Knee Surg Sports Traumatol Arthrosc
DOI 10.1007/s00167-006-0122-x

SPORTS MEDICINE

Self-estimation of ability among skiers and snowboarders in alpine skiing resorts

Steinar Sulheim · Arne Ekeland · Roald Bahr

Received: 9 December 2005 / Accepted: 30 January 2006

Abstract Skiing ability is thought to be an important risk factor for injuries, but the best method to classify skiing ability is not known. The objective of this study was to validate five different questions designed to self-report skiing ability for ski injury surveillance. To this end 512 alpine skiers, Telemark skiers, snowboarders and skiboarders were asked to selfestimate their skiing ability using five different questions based on skiing skill, piste difficulty, turning technique, skiing experience and falling frequency, each with four categories. The participants then made a test run to test their skiing ability. Observed and self-reported skiing ability were compared using kappa statistics. The correlation between observed and self-reported skiing ability was low to fair, with kappa values of 0.34 for skiing skill), 0.33 for piste difficulty, 0.38 for turning technique, 0.26 for experience and 0.16 for falling frequency. However, the sensitivity and specificity for each of the questionnaires in discriminating between individuals in the poorest skiing ability category on the test and the rest of the group was relatively good (skiing skill: sensitivity 75%, specificity 91%; piste difficulty 68, 96%; turning technique 75, 91%; experience 75, 90%; falling frequency 61, 97%). The results show that the capacity to self-assess skiing ability is limited, but estimation based upon turning technique or skiing skill seem to be best methods for epidemiological studies on injuries in snow sports.

Keywords Snow sport · Alpine skiing · Athletic injuries · Risk factors · Snowboarding

S. Sulheim · R. Bahr (✉)
Oslo Sports Trauma Research Center,
Department of Sports Medicine,
Norwegian School of Sport Sciences, Oslo 0806, Norway
e-mail: Steinar.sulheim@nih.no

R. Bahr
e-mail: roald.bahr@nih.no

A. Ekeland
Martina Hansens Hospital, Bærum, Norway

Introduction

In epidemiologic studies examining potential risk factors for skiing injuries, it is important to know the ability of the skier or snowboarder. Recent studies have established that beginners suffer far more injuries than more experienced skiers [2, 3, 4, 10, 15], and that skiing ability is the most important risk factor in itself [4]. It is also important to correct for ability when examining the effect of other risk factors or protective factors, e.g. helmet use [5, 16].

The estimation of ability is usually done through self-reporting based on a single question asking the skier to classify his ability into different categories. The most frequently used questions for this purpose have been based upon turning technique, experience, skill, or slope difficulty, self-reporting ability into three, four or five different categories. However, although a number of different questions have been used [2, 4, 10, 15], their ability to discriminate between better and less able skiers has not been studied. We wanted to validate five different questions designed to self-report skiing ability, aiming to identify the best questions to describe actual skill through self-reporting, to establish a standard for future epidemiological studies as well as for ongoing injury registrations at ski areas around the world.

Materials and methods

Throughout the winter season of 2002, a group of skiers and boarders in four different Norwegian alpine skiing resorts (Trysil, Hafjell, Hemsedal and Kvitfjell) were first asked to self-classify their ability based on a questionnaire and then we determined ability based on their performance during a test run. In addition, we recorded age, sex and equipment type used; alpine skis, Telemark skis (which permit a turning technique with free heel lift), snowboard or skiboards (short alpine skis with non-releasable bindings). Two test sessions were held at each resort from January through March 2002, with 64 participants each time.

The investigation took place in the main bottom runs of the resort, and we selected runs of different difficulty (easy to difficult) to recruit skiers with a range of different abilities. We were positioned in the middle of the run, where skiers could be observed in the open for at least 100 m above us, and then had at least 100 m of open area below us for the test run. When we were ready to do a new test, the next subject to be tested was selected as the third skier to pass an imaginary line in the snow at the top of the hill. Skiers with skiboards were oversampled to achieve a minimum sample five on each test occasion. Subjects were then observed unobtrusively during their run down to the test station to get a preliminary impression of ability, and then they were stopped. Consent was obtained after the subjects had been informed of the purpose of the study and that their participation was voluntary. Children were assisted by their parents when completing the form.

