

*J. T. Weston,<sup>1</sup> M.D.; S. M. Moore,<sup>2</sup> M.D.; and  
T. H. Rich,<sup>3</sup> M.D.*

## A Five-Year Study of Mortality in a Busy Ski Population

---

In the late 1920s there were approximately 30 000 active skiers in the United States, of whom the vast majority were outdoorsmen, many identified with outing clubs within northeastern universities [1]. In this country today there are more than 4 million active skiers involved in this participant sport with more than 800 resorts in North America. For every active skier in the 1920s there are more than a thousand in this sport in the 1970s. Skiing, perhaps better than any other sport in contemporary society, reflects the trend from spectator to participant sport, and within the latter from a less active and perhaps less dangerous participant adventure to one with increased activity and greater danger than many of the others. Skiing is considered today to be, with tennis, the most rapidly growing participant sport in the nation. Recognizing the already identified and exhaustively reported morbidity associated with this sport the authors deemed it desirable to review a large active ski population where it is possible to determine with a reasonable degree of accuracy the number of individuals at risk, and identify the number and nature of mortalities associated directly or indirectly with this sport.

Before doing this perhaps it is desirable to summarize some of the changes which have occurred in skiing since the 1920s. Some of these are no doubt responsible for the growth of the sport while others represent a result of this growth. Many of the older readers and one of the authors commenced their skiing on wooden skis, usually hickory or occasionally ash, usually considerably longer than their contemporary counterparts. These were fitted with steel edges along the undersurface to protect this vulnerable edge of the ski and afford a greater turning ability on hard surfaces.

In the mid-1950s metal skis, usually aluminum, began to replace wooden ones; by 1965 the introduction of epoxy and fiberglass, usually combined with aluminum, afforded the skier varying degrees of flex and torque. The rigid, somewhat longer, ski was reserved for high-speed racing among the experienced skiers who desired stability. The readily torqued short ski has increasingly also become popular with the experienced skier who, while desiring to stay close to the "fall line" or straightest line down the side of a mountain, nonetheless maintains his control by numerous short turns, in some instances with the flat surface of the ski on the snow (wedeln) or on steeper surfaces with rather extensive use of the metal edges to carve turns (short swing). The novice skier more readily

Presented at the 27th Annual Meeting of the American Academy of Forensic Sciences, Chicago, Ill., February 1975. Received for publication 5 May 1976; accepted for publication 15 June 1976.

<sup>1</sup>Professor of pathology and medical investigator, Office of the Medical Investigator, School of Medicine, The University of New Mexico, Albuquerque, N. Mex. 87131.

<sup>2</sup>Chief medical examiner, Utah State Division of Health, 44 Medical Drive, Salt Lake City, Utah 84113.

<sup>3</sup>Resident, University of Utah Medical Center, Salt Lake City, Utah, during the studies. Current address: 4160 W. 3400 South, Granger, Utah 84120.

learns the newer techniques with these shorter skis. The considerably shortened ski makes the possible increased torque very desirable, especially on irregular surfaces, and makes it possible to sequentially turn around closely spaced "moguls" (mounds of packed snow), which occur largely as a result of snow tossed up by the skiers' actions.

The boots of the 1920s, leather, relatively nonrigid, with square toes and laces, were fastened to the skis by a combination of a metal plate with medial and lateral guards, leather straps, and shortly thereafter cables, many of which were spring loaded and passed around the heel of the skier. These often allowed the heel to be lifted from the ski. In the evolution in equipment the flexible leather boot has been replaced by a more rigid counterpart, which in turn has been succeeded by various types of semirigid metal and plastic shells within which the foot is held virtually immobile by the introduction of air, plastic, or even wax between the inner liner and the hard outer surface. The height of the boot has varied from just above the ankles in the early days of skiing to lower mid-calf and mid-calf in some of the latest models, altering the pattern of injury to the lower leg and knee considerably.

The attachment to the boot, the binding, has likewise undergone revolutionary changes during these three decades with combinations of lightweight metal moving parts increasingly fixing the boot to the ski in a more rigid fashion although increasingly allowing escape of the boot from the ski when lateral, anterior, or posterior torque exceeds the setting on these bindings, thereby reducing fractures, sprains, and strains in the properly equipped skier. While skiing in its early days was an activity conducted with one pole, the contemporary skier uses two lightweight, usually aluminum, poles with handles that readily allow separation from the skier in the event of fall and greatly reduce the probability of injury by contact with the pole or because the pole is entangled with some stationary object.

The introduction of quilted and down clothing to cope with temperatures [which may vary from  $-10$  to  $-20^{\circ}\text{F}$  ( $-24$  to  $-29^{\circ}\text{C}$ ) at the upper elevations in the early morning to  $+20$  to  $+30^{\circ}\text{F}$  ( $-7$  to  $-1^{\circ}\text{C}$ ) at the lower elevations in mid-afternoon, even in mid-winter] has rounded out the skier's package of relatively expensive equipment. This is not necessarily uniformly purchased. A portion or all may be acquired by rental either before leaving home or by prearrangement upon arrival at the vacation resort.

