0363-5465/100/2828-0506$02.00/0
THE AMERICAN JOURNAL OF SPORTS MEDICINE, Vol. 28, No. 4

Risk of Injury During Alpine and Telemark Skiing and Snowboarding

The Equipment-Specific Distance-Correlated Injury Index

Roar Rønning,*†‡ MD, Tom Gerner,* MD, PhD, and Lars Engebretsen,† MD, PhD

*From the *Department of Surgery, Lillehammer Central Hospital, Lillehammer, and †Department of Orthopaedic Surgery, Ullevål University Hospital, Oslo, Norway*

ABSTRACT

Estimation of injury risk in alpine sports is difficult. We present a new method of calculating an injury index related to the distance traveled on ski or snowboard. The distance-correlated injury index equals the number of injuries per 100,000 km traveled distance. This injury index can also be correlated to the type of equipment used. The equipment-specific distance-correlated injury index is the same as the distance-correlated injury index, but it is sport-specific. We found the distance-correlated injury index for alpine skiing to be 3.9 (95% CI = 2.8 to 5.4); for snowboarding, 13.5 (95% CI = 8.3 to 22.0); and for telemark skiing, 3.0 (95% CI = 1.0 to 9.4), suggesting a three- to four-times higher incidence of injuries requiring hospital treatment among snowboarders than among alpine and telemark skiers.

Accurate estimation of injury incidence in skiing events is difficult. All current methods have weaknesses. Incidence of injury during alpine skiing activities is most often referred to as number of injuries per 1000 skier days[1,3–6,8,9,11] or mean days between injury.[7] With this method, the number of ski passes sold in a period is used to calculate the number of skier days. But little is known about each skier's activity during the day. A trained athlete or a regular recreational skier will, in most cases, ski a longer distance in 1 day than will a beginner. The number of hours skied every day will also vary considerably.

Ski passes are sold to many subgroups of skiers such as alpine, telemark, and cross-country skiers, as well as snowboarders. It is difficult to estimate the distribution of ski passes sold to each subgroup.

Studies where a self-estimate of skiing hours per day is used as a basis for the calculation have been suggested. This might result in more accurate estimations, but this method demands interviews or questionnaires from all skiers involved and is time-consuming and limited by response rates and the reliability of the subjective answers.

The goal of the present study was to develop a more accurate and objective method of injury incidence monitoring. By finding the distribution of alpine skiers, snowboarders, telemark skiers, and "others" in the alpine area, we could estimate the total distance skied for each of these subgroups. Then, using the number of injuries treated in Lillehammer Central Hospital, we could calculate the injury incidence based on skied distance for each subgroup, which we call the equipment-specific distance-correlated injury index.

MATERIALS AND METHODS

The study was performed during the period from February 18, 1997, to March 17, 1997, at Hafjell Alpine Center, the area used for giant slalom and slalom during the Olympic Games in Lillehammer in 1994, and the national venue for alpine sports in Norway. Hafjell is the third-largest alpine area in Norway, with 240,000 guests every season.

All skiers must use the lifts to get access to the slopes in the area. All lifts in the area correspond to a descending slope of definite length. The lift-pass system registers the total number of trips in each lift every day.

We divided all skiers into four subgroups: alpine, snowboard, telemark, and others. The other group includes a variety of different categories, including cross-country skiers, "big-foot" skiers, monoskiers, pedestrians, and handicapped skiers. The registration was done by one investigator only.

To find the distribution of the subgroups in each of the

‡ Address correspondence and reprint requests to Roar Rønning, MD, Department of Surgery, Lillehammer Central Hospital, N-2600 Lillehammer, Norway.

No author or related institution has received any financial benefit from research in this study.

eight lifts open for use in the investigation period, we counted all skiers using the lifts in a predesigned random fashion in periods of 20 minutes, ensuring a representative sample from the total number of skiers. Observations were done 13 times for each lift. On the basis of the observed distribution and the registered total number of trips in the lifts, we estimated the total skied distance in the subgroups.