Skiers were first asked to self-record their ability by completing a questionnaire with five different questions based on *skiing skill*, *piste difficulty*, *turning technique*, *skiing experience* and *falling frequency*, each with four categories. *Skiing skill* was classified into four categories termed expert, advanced, intermediate or beginner [2, 9]. *Piste difficulty* was classified according to the most difficult run they were able to control: off-piste, black piste (difficult), red piste (medium difficulty) or blue piste/children's piste (easy) [4]. *Turning technique* was classified for alpine skiers and Telemark skiers as the most advanced technique they could control: carving/short turns, parallel turns, stem turns or plough [4]. For boarders the corresponding categories were carving/short turns, continuous turns, interrupted turns or just sliding on the edge. *Skiing experience* was classified into four categories termed "skiing more than 5 seasons", "3 to 5 seasons", "1 to 2 seasons", or "less than 1 season" [17]. The categories for *falling frequency* were "never", "falling now and then", "falling every day" or "falling every run" [6]. After completing the questionnaire, the participants were asked to make a test run under observation to define his or her skill level. The test run was made partly as a free ride, and partly through a slalom course set at the upper half of the run below us. The skier or snowboarder was asked to perform optimally, to demonstrate his or her maximum skill related to turning technique, continuous turns, carving and ability to make the run through a set course. The run was made under observation of two certified ski instructors, who determined his or her skill level. Each performance was discussed and a consensus decision was made on the spot. The ski instructors were unaware of how the subject had noted his/her skiing ability in the interview.

The observed skill level was thus registered into four categories, referred to as ploughing, hesitating, fluently or carving. *Ploughing* was the term used for skiers who could only make ploughing turns or for snowboarders that could not make turns, but simply just slide down on an easy slope. *Hesitating* was the next ability category, used for skiers who could not make parallel turns, but used a stem technique, or had to interrupt turns through stops, rotation, or by sliding sideways. The term was also used for snowboarders who could make turns to both sides, but not without interruption or stops in between. The third category—*smooth*—was used for advanced skiers or snowboarders who were able to make fluent continuous turns without interruptions. The most advanced category—*carving*—referred to the best skiers or snowboarders, who were able to make quick turns, carving turns and short turns through the set course.

Statistical methods

Observed and self-reported ability were compared using kappa analyses [1]. Coefficients of 0.81–1.00 are generally interpreted as very good, 0.61–0.80 as good, 0.41–0.60 as moderate, 0.21–0.40 as fair, and less than 0.20 as poor [1]. We also calculated the sensitivity and specificity in discriminating between skiers and snowboarders in the lowest skill group (i.e. in the ploughing category on the test run) and the more skilled subjects [7]. Sensitivity was calculated for each scoring scale as the number of subjects who were in the lowest skill group on the test divided by the number of subjects who reported themselves to be in the lowest skill category [7]. Specificity was calculated as the number of skilled subject who reported themselves to be skilled divided by the number of observed subjects who reported themselves to be in the skilled category [7].

Sensitivity and specificity were expressed as a percentage.

Results

Of the 512 subjects (243 females and 269 men) who participated in the study, 186 were alpine skiers, 164 snowboarders, 116 Telemark skiers and 46 used skiboards. The mean age (±SD) of the participants was 22 ± 13 years (range: 4–70).

Tables 1–5 demonstrate the relationship between self-reported and observed skiing skill for the five different questions used. The kappa values were 0.34 for *skiing skill* (Table 1), 0.33 for *piste difficulty* (Table 2), 0.38 for *turning technique* (Table 3), 0.26 for *experience* (Table 4) and 0.16 for *falling frequency* (Table 5).

When comparing self-reported ability to observed skill level (Table 1), there was a tendency for underestimation. Of the 84 subjects who estimated themselves as beginners, 53 actually skied "better." Furthermore, we see that 105 of 197 subjects who estimated themselves as intermediate skiers actually did belong in a better group.

Table 2 shows the relationship between observed and self-reported ability based on piste difficulty. There was a tendency for overestimation of off-piste ability, since 102 of 158 subjects who regarded themselves in the highest skill category (able to ski off-piste) did not demonstrate expert skiing ability. At the same time, there was a tendency for underestimation among skiers and snowboarders who skied fluently.

For turning technique (Table 3), there was a tendency for overestimation of carving technique, where 119 of 190 subjects claiming to be able to perform a carving turn actually did not do so during the test run. The same trend was seen for the parallel turn category.

Table 4 demonstrates that skiing experience did not correlate well with skiing skill. For example, of 132 skiers reporting 1–2 seasons of skiing experience, 68 actually skied fluently. Even in the group of 80 subjects reporting less than 1 season of skiing experience, 48 performed better than the lowest category, "ploughing."

