J Orthop Sci (1997) 2:367–371

Journal of
Orthopaedic Science

Original articles

Factors determining the severity of ski injuries

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Abstract: We investigated the relationship between the severity of ski injuries ($n = 895$) classified according to the abbreviated injury score (AIS; based on objective criteria for judging the severity of injuries) and the following factors: sex, site and mode of injury, skill level, speed at the time of injury, binding release, gradient, type of snow, surface conditions, weather, visibility, and the month and day of the week on which the injury was sustained. Age, sex, mode and site of injury, speed at the time of injury, binding release, visibility, and the month and day of the week on which the injury was sustained were associated with the severity of injuries, but the skill level, gradient, type of snow, surface conditions, and weather were not. Injuries with an AIS of 4 or higher accounted for only 4.6% of injuries (AIS scores range from 1; e.g., mild sprains, to a maximum of 6; injuries with scores of 4 and above are regarded as life-threatening). Given that patients with very severe injuries tend to be taken to our facility, the actual incidence of severe ski injuries may be even lower. However, measures to protect against severe injuries are needed to ensure greater safety for skiers.

Key words: ski injury, abbreviated injury score, severity, cause, statistical analysis

Introduction

Previous studies evaluating the severity of ski injuries[2–6,8,10–12,14,17,18] have used inconsistent and subjective definitions of "severe", that do not necessarily correspond to a "life-threatening" injury. Some studies classified femoral fractures,[17,18] rupture of three ligaments of the knee,[4] or dislocation of the hip joint[14] as severe, whereas other studies defined severe injuries as injuries that required prolonged hospitalization.[3,6] The abbreviated injury scale (AIS)[1] initially formulated by the Committee on the Medical Aspects of Automotive Injury of the American Medical Association to score the severity of injuries caused by traffic accidents, has become the conventional scoring system for assessing the severity of injuries. Knee sprains and ligament ruptures, lower leg fractures, cut wounds of the head, and sprains of the first finger are mild ski injuries with a corresponding AIS of 1 or 2. Severe orthopedic injuries, such as femoral fractures, rupture of three ligaments of the knee, and hip joint dislocations correspond to an AIS of 3. Fatal injuries,[7,13,15] thoraco-abdominal injuries,[5,11,12] and cerebrospinal injuries[8–10] correspond to an AIS of 4 or higher.

We retrospectively assessed the AIS of patients with ski injuries to determine factors that affect the severity of injuries.

Offprint requests to: T. Takakuwa
Received for publication on March 10, 1997; accepted on May 19, 1997

Subjects and methods

We retrospectively evaluated 895 patients with ski injuries treated at the Critical Care and Emergency Center of Iwate Medical University between 1987 and 1993. Patients were classified into groups according to their AIS. We assessed the severity of injuries in terms of age, sex, site and mode of injury, and other factors likely to affect the severity of injuries, such as the skill level, the speed at the time of injury, binding release, gradient, type of snow, surface conditions, weather, visibility, and the month and day of the week on which the injury was sustained. Data were obtained from the patients' medical records and the records of injuries maintained at the offices of the ski grounds.

Skill levels were defined as follows: beginner, little experience, difficulty negotiating a slope; novice, 1–2 years' experience, able to negotiate a slope; middle level, 3 or more years' experience, able to negotiate a medium or steep slope; advanced, ability comparable to that of a competitive skier. The speed at which the injury occurred was classified as excessive (out of control), safe (under control by the patient), or stationary (full stop on the slope, including a stop due to a fall). Speed was assessed on the basis of the patient's description. The gradient was classified as gentle (0–9 degrees), moderate (10–19 degrees), or steep (20–29 degrees). The type of snow was classified as fresh, wet, crystal, or frozen. The surface condition of the slope was classified as smooth, irregular, rough, or deeply snow-covered. Weather at the time of injury was classified as fair, cloudy, snowy, or other. Visibility was classified as good, moderate, or poor. Differences in mean age among the patient groups were analyzed by an unpaired non-parametric test (Wilcoxon's test). The independence of each item was analyzed by the χ^2 test for patients classified into groups according to the AIS as follows: AIS of 1, 2, 3, and AIS of 4–6. A P value <0.01 was considered statistically significant.