As the equipment has changed, so have the facilities. The skier in the early 1920s usually found it necessary to climb a considerable distance to ski downhill distances which, in most instances, did not begin to approach the runs on the mountains within the major resorts of this country today. Contemporary skiers are quickly loaded by twos or threes into chairs or gondolas suspended from a cable which move skiers by the thousands to the upper reaches of even the highest mountains in North America. Lunch stands and, indeed, first class restaurants occupy sites on many of these slopes which the early skier would have had difficulty in reaching even with his rabbit skins and other paraphernalia designed to facilitate uphill climbing on skis. Among a large group of skiers, the reasons given for indulging in this sport may be numerous, but among the responses most frequently heard are "the thrill, excitement, and speed of downhill skiing," "the feeling of mastering the mountain," "the satisfaction of complete control that comes with experience in skiing," "the always available 'challenge' that comes in knowing that, except for perhaps a handful of skiers, there is always another mountain which is longer, harder, and steeper, or a course which is straighter and faster than before." Among the older skiers one hears comments which refer to "the serenity, the beauty, or the sensation of getting away from it all."

Recognizing the growth of this sport in Utah, paralleling that within the remainder of North America, the authors considered it desirable to review the mortalities which were directly or indirectly attributed to skiing within the five major resorts in close proximity to Salt Lake City. By comparison with the at-risk population, the relative safety of this rapidly growing sport was determined.

### Materials and Methods

Within 25 miles (40 km) of central Salt Lake City are five major ski resorts: Alta, Snowbird, Park City, Park City West, and Brighton. The bases of these resorts are geographically located at altitudes which vary from 7000 to 8500 ft (2 to 2.6 km) above sea level. The vertical drop, or vertical distance between the upper end of the uppermost lift and the bottom, varies from 1800 to 3100 ft (0.5 to 0.9 km); each of these resorts has many miles of groomed trails, and the larger higher areas include many miles and acres of relatively ungroomed mountainside for the experienced skier desiring to make his own pathway down the mountain.

Table 1 presents the skier-days at risk during the 5-year period commencing with the season in 1969-1970. This information is presented by the ski operators who make a

TABLE 1—*Skier-days at risk in central Utah resorts.*

Area	1969-1970	1970-1971	1971-1972	1972-1973	1973-1974
Resort A	196 985	182 248	223 626	280 571	268 923
Resort B <sup>a</sup>	69 000	83 000	89 000	110 000	100 000
Resort C <sup>a, b</sup>	...	...	85 000	198 000	235 000
Resort D	37 477	54 188	61 720	65 128	65 720
Resort E <sup>a</sup>	128 000	140 000	190 000	290 000	340 000
Totals	431 462	459 436	649 346	943 699	1 009 643

<sup>a</sup>Rounded off to nearest thousand.

<sup>b</sup>Opened season of 1971-1972.

daily determination of the usage of their facilities and represents a composite of the number of single-day lift passes purchased and an estimation of the number of local citizens using season passes. This estimation is accomplished by a regular count conducted by the lift operators at several of the resorts, or, more accurately, at the other areas by requiring substitution of a daily pass for the season pass upon the skier's arrival at the area. In several instances the figures are rounded off to the nearest thousand. Usage figures for one of the areas reflects its novelty during the first year it opened and very rapid growth because of its unusual "challenge," attractive facilities, and exceptional snow accumulation, affording the possibility of skiing late in the season.

The overnight accommodations at the resorts in Utah have been slow to develop so that the day ski population in these areas reflects a larger percentage of the total skiers than in some of the other more isolated resorts. Nonetheless, increasing overnight accommodations at a reasonable rate within Salt Lake City and, to a lesser degree, at the resorts, is reflected by an increasing number of skiers. This, in turn, has resulted in increased lift facilities in the last 5 years. A review of the table indicates that in the last year intensively studied, 1973-1974, there were more than a million skier-days of risk within these primary areas.

During this period the Office of the Medical Examiner, an integral part of Utah's State Division of Health, was operative. Legislation, while it did not mandate the reporting of all unexpected or unnatural deaths to this office, made these services available to the local county officers, physicians, and attorneys serving this population. The skier mortalities were divided into two groups: those which were nonnatural, that is, completely as a result of injury without any significant role by antecedent disease, and those which were natural or a consequence of antecedent natural disease combined with the physical stress of skiing. These, in turn, were further subdivided into those which were considered to be ski-related, that is, a direct consequence of the activity of skiing, and a much smaller group of individuals whose death was considered to be non-ski-related,

natural or nonnatural. These individuals died of conditions and under circumstances which might have prevailed exclusive of the ski area. Quite naturally, these observations of the group were made only while they were in residence at the ski areas.