As seen in Table 5, falling frequency is not a good predictor of skiing skill. Of 161 subjects who reported that they never fall, and thus would be classified in the most advanced category, 117 actually did not ski that well in the test.

Table 1 Relationship between observed and self-reported skiing ability based on skill level

Self-reported	Observed skill level			
	Plough turn (n = 44)	Hesitating (n = 141)	Fluent (n = 248)	Carving (n = 79)
Beginner	31	46	7	
Intermediate	12	80	101	4
Advanced	1	15	131	39
Expert			9	36

Table 2 Relationship between observed and self-reported skiing ability based on piste difficulty

Self-reported	Observed skill level			
	Plough turn (n = 44)	Hesitating (n = 141)	Fluent (n = 248)	Carving (n = 79)
Blue piste	23	17	2	
Red piste	20	107	75	2
Black piste	1	10	76	21
Off-piste		7	95	56

Table 3 Relationship between observed and self-reported skiing ability based on turning technique

Self-reported	Observed skill level			
	Plough turn (n = 44)	Hesitating (n = 141)	Fluent (n = 248)	Carving (n = 79)
Plough	22	2	1	
Stem	17	53	1	
Parallel	3	68	147	8
Carving	2	18	99	71

Table 4 Relationship between observed and self-reported skiing ability based on skiing experience

Self-reported	Observed skill level			
	Plough turn (n = 44)	Hesitating (n = 141)	Fluent (n = 248)	Carving (n = 79)
< 1 season	32	41	7	
1–2 seasons	10	54	65	3
3–5 seasons	1	22	95	23
> 5 seasons	1	24	81	53

Table 5 Relationship between observed and self-reported skiing ability based on falling frequency

Self-reported	Observed skill level			
	Plough turn (n = 44)	Hesitating (n = 141)	Fluent (n = 248)	Carving (n = 79)
Every run	10	13	2	
Every day	17	42	34	7
Now and then	10	64	124	28
Never	7	22	88	44

For the different categories of skiers and snowboarders, the kappa values ranged between 0.28 and 0.43 for skill level; 0.23 and 0.47 for piste difficulty; 0.33 and 0.46 for turning technique; 0.19 and 0.46 for experience and 0.06 and 0.26 for falling frequency (Table 6). Turning technique showed the highest kappa values for alpine skiers, whereas skill level had the highest values for snowboarders (Table 6). Table 7 documents that the accuracy of self-estimation increases with age, but with some differences between scoring scales.

Table 8 demonstrates that the various questionnaires demonstrated a fairly high sensitivity and specificity in discriminating between skiers and snowboarders in the lowest skill group (i.e. in the ploughing category on the test run) and the more skilled subjects.

Discussion

This study disclosed that classification of ability based on self-report is difficult, but that there were some differences between the various questions traditionally used in research on risk factors for alpine skiing and snowboarding injuries. Kappa values were generally low, possibly due to confusion concerning some of the terms used. We found a tendency for underestimation of ability when terms like expert, advanced and carving technique were used, and overestimation when questioning for off-piste skiing ability. The limited ability of some of the questions used to group skiers correctly and discriminate between groups may have lead to an underestimation of skill level as a risk factor in epidemiological studies of skiing and snowboarding injuries.

There are a number of factors that may contribute to the limited ability to self-report skiing and snowboarding ability. The skiers and snowboarders included were between 4 and 70 years of age. There are many children in the slopes, and we noted a certain amount of confusion with the terms used, when asking questions. This is also reflected by the lower kappa values for the youngest age group, except for the question on turning technique. Adult subjects also experienced problems with some of the questions, since many of the terms that are used to classify ability in the various questionnaires are not clearly defined, which leads to difficulties and misinterpretation. As an example, piste categories and piste difficulties can vary considerably between different skiing resorts.

The gold standard we used in this study, observed skill level, may be questioned. It may be difficult to be exact in defining a skier's actual skill level based upon only one observation of a single run. We strictly applied the terms for the categories used. For example, ''carving'' may be defined in different ways, allowing different amounts of sliding in the turn. We strictly defined it as a turn following the circumference of the ski edge, allowing only occasional and minimal sliding. In the same way, we applied the technique criteria strictly when evaluating the run, regardless of the fact that many of the participants never had skied through a set course before, which may have added some stress to the way they performed. We wanted to observe the skiers both in free riding, but also in a set course, to evaluate their capability to make turns on command. Also, we could not test the participants in all piste conditions (off-piste, icy slopes etc), so we had to do the estimation based upon the existing conditions. However, snow conditions differed somewhat between different loca-