Results and discussion

Of the 895 injured skiers, 1 patient (0.1%) had an AIS of 6 (maximum injury), 8 (0.9%) had an AIS of 5 (survival uncertain), 34 (3.8 %) had an AIS of 4 (life-threatening), 70 (7.8%) had an AIS of 3 (severe but not life-threatening), 340 (38.0%) had an AIS of 2 (moderate), and 442 (49.4%) had an AIS of 1 (minor) (Fig. 1).

The site of injury was significantly correlated with the AIS ($P < 0.0001$). Injuries to the extremities were significantly more common in patients with an AIS of 1–3 than in patients with a higher AIS (Fig. 1). Among patients with an AIS of 1, the next most common injuries were head and face injuries. Injuries to the abdomen were the second most common injury in patients with an AIS of 3, followed by head and chest injuries. Among patients with an AIS of 4 or higher, there was only one injury to the extremities; the most common sites of injury in these patients were the head, neck, and chest.

The 895 patients consisted of 577 men (64.5%) and 318 women (35.5%). There was a significant association between sex and AIS distribution ($P < 0.0001$). The proportion of men increased significantly with increasing AIS (Fig. 2). All injuries with an AIS of 5 or 6 occurred in men.

The mean age of the 895 patients was 30.9 ± 11.0 years; the majority of patients were in their twenties. There was no significant difference in age between sexes. There was a significant association between age and AIS ($P < 0.0001$). The proportion of patients between 40 and 60 years of age increased significantly as the AIS increased from 1 to 4 (Fig. 3). All patients with an AIS of 5 or 6 were in their teens or their twenties. It is possible that age-related decreases in physical strength and motor ability contributed to this phenomenon. Most injuries with an AIS of 5 or 6 occurred in physically strong young men in their early twenties. Other studies have suggested that recklessness in this young group contributes to injuries.[7–9,13,15]

There was a significant association between the cause of injury and AIS ($P < 0.0001$; Fig. 4). Fall-related injuries accounted for about 70% of injuries with an

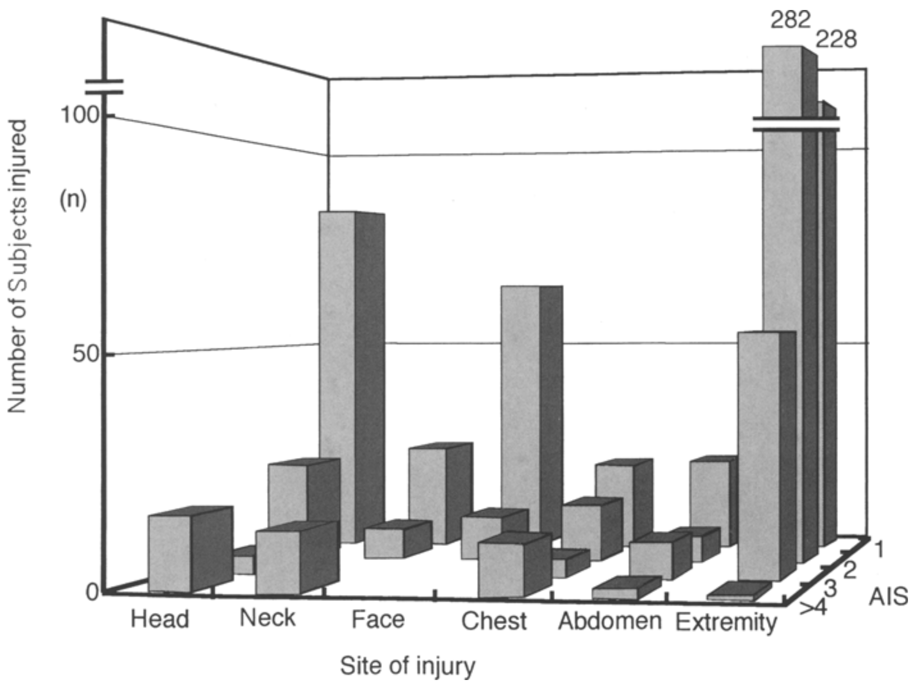

Fig. 1. Ski-related injuries by abbreviated injury score (*AIS*)[1] and site of injury

