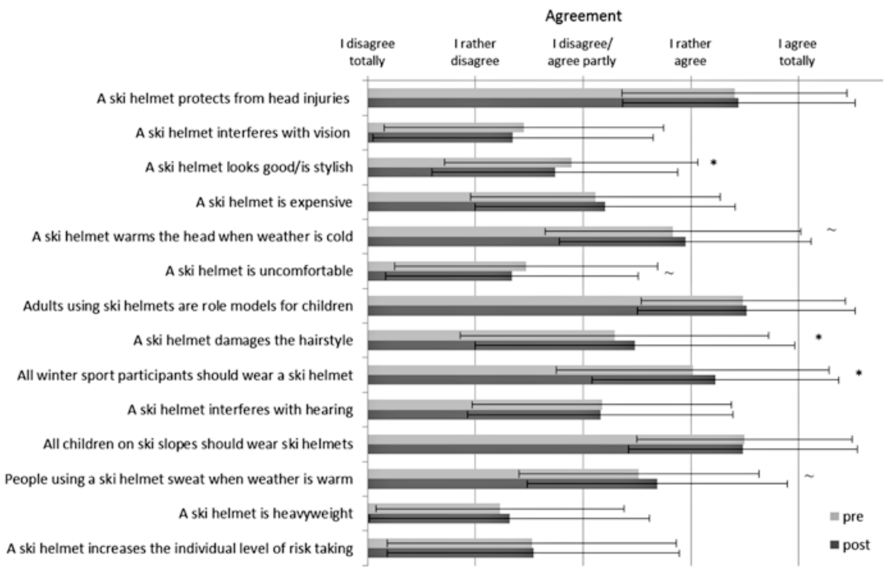

Fig. 1 Means and standard deviations of 14 statements on attitudes about ski helmets pre- and post-borrowing; $*p < .05$, $\sim p < .10$

Table 1 Ski helmet attitudes and factor loadings pre- and post-borrowing

	*F*1 (safety awareness/ comfort)		*F*2 (subjective disadvantages)	
	Pre	Post	Pre	Post
A ski helmet protects from head injuries	**.71**	**.66**	−.05	.08
A ski helmet interferes with vision	−.47	−.49	**.53**	**.46**
A ski helmet looks good/is stylish	.26	.09	**−.36**	**−.42**
A ski helmet is expensive	.02	.05	**.43**	**.48**
A ski helmet warms the head when weather is cold	**.81**	**.72**	.06	.07
A ski helmet is uncomfortable	**−.44**	**−.60**	.39	.30
Adults using ski helmets are role models for children	**.81**	**.75**	.03	.20
A ski helmet damages the hairstyle	.01	−.09	**.63**	**.61**
All winter sport participants should wear a ski helmet	**.69**	**.62**	−.28	−.16
A ski helmet interferes with hearing	−.08	−.08	**.65**	**.59**
All children on ski slopes should wear ski helmets	**.81**	**.76**	.03	.10
People using a ski helmet sweat when weather is warm	.13	.15	**.65**	**.67**
A ski helmet is heavyweight	**−.56**	**−.64**	.44	.30
A ski helmet increases the individual level of risk taking	**−.20**	**−.40**	.43	.28

2.4 Statistics

All statistical analyses were performed using SPSS (IBM, New York, USA).

Data are presented as means ± standard deviations if not otherwise stated. Wilcoxon tests were used to compare the mean tendency of the 14 items separately pre- and post-borrowing. In addition to the analysis of the single items, a principal components factor analysis (Varimax rotation) was applied to analyse the dimensions of underlying attitudes. This approach reduces the probability of a type I error. After defining the factor structure and reverse scoring of the negatively poled items, all items of each dimension were summarized. These calculated dimensions were the primary outcome parameters of the study. Cronbach's α was calculated for each dimension at both time points to determine the internal consistency of the dimensions.