Table 7 Kappa values for the different questionnaires for each of three different age groups

	< 13 years (n = 130)	13–20 years (n = 163)	> 20 years (n = 219)
Skill level	0.23	0.33	0.41
Piste difficulty	0.26	0.23	0.42
Turning technique	0.39	0.35	0.38
Experience	0.20	0.29	0.24
Falling frequency	0.06	0.32	0.09

Table 6 Kappa values for the different questionnaires for each of the equipment groups

	Alpine (n = 186)	Snowboard (n = 164)	Telemark (n = 116)	Blades/ Big-foot (n = 46)
Skill level	0.28	0.35	0.43	0.34
Piste difficulty	0.38	0.23	0.47	0.24
Turning technique	0.43	0.33	0.46	0.36
Experience	0.19	0.31	0.36	0.46
Falling frequency	0.06	0.22	0.20	0.26

Table 8 Sensitivity and specificity for each of the questionnaires in discriminating between individuals in the poorest skiing ability category on the test and the rest of the group

	Sensitivity (%)	Specificity (%)
Skill level	75	91
Piste difficulty	68	96
Turning technique	75	91
Experience	75	90
Falling frequency	61	97

tions and days. It is in fact more difficult to demonstrate a fluent turn or carving turn on an icy slope, which may have lead to misclassification of some skiers, although this should not lead to any bias in favour of one or the other self-estimation scales. It could in fact be argued that because testing was done at different resorts at different times throughout the season, the test actually reflects the variability in conditions skiers experience, which would adds to the validity of the test. The two assessors who evaluated the actual skill performance during the test run were blinded to the self report, which was done by a different person. Also, the subjects rated their skiing ability prior to the test run, which means that their assessment was not influenced by how they did on the test.

We observed a tendency towards underestimation of skiing ability, especially among female skiers, which may reflect a modest attitude. They may have been unwilling to rate themselves as ‘‘advanced’’ or to place themselves in the difficult piste group. We also noted an overestimation of ability among snowboarders and Telemark skiers on the question on piste difficulty. This may reflect the fact that it may be easier to ski off-piste than on a black (and possibly icy) piste, especially for snowboarders and Telemark skiers. We also noticed that the term carving seemed to lead to some misunderstanding. The carving technique is a quite difficult technique, where the skier or snowboarder makes the turn on the edge of the ski without sliding or throwing snow. Most skiers and snowboarders use carving equipment today, and thus some may think they can do a carving turn just by virtue of the equipment they use.

For skiing experience, there are various explanations for the low kappa values. Some skiers ski 1 or 2 weeks a year (like many tourist from low altitude areas, Denmark and parts of Sweden), and thus gain little experience from year to year. Others ski every day in 3 to 4 months, and become experienced skiers within as little as one season experience. Some techniques are easier learned than other. For example, skiing on very short skis (skiboards) can be learned within few days, and it is relatively easy to ski with parallel or even carving turns. In contrast, Telemark skiing and alpine skiing on carving skis requires longer experience to do well. Frequency of falling probably reflects the behaviour or attitude of the skier or snowboarder, rather than actual skill level. It has been shown to correlate more to skiing experience than to ability [13]. For example, a top snowboarder will do many jumps with rotations and therefore risk falling, whilst a beginner will be more cautious and not take as many risks.

Every attempt was made to recruit a random sample, since we wanted to test the various questionnaires in a sample of skiers and snowboarders representative of the population at risk of injury in Norwegian ski resorts. Still, a selection bias may have been introduced by which runs we chose as test stations. The most advanced skiers probably spent most of the day going off-piste or on the most difficult black slopes, where we did not do any testing. In the same way, real novices may not have ventured from the children’s play area, perhaps even some first-time adult skiers and snowboarders. We also needed to oversample the smallest category, skiboarders, since we needed about 50 subjects in each category for reliable analyses within each group.

Several recent studies have linked skiing ability to injury risk. Langran et al. [8] looked exclusively at first day skiing or snowboarding, and concluded that they are at increased risk of injury. O’Neill and McGlone [13] compared the risk of injury between more than 22,000 first-time skiers and snowboarders, and reported that first time snowboarders sustain more serious injuries than first time skiers. Sulheim et al. [16] demonstrated a much higher incidence of head injuries among beginners than non-beginners. Rønning et al. [14] found that beginners are at higher risk for wrist injuries. Matsumoto et al. [11] reported that there seemed to be a difference in fracture type pattern between beginners and non-beginners. Other studies have also identified skiing ability as a risk factor [2, 3, 4, 5, 10, 15] although the methods used to classify ability or the questions asked have not always been described in detail.