In a similar manner, we also recorded the activity in the "half-pipe." This is a part of the area specially designed for snowboard activities. Here the terrain is formed like the bottom half of a pipe, and it is mainly used by the snowboarders for jumping practice and acrobatic maneuvers. This area is closed to other skiing activities. The snowboarders generally walk up the rink of the half-pipe rather than taking the lift. One run in the half-pipe is 200 meters. We counted all snowboarders walking up the rink passing a certain point in the half-pipe. We looked on this in the same way as we looked on a trip in the lift. During the investigation period, all skiers treated in Lillehammer Central Hospital were recorded.

It is likely that the hazard function was constant during the time we performed the observations, that is, $h(t) = h$. We have called this hazard function the distance-correlated injury index (DCI). It is calculated for every subgroup and called the equipment-specific distance-correlated injury index (ESDCI). For injuries during alpine skiing, the DCI will be referred to as $ESDCI^{alpine}$, for snowboarding as $ESDCI^{snowboard}$, and for telemark skiing as $ESDCI^{telemark}$.

The DCI equals the number of injuries per 100,000 km traveled distance. Ninety-five percent confidence intervals were estimated according to the standard formula for estimation of confidence intervals for incidence rates. Injury incidence rate ratios were also estimated and the differences between these were statistically tested, assuming that the test statistic z had a normal distribution under the null hypothesis. The threshold for statistical significance was set at $P = 0.05$.

RESULTS

In the investigation group, 14,736 skiers were registered (Table 1). The overall distribution in the lifts was 81.16% alpine, 9.58% snowboard, 8.28% telemark, and 0.97% others. According to the lift-pass system in the area, 849,904 lift trips were taken during the investigation period. Based on the number of lift trips and the length of the corresponding slopes, there was a total skied distance of 1,118,234 km. During the investigation period, 55 skiers from Hafjell were treated at Lillehammer Central Hospital: 35 alpine skiers, 16 snowboarders, 3 telemark skiers, and 1 other (a cross-country skier).

Adjusting for the use of the half-pipe, the $ESDCI^{alpine}$ was 3.9 (95% CI = 2.8 to 5.4), the $ESDCI^{snowboard}$ was 13.5 (95% CI = 8.3 to 22.0), and the $ESDCI^{telemark}$ was 3.0 (95% CI = 1.0 to 9.4). The injury incidence rate ratio between alpine and snowboard was 0.29 ($z = -4.11$, $P < 0.0001$); between telemark and snowboard, 0.22 ($z = -2.39$, $P < 0.02$); and between telemark and alpine, 0.77 ($z = -0.44$, $P > 0.65$).

DISCUSSION

Other authors have found injury rates of 2 to 10 injuries per 1000 skier days for alpine skiing, 1 to 16 injuries per 1000 snowboarding days, and 10.7 injuries per 1000 skier days for telemark skiing.[1–5,7,11] A number of studies state that snowboarding is at least as safe as alpine skiing.[3,4,10]

Numerous approximations must be done to calculate injuries per skier days. The number of persons is most often estimated from the sale of lift passes. Lift passes are sold as part-of-day, day, 2-day, weekend, week, or season passes. It is difficult to estimate the real use of each pass, because one pass-owner can choose to ski the whole day or only part of the day or even not at all. The use of self-estimation of skiing hours per day may give a more accurate time estimate, but this method is difficult to apply in large populations because of the need for interviews or questionnaires.

Injuries per skier days do not consider the distance skied. The risk of being injured during skiing is a priori related to this distance. The method of calculating injury incidence per skier days will give the same result for a group of skiers who ski a long distance in a period of time (such as trained athletes) as for another group of skiers who ski only a short distance in the same period (such as beginners), if both groups sustain the same number of injuries.

To be able to calculate the DCI we need to know the traveled distance. This is estimated on the basis of the number of lift trips. This estimation is difficult in many ski resorts because often the lifts take the skiers up to a point where there are numerous possible slopes, or

TABLE 1
Calculation of ESDCI (Equipment-Specific Distance-Correlated Injury Index)

Parameter	Alpine	Snowboard	Telemark	Other[a]	Total
Observed lift trips, investigation group	11,961	1411	1221	143	14,736
Total estimated distance skied (km)	890,838	118,645	99,393	9358	1,118,234
Total number of injuries	35	16	3	1[a]	54
95% CI	2.8–5.5	8.3–22.0	1.0–9.4		3.7–6.4
ESDCI	3.9	13.5	3.0		4.9

[a] This injury was to a cross-country skier during crossing of the alpine area. This injury is not considered in calculating total injuries. The number of injuries in the total column represents alpine, snowboard, and telemark injuries.