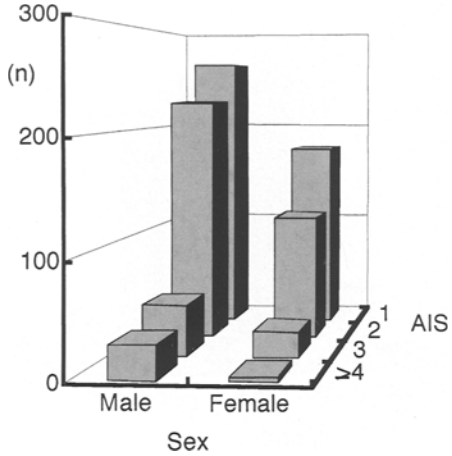

Fig. 2. Male/Female distribution

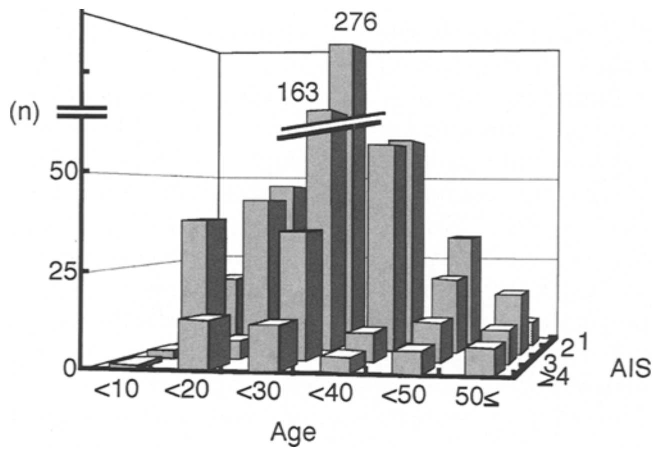

Fig. 3. Age distribution of subjects with ski-related injuries

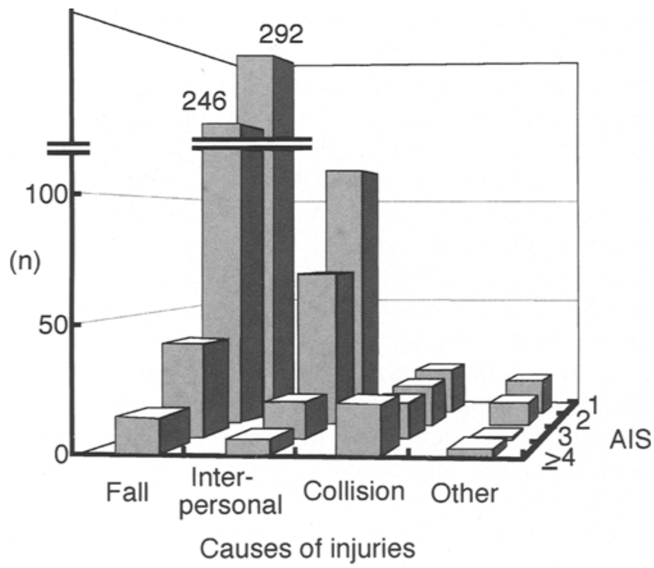

Fig. 4. Causes of ski-related injuries. *Interpersonal*, Collision with another person; *Collision*, Collision with an object

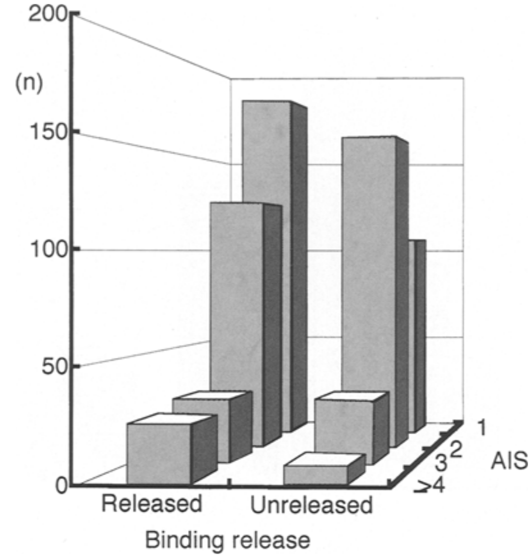

Fig. 5. Relation of binding release to injury; data for 232 subjects for whom details were not known are omitted from this graph