Currently, there is no agreement in the literature on which terms are most suitable to classify skiing ability using a self-report questionnaire. The ability of the skiers and snowboarders to define their own ability based upon the given forms was only moderate. However, the sensitivity and specificity of the questions in differentiating between skiers in the low ability (and high risk) group and the better skilled subjects was good. Among the questions tested, we found that the questions based on skiing skill or turning technique were best suited to classify actual skiing ability. Thus, our recommendation is to use these questions for future research and ongoing injury surveillance.

Acknowledgment The Oslo Sports Trauma Research Center has been established at the Norwegian School Sport Sciences through generous grants from the Norwegian Eastern Health Corporate, the Royal Norwegian Ministry of Culture, the Norwegian Olympic Committee & Confederation of Sport, Norsk Tipping AS, and Pfizer AS. The study complies with the current laws of Norway.

References

1. Altman DG (1991) Some common problems in medical research. In: Altman DG (ed) Practical statistics for medical research. Chapman & Hall, London pp 403–439
2. Ekeland A, Holtmoen Å, Lystad H (1993) Lower-extremity equipment-related injuries in alpine recreational skiers. Am J Sports Med 21:201–205
3. Goulet C, Régnier G, Grimard G, Valois P, Villeneuve P (1999) Risk factors associated with alpine skiing injuries in children. A case-control study. Am J Sports Med 27:644–650
4. Goulet C, Régnier G, Valois P, Ouellet G (2000) Injuries and risk taking in alpine skiing. In: Johnson RJ, Zukko P, Shealy JE (eds) Skiing trauma and safety: Thirteenth Volume. American Society for Testing and Materials, West Conshocken, pp 139–146
5. Hagel BE, Pless IB, Goulet C, Platt RW, Robitaille Y (2005) Effectiveness of helmets in skiers and snowboarders: case-control and case crossover study. BMJ 330:281
6. Hauser W. Experimental prospective skiing injury study (1989) Skiing Trauma and Safety: Seventh International Symposium. In: Johnson RJ, Mote Jr CD, Binet MH (eds) American Society for Testing and Materials, Philadelphia, pp 18–24
7. Lang TA, Secic S (1997) How to report statistics in medicine. American College of Physicians, Philadelphia
8. Langran M, Selvaraj S (2004) Increased injury risk among first-day skiers, snowboarders, and skiboarders. Am J Sports Med 32:96–103
9. Laporte JD, Binet MH, Constans D (2000) Evolution of ACL ruptures in French ski resorts 1992–1999. In: Johnson RJ, Zukko P, Shealy JE (eds) Skiing trauma and safety: Thirteenth Volume. American Society for Testing and Materials, West Conshocken, pp 95–107
10. Made C, Elmqvist LG (2003) A 10-year study of snowboard injuries in Lapland Sweden Scand. J Med Sci Sports 14:128–33
11. Matsumoto K, Sumi H, Sumi Y, Shimizu K (2004) Wrist fractures from snowboarding - a prospective study for 3 seasons from 1998 to 2001. Clin J Sports Med 14:64–71
12. Nakaguchi H, Fujimaki T, Ueki K, Takahashi M, Yoshida H, Kirino T (1999) Snowboard head injury: prospective study in Chino, Nagano, for two seasons from 1995 to 1997. J Trauma 46:1066–1069
13. O'Neill DF, McGlone MR (1999) Injury risk in first-time snowboarders versus first time skiers. Am J Sports Med 27:94–97
14. Rønning R, Rønning I, Gerner T, Engebretsen L (2001) The efficacy of wrist protectors in preventing snowboarding injuries. Am J Sports Med 29:581–585
15. Shealy JE, Ettlinger CF (1996) Gender-related injury patterns in skiing. In: Mote Jr CD, Johnson RJ, Hauser W, Shaff PS (eds) Skiing trauma and safety: 10th Volume. American Society for Testing and Materials, West Conshocken, pp 45–57
16. Sulheim S, Holme I, Ekeland A, Bahr R (2006) Helmet use and risk of head injuries in alpine skiers and snowboarders. JAMA 295(8):919–924
17. Tuggy ML, Ong R (2000). Injury risk factors among telemark skiers. Am J Sports Med 28:83–89