The differences between the two time points were calculated for the dimensions and tested on group differences to check for different attitude changes after borrowing in certain subgroups. Since the data was not normally distributed (tested by Kolmogorov–Smirnov-Test), we used nonparametric methods to compare the subgroups (Mann–Whitney-*U*-Test for two subgroups and Kruskal–Wallis for more than two subgroups). To assess possible influences on changes of the attitudes of the participants' age and duration of borrowing, Spearman correlation was used.

All *p*-values were two-tailed and values of $p < .05$ were considered to indicate statistical significance while values of $p < .10$ were considered as tendencies.

3 Results

A total of 231 (43.7% females) subjects with a mean age of 35.2 ± 14.3 years fulfilled the inclusion criteria. Regarding nationality, 26.8% were Austrians and 73.2% were from other countries. The preferred winter sport was alpine skiing in 67.0%, snowboarding in 29.6%, and other sports in 3.4%. With regard to the self-estimated skill level, 8.3% were first-day skiers/snowboarders, 17.5% were beginners, 33.2% intermediated, 33.6% advanced, and 7.4% experts. A total of 54.1% considered themselves to be rather cautious on ski slopes. A ski helmet was used never before, one time, and more times by 21.2, 16.7, and 62.1%, respectively. Mean borrowing time of the ski helmet was 5.1 ± 3.4 days.

Figure 1 shows means and standard deviations of all single items pre- and post-borrowing. There was a significant increase after borrowing in the agreement that all winter sport participants should wear a ski helmet (p = .003) and that a ski helmet damages the hairstyle (p = .021) while there was a decreasing agreement that a ski helmet looks good/is stylish (p = .030). There were also trends of an increasing agreement that a ski helmet warms the head when the weather is cold (p = .058) and that people using a ski helmet sweat when the weather is warm (p = .071) as well as of a decreasing agreement that a ski helmet is uncomfortable (p = .090).

Since the four-dimensional solution of Ruedl et al. [9] could not be confirmed in our sample, we proposed a two-dimensional solution (Table 1; dimension 1 = safety awareness/comfort, dimension 2: subjective disadvantages). The scree-plots from the pre- and post-measurements indicated two dimensions on the basis of the points of inflexion. Thereby, 42.8% (pre) and 41.5% (post) of the overall variance could be explained. The dimension “safety awareness/comfort” showed a Cronbachs α pre- and post-helmet borrowing of .81 and .80, respectively, and the dimension “subjective disadvantages” showed a Cronbachs α pre- and post-of .61 and .57, respectively.

A significant increase in the dimension “safety awareness/comfort” from pre-31.8 ± 5.9 to post-borrowing 32.6 ± 5.9 (p < .001) was found while the dimension “subjective disadvantages” did not significantly change (pre: 18.6 ± 4.3 vs. post: 19.1 ± 4.3, p = .091). Regarding subgroup analysis with these two dimensions, neither factors preferred winter sport, sex, and nationality, nor self-estimated skill level, and risk-taking behaviour, nor previous helmet use showed significant differences in the change in attitudes. However, when never-helmet users, one-time helmet users and frequently helmet users were compared at pre- and post-time points separately (Table 2), Kruskal Wallis test showed differences in the factor “safety awareness/comfort” (both p < .05). Post hoc comparisons revealed that one-time helmet users scored significantly lower in “safety awareness/comfort” than frequently helmet users both pre- (p = .004) and post-borrowing (p = .009). At pre-borrowing, never-helmet users scored significantly lower in “safety awareness/comfort” than frequently helmet users (p = .015).

No significant correlation between the duration of borrowing, age, and the change of attitudes could be observed.

Table 2 Means and standard deviations of the two dimensions in different subgroups of the factor previous helmet use pre- and post-loaning

		Previous helmet use			
		Never	One time	Frequently	*p*
Safety awareness/comfort	Pre	30.2 ± 6.0	29.3 ± 6.9	33.0 ± 5.5	.001
	Post	31.4 ± 6.8	30.0 ± 6.6	33.5 ± 5.3	.009
Subjective disadvantages	Pre	19.3 ± 3.9	19.6 ± 4.3	18.2 ± 4.2	.159
	Post	19.9 ± 4.6	19.8 ± 3.8	18.7 ± 4.5	.311

P value according to the Kruskal–Wallis test

4 Discussion

The aim of the study was to evaluate whether and to what extent attitudes regarding ski helmets changed after a period of utilization. As a main result a significant increase in the dimension “safety awareness/comfort” was found after returning the helmets while the dimension “subjective disadvantages” did not significantly change. In addition, frequently helmet users showed a significant higher score within the dimension “safety awareness/comfort” compared to one-time helmet users.