"pistes," of varying length to run down. Another problem would be areas were skiers stay in the slopes for a long time, not using the lifts. This might be the case for some snowboarders and telemark skiers who like to go "free-riding" off-piste. In our study, this must be said to be an insignificant problem because nearly all activity in Hafjell is closely attached to pistes of definite length. The only problem in calculating distance skied on the basis of lift trip in this study is the snowboarder group, in which the activity in the half-pipe must be considered. We have done this by counting snowboarders walking up the rink on the half-pipe, handling this in the same way as a trip in the lift.

The "other" group is a nonhomogenous group, including all other persons who use the lifts in the area. This also includes people who just take the lift up the mountain to get a great view of the valley before they take the lift back down again. Any calculation of ESDCI for this group is not meaningful.

Only skiers admitted to Lillehammer Central Hospital were included in the study. Lillehammer Central Hospital is located only 15 km south of Hafjell and is the natural referring hospital for traumas. Smaller injuries, not demanding urgent treatment, might therefore be lost to our study. However, there is no reason to believe that this would change the injury distribution between the observed groups when considering injuries demanding hospital treatment.

To be able to compare our figures with other studies, we can estimate the injury rate per 1000 skier days, given a daily skied distance of 30 km. This gives the injury rates per 1000 skier days: 1.2 for alpine skiing, 4.0 for snowboarding, and 0.9 for telemark skiing.

We believe that even though the number of athletes, the number of injuries, and the distances skied or snowboarded in this study are relatively small, we have presented a valid method of monitoring the injury incidence in an alpine area.

We will encourage the use of the ESDCI as an estimate of injury incidence because of the advantage in accuracy and because it is a method that can be established to monitor injury incidence on a permanent basis.

During the 1997 ski/snowboard season, we registered a sample of athletes by type of equipment used, but our goal is to connect the lift-pass system to type of ski equipment in a permanent manner. This can be done by assigning an electronic code to the lift-pass ticket, which can be identified in the registration apparatus in every lift. We will then be able to calculate the frequency of the different ski equipment types used in the area and the estimated distance skied. Thus, the ESDCI will be able to be calculated automatically. A consecutive registration of injuries is already being performed at Lillehammer Central Hospital.

REFERENCES

1. Abu-Laban RB: Snowboarding injuries: An analysis and comparison with alpine skiing injuries. *CMAJ 145:* 1097–1103, 1991
2. Biasca N, Battaglia H, Simmen HP, et al: An overview of snow-boarding injuries [in German]. *Unfallchirurg 98:* 33–39, 1995
3. Bladin C, Giddings P, Robinson M: Australian snowboard injury data base study. A four-year prospective study. *Am J Sports Med 21:* 701–704, 1993
4. Bladin C, McCrory P: Snowboarding injuries. An overview. *Sports Med 19:* 358–364, 1995
5. Crisp T: Ski trauma: Prevention and treatment. *Practitioner 239:* 88–94, 1995
6. Davidson TM, Laliotis AT: Alpine skiing injuries. A nine-year study. *West J Med 164:* 310–314, 1996
7. Johnson RJ, Ettlinger CF: Alpine ski injuries: Changes through the years. *Clin Sports Med 1:* 181–197, 1982
8. Kocher MS, Feagin JA Jr: Shoulder injuries during alpine skiing. *Am J Sports Med 24:* 665–669, 1996
9. Macnab AJ, Cadman R: Demographics of alpine skiing and snowboarding injury: Lessons for prevention programs. *Inj Prev 2:* 286–289, 1996
10. Pino EC, Colville MR: Snowboard injuries. *Am J Sports Med 17:* 778–781, 1989
11. Tuggy ML: Telemark skiing injuries. *J Sports Med Phys Fitness 36:* 217–222, 1996