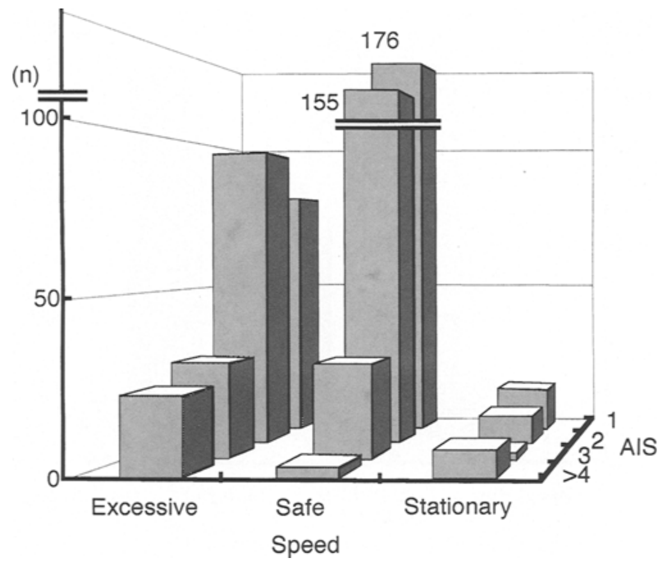

Fig. 6. Speed at which injury was sustained; data for 271 subjects for whom data were not known omitted from this graph

AIS of 1 or 2, and injuries related to a collision with an object accounted for about 5%. A higher AIS was significantly more common among injuries related to collisions with an object than in injuries related to falls or collisions with other skiers.

The obstacle the skiers collided with was an upright tree in 47 individuals, a lift post in 8, a structure such as a signboard, guidepost, or light post in 5, a protective fence in 5, a stretched protective rope in 4, an upright pole for competition in 2, and a snowbank in 1. Injuries

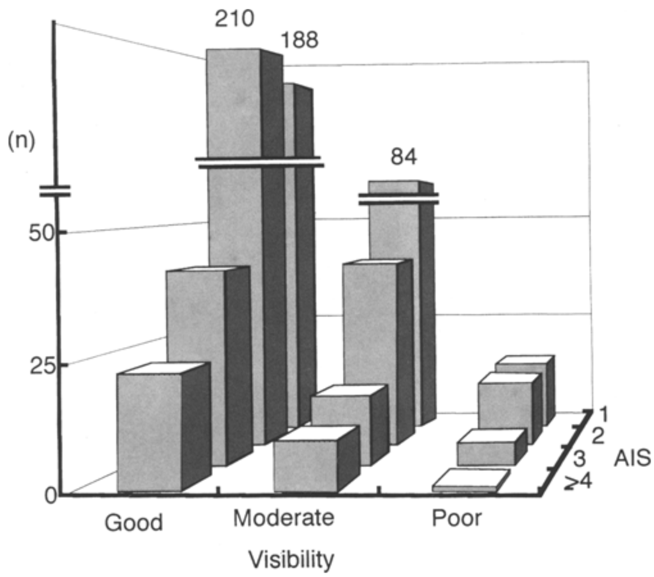

Fig. 7. Visibility when injury was sustained; data for 248 subjects for whom details were not known omitted from this graph

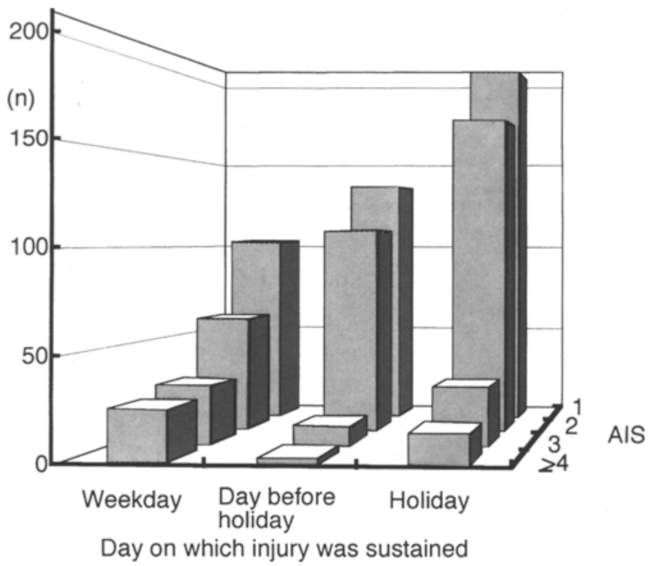

Fig. 8. Day on which injury was sustained

due to collision with a stretched rope or competition pole had an AIS of 1 or 2.

Bindings released in 361 injuries and failed to release in 302. Binding release was more common than failure to release at an AIS of 1 (Fig. 5). At an AIS of 2, failure to release was slightly more frequent than release. When the AIS was 4 or higher, the bindings released in most instances. Binding release was significantly correlated with a higher AIS ($P < 0.0001$). The present findings showed that the application of a strong external force to the head, neck, or trunk caused serious trauma.