In our earlier work, the dimension “subjective disadvantages” including attitudes about hearing, vision, sweating, hairstyle, costs, and weight was highly predictive (OR: 2.3) for helmet non-use while the dimension “safety awareness” was negatively associated with helmet non-use (OR: 0.3), i.e. skiers with higher safety awareness are more likely to wear ski helmets [9]. We therefore speculated that the less fundamental issues of the dimension “subjective disadvantages” would be more amendable to attitude change when non-helmeted skiers and snowboarders try out helmets to eliminate their potential prejudices [9]. However, current results in this study found no attitude change in the dimension “subjective disadvantages” while the dimension “safety awareness/comfort” increased to a small but significant extent.

Interestingly, post hoc analysis revealed significant higher scores within the dimension “safety awareness/comfort” among frequently helmet users compared to persons who never wore a ski helmet before and who once wore a ski helmet before, respectively. Keeping in mind TPB [12] and TTM [13], one might argue that practising the behaviour might influence attitudes toward the behaviour itself and subjective norms related to this behaviour. Interpreted with caution, acceptable consequences of a repeated behaviour may increase the chance to enter the stage of “maintenance” in the TTM [13] abetted by redefined attitudes and subjective norms.

With regard to the significant results of single items, after the returning of the helmet, participants agreed to a significantly higher extent that all winter sports participants should wear a ski helmet. In the study by Ruedl et al. [9] also about one-third of helmet non-wearers advocated helmet use for all winter sport participants possibly indicating an overall acceptance that a ski helmet protects from head injuries.

Russell et al. [1] found in their meta-analysis that ski helmet use could reduce head injury risk by 35% in the general ski population and by 59% in children. In addition, a study by Rughani et al. [5] showed that ski helmet use was associated with reduced rates of skull fractures among hospitalized children. More recently, Shealy et al. [3] observed that ski helmet use offers very effective mitigation for head injuries such as skull fractures and scalp lacerations. In addition, Shealy et al. [3] found that an increased use of helmets was also associated with a significant reduction in potentially serious head injuries, as well as all head injuries.

After the returning of the helmet, participants agreed to a significantly less extent that a ski helmet looks stylish. The style factor of a ski helmet might be an important individual factor when people decide to buy a helmet. Therefore, manufacturers of ski helmets continuously try to improve the style, weight, air ventilation, and comfort of their products.

In addition, after returning the borrowed helmet participants also agreed to a significantly higher extent that a ski helmet damages the hairstyle. In comparison, in the study by Ruedl et al. [9] about a quarter of helmet wearers and non-wearers found that a helmet damages one's hairstyle. However, keeping in mind that most head injuries occur when the skier or snowboarder hits his head on the snow during a self-inflicted fall [15], head protection should be more important than hairstyle protection. In addition, when using a ski cap instead of a ski helmet, hairstyle also would be damaged.

In this study, no significant changes could be found according to the most common reported reasons for helmet non-use, i.e. impaired hearing, impaired vision, and an increasing level of risk taking [6–8]. As shown in Fig. 1, the mean level of agreement to these three questions was relatively low compared to other questions. With regard to these three issues and beside the subjective attitudes of the individuals, there are some evidence-based results from recent studies. Tudor et al. [16] and Ruedl et al. [17] found that compared to a ski cap a ski helmet showed an increased hearing threshold. However, according to Ruedl et al. [17] the degree of the hearing impairment when using a ski helmet is less than what is termed as a hearing impairment. In addition, as most injuries on ski slopes occurred after a self-inflicted fall without involvement of another skier or snowboarder [2, 15, 18], compared to an impaired hearing an impairment of vision might be a more essential factor for safety in alpine skiing.

Regarding a limited field of vision when wearing a ski helmet, a study found that not the ski helmet per se but an additional use of ski goggles increased mean reaction time when using a continuous-tracking-test combined with peripheral signals [19].

According to the so-called risk-compensation hypothesis, there is an ongoing debate whether the use of a ski helmet provides a false sense of security, resulting in a riskier behaviour on ski slopes [20–22]. We found in a study [14] that self-reported risk-taking skiers and snowboarders skied on average 8 km/h faster than cautious persons; however, helmet use was nearly equal in both groups. Also, Scott et al. [22] found no evidence of risk compensation in their study. In addition, in past years ski helmet use increased up to 80% of the overall population on ski slopes [3, 4] expecting also partly an increase in the overall rate of ski injuries due to self-inflicted falls or collisions with other winter sport participants if ski helmet use would increase one's risk-taking behaviour. However, ski injury rate continuously decreased during the last decades [18, 23] while at the same time ski helmet rate continuously increased [2, 3].

In general, the results of this study show that practicing a new safety or health behaviour has the potential not only to influence perceived behavioural control as indicated in the theory of planned behaviour but also attitudes toward the behaviour. According to the TTM of behaviour change [13], not only information but also practising the behaviour should be implemented in helmet campaigns focusing to increase helmet use on ski slopes. This aspect might be interesting to foster more research on the short- and long-term consequences after enhancing new health and safety behaviours.

When interpreting the results of our study, it has to be taken into account that the reported effects of wearing a ski helmet were relatively small which might partly due to a mean borrowing time of only 5 days. It is therefore unknown, how repeatable the observed effects are in future studies. Furthermore, a prospective study design would bring out more reliable results. Factor analysis of the 14 statements on ski helmet attitudes in this study showed a two dimensions solution contrasting the four dimensions solution in our earlier study [9] which might be due to differences in the number of participants, sex distribution, mean age, preferred winter sport, etc. between the two studies. However, the current solution explained about 43% of the overall variance which is in accordance with 48% in the study by Ruedl et al. [9]. Cronbachs α pre- and post-helmet borrowing of .81 and .80 for the dimension "safety awareness/comfort" and Cronbachs α pre- and post-helmet borrowing of .61 and .57 for the dimension "subjective disadvantages" are higher compared to the equivalent values of these two dimensions of .59 and .52, respectively, in the study by Ruedl et al. [9]. However, an attitude questionnaire previously validated would facilitate the embedding in psychological literature.

Furthermore, results of this study are limited by the fact that only German-speaking people were asked and that during the data collection period the helmet-wearing rate in Austria increased from about 60% to about 80%. However, this study was the first of its kind to observe effects of a period of utilization on ski helmet-related attitudes.

In conclusion, repeatedly trying out a ski helmet is positively associated with an increase in the dimension "safety awareness/comfort" of winter sport participants. Therefore, it is recommended to promote ski-helmet use during the general ski rental process by reducing barriers like additional costs or separate ways for customers.