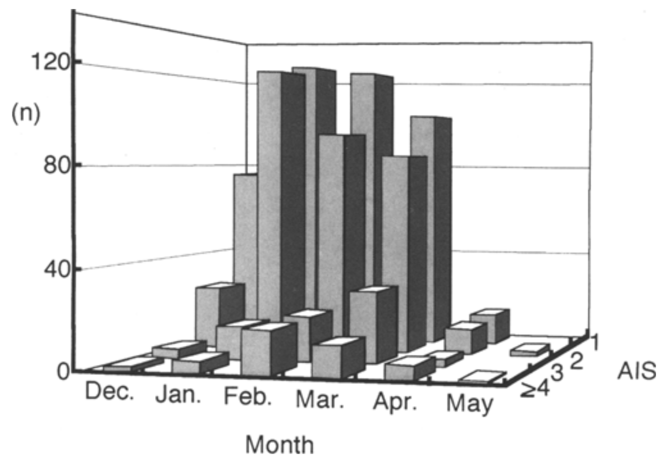

Fig. 9. Month in which injury was sustained

Collision with an obstacle and binding release may produce such an external force.[3,4,16]

Injuries occurred at an excessive speed in 228 instances, a safe speed in 363, and with the individual in the stationary position in 33 (Fig. 6). Injuries at a safe speed were common in patients with AIS 1 and 2 injuries. As the AIS increased, the incidence of injuries that occurred at an excessive speed increased. There was a significant association between excessive speed at the time of injury and a higher AIS ($P < 0.0001$). Downhill skiing at a high speed is associated with severe injuries.[2,3,5,6,15]

In our study, visibility was good in 462 instances, moderate in 150, and poor in 35. At an AIS of 4 or higher, only one injury occurred at poor visibility (Fig. 7). There was a significant association between good visibility at the time of injury and the AIS ($P = 0.010$). Good visibility may facilitate downhill skiing at high speed.

Injuries were sustained most frequently on holidays and on Sundays ($n = 419$), followed by the day preceding a holiday and Saturdays ($n = 257$), and then weekdays ($n = 219$) (Fig. 8). AIS 1 and 2 injuries occurred more frequently on holidays/Sundays or the day preceding holidays or Saturdays. With higher AIS, the number of injuries sustained on a weekday increased. There was a significant association between the day of the week on which the injury was sustained and the AIS ($P < 0.0001$). The lack of crowding on weekdays appears to facilitate downhill skiing at a high speed. On weekends and holidays, when the slope is crowded, the high density of people on the slope prevented skiers from skiing at a high speed.

The AIS was not significantly associated with the skill level ($P = 0.18$). Although some studies have suggested that advanced skill level is a risk factor for severe injuries because it is associated with increased speed,[14] we found no significant association between advanced skill level and the severity of injury. These findings may be related to recent improvements in ski equipment that enable even novice skiers to achieve high speeds.

Injuries occurred most frequently in January and February (Fig. 9). Moderate or minor injuries with an AIS of 1 or 2 were common in December; injuries with an AIS of 3–5 were frequent from February to April. The association between the month of injury and distribution of AIS was significant ($P < 0.0001$).

There was no significant association between AIS and the gradient ($P = 0.33$), the type of snow ($P = 0.27$), the surface conditions ($P = 0.32$), or the weather ($P = 0.28$). Almost all ski slopes in Iwate Prefecture are artificial courses made by felling trees, and their surface conditions, and the type of snow, and the gradients make for good conditions; possibly because of these good conditions these factors did not influence the severity of injuries.

Conclusions

The AIS was developed by the Committee on Medical Aspects of Automotive Injury of the American Medical Association for use in grading the severity of anatomic injuries in automobile accident victims. This scale was revised three times and is now an integral part of what has become an internationally recognized scale for grading the severity of anatomic injury following trauma. We classified ski injuries according to the AIS and forced that age, sex, mode and site of injury, speed at the time of injury, binding release, visibility, and the month and day of the week on which the injury was sustained were associated with the severity of injuries, but the skill level, gradient, type of snow, surface conditions, and weather were not. Injuries with an AIS of 4 or higher accounted for only 4.6% of all patients. Given that patients with very severe injuries tend to be taken to our facility, the actual incidence of severe ski injuries may be even lower. However, measures to protect against severe injuries are needed to ensure greater safety for skiers.

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