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References

1. Russell K, Christie J, Hagel BE (2010) The effects of helmets on the risk of head and neck injuries among skiers and snowboarders: a meta-analysis. CMAJ 182(4):333–340
2. Ekeland A, Rodven A (2012) Alpine skiing, telemarking, snowboarding, and skiboarding injuries related to gender and ability. In: Johnson RJ, Shealy JE, Greenwald RM, Scher I (eds) Skiing trauma and safety, vol 19. ASTM International, West Conshohocken, pp 216–227
3. Shealy JE, Ettlinger CF, Johnson RJ, Scher I (2015) Role of helmets in mitigation of head injuries: epidemiologic study of head injuries to skiers. In: Johnson RJ, Shealy JE, Greenwald RM (eds) Skiing trauma and safety, vol 20. ASTM International, West Conshohocken, pp 22–36
4. Philippe M, Ruedl G, Woldrich T, Nachbauer W, Burtscher M (2014) How frequent and why are skiers and snowboarders fallin? Sportverletz Sportschaden 28(4):188–192
5. Rughani AI, Lin C, Ares WJ, Cushing DA, Horgan MA, Tranmer BI, Jewell RP, Florman JE (2011) Helmet use and reduction in skull fractures in skiers and snowboarders admitted to the hospital. J Neurosurg Pediatr 7:268–271
6. Cundy TP, Systermans BJ, Cundy WJ, Cundy PJ, Briggs NE, Robinson JB (2010) Helmets for snow sports: prevalence, trends, predictors and attitudes to use. J Trauma 69:1486–1490
7. Ruedl G, Kopp M, Burtscher M (2011) The protective effects of helmets in skiers and snowboarders. BMJ 342:d857
8. Terwiel A, Dickson T (2015) Helmets: what do snowsport instructors and guests know and expect? In: Johnson RJ, Shealy JE, Greenwald RM (eds) Skiing trauma and safety, vol 20. ASTM International, West Conshohocken, pp 3–21
9. Ruedl G, Kopp M, Rumpold G, Holzner B, Ledochowski L, Burtscher M (2012) Attitudes regarding ski helmet use among helmet wearers and non-wearers. Inj Prev 18(3):182–186
10. Andersen PA, Buller DB, Scott MD, Walkosz BJ, Voeks JH, Cutter GR, Dignan MB (2004) Prevalence and diffusion of helmet use at ski areas in Western North America in 2001-02. Inj Prev 10(6):358–362
11. Rogers EM (2003) Diffusion of innovations, 5th edn. The Free Press, New York
12. Ajzen I (2002) Perceived behavioral control, self-efficacy, locus of control, and the theory of planned behavior. J Appl Soc Psychol 32:665–683
13. Prochaska JO, DiClemente CC (1983) Stages and processes of self-change of smoking: toward an integrative model of change. J Consult Clin Psychol 51:390e5
14. Ruedl G, Pocecco E, Sommersacher R, Gatterer H, Kopp M, Nachbauer W, Burtscher M (2010) Factors associated with self-reported risk taking behaviour on ski slopes. Br J Sports Med 44(3):204–206
15. Greve MW, Young DJ, Goss AL, Degutis LC (2009) Skiing and snowboarding head injuries in 2 areas of the United States. Wilderness Environ Med 20(3):234–238
16. Tudor A, Ruzic L, Bencic I, Sestan B, Bonifacic M (2010) Ski helmets could attenuate the sounds of danger. Clin J Sport Med 20(3):173–178
17. Ruedl G, Seebacher J, Koci V, Stephan K, Weichbold V, Zorowka P, Burtscher M, Kopp M (2014) Effect of wearing a ski helmet or a ski cap on perception and localization of sounds. Int J Sports Med 35(8):645–650
18. Ruedl G, Philippe M, Sommersacher R, Dünnwald T, Kopp M, Burtscher M (2014) Current incidence of accidents on Austrian ski slopes. Sportverletz Sportschaden 28(4):183–187
19. Ruedl G, Herzog S, Schöpf S, Anewanter P, Geiger A, Burtscher M, Kopp M (2011) Do ski helmets affect reaction time to peripheral stimuli? Wilderness Environ Med 22:148–150
20. Hagel B, Meeuwisse W (2004) Risk compensation: a “side effect” of sport injury prevention? Clin J Sports Med 14:193–196
21. Ruedl G, Kopp M, Burtscher M (2012) Does risk compensation undo the protective effect of ski helmet use? Epidemiology 23(6):936–937

22. Scott MD, Buller DB, Andersen PA, Walkosz BJ, Voeks JH, Dignan MB, Cutter GR (2007) Testing the risk compensation hypothesis for safety helmets in alpine skiing and snowboarding. Inj Prev 13(3):173–177
23. Shealy JE, Ettlinger CF, Scher I, Johnson RJ (2015) 2010/2011 NSAA 10-year interval injury study. In: Johnson RJ, Shealy JE, Greenwald RM (eds) Skiing trauma and safety, vol 20. ASTM International, West Conshohocken, pp 93–111