### Observations and Conclusions

Table 2 summarizes the deaths associated with skiing during this period within a study population of 3.5 million skier-days. There were six reported deaths resulting from ski-related injuries, one death from a natural condition which occurred while the victim was actively engaged in the sport of skiing, and three deaths that could be considered unrelated to skiing. One of these was a suicide, another was a middle-aged male who had been participating in the sport but was at the lodge area, and the third was a 14-year-old female student with preexisting acute myocarditis. Table 3 summarizes the findings, skills, and precipitating cause of the terminal injuries.

TABLE 2—*Skier-days at risk with skier fatalities.*

Year	At-Risk Population <sup>a</sup>	Ski-Related Fatalities		Non-Ski-Related Fatalities, All Cases <sup>b</sup>
		Nonnatural	Natural	
1969-1970	431 462	0	0	0
1970-1971	459 436	2	1	0
1971-1972	649 346	1	0	1
1972-1973	943 699	2	0	1
1973-1974	1 009 643	1	0	1
Totals	3 493 586	6	1	3

<sup>a</sup>Total.

<sup>b</sup>At resorts only.

#### Case 1

This 50-year-old male professor, an intermediate skier, was in Utah for a 3-day ski vacation from California when, on the morning of his demise, he was observed by his son to fall face down on the slope. He immediately recovered and continued skiing down the run. He continued to ski throughout the remainder of the afternoon. Upon arrival at his room he complained of feeling ill, collapsed, and was pronounced dead by his physician at the room in the lodge. Autopsy revealed a well-developed Caucasian male with no significant external evidence of injury. Internally there was 150 ml of clotted blood over the dome of the liver, with approximately 400 ml of fresh coagulated blood filling the peritoneal cavity. A 6-cm laceration extended through the capsule over the dome of the right lobe of the liver and was circumscribed by two subcapsular hemorrhages extending to the inferior surface of this lobe. Incidental findings on microscopic examination were the presence of noncaseating granulomata within the lungs and myocardium, consistent with sarcoiditis. The intra-abdominal hemorrhage, secondary to the laceration of the liver, was considered the cause of death. Toxicological examination was negative for the presence of alcohol or illicit drugs.

#### Case 2

This 17-year-old male advanced skier, a native of Utah, in good health, was in the act of jumping a mogul when he lost control, veered off the trail, and struck a tree. Post-mortem examination revealed abrasions and lacerations of the head and neck, a com-

TABLE 3—*Summary of ski-related, nonnatural deaths.*

Deceased	Injury Causing Death	Nature of Accident	Skiing Skill
50-year-old male college professor	laceration, liver	forward fall	intermediate
60-year-old female housewife	craniocerebral injuries	out of control on ice; collision with tree	advanced
17-year-old male student	craniocerebral injuries	out of control; speed; collision with tree	advanced
28-year-old male physician	myelocervical injuries	apparently out of control; skied over embankment	intermediate
47-year-old male	ruptured ascending aorta	forward falls (2)	intermediate
26-year-old male ski instructor	suffocation	avalanche	advanced

pound fracture of the calvarium extending into the base of the skull, multiple rib fractures, hemopneumothorax, and pneumocranium. Death was attributed to the cranio-cerebral injuries. Toxicological examination was negative for alcohol or illicit drugs.

#### *Case 3*

A 28-year-old male physician of intermediate skiing ability, a native of California, had skied for several days at the same resort. On the last day of his visit, skiing on an unmarked run at the base of the lodge, he skied over an embankment and dropped approximately 9 ft (2.7 m) from the snow into a boulder-strewn narrow creek bed from which he was recovered. Postmortem examination revealed a laceration over the bridge of the nose extending to the right parietal area of the skull, exposing the calvarium. There was a laceration over the convexity of the skull in the right occipital parietal region and a laceration in the region of the left superior iliac crest. Internally there were fractures of the fifth and sixth cervical vertebrae with hemorrhage into the surrounding soft tissue. The adjacent spinal cord was crushed and transected. There were also fractures of the left posterior fifth, sixth, and seventh ribs associated with intrapulmonary hemorrhage in the adjacent lung. There was bilateral mastoid hemorrhage. The remaining internal examination was unremarkable. Myelocervical injury was considered the cause of death. The toxicological examination was negative for alcohol and illicit drugs.

#### *Case 4*

This 47-year-old male schoolteacher of intermediate ability, not a native of Utah, on the first day of a 3-day ski vacation fell forward on the unloading ramp of a chair lift, suffering a blow to the anterior thorax. He removed his equipment, went into the warm-up hut for a few minutes, and then resumed skiing. Several hours later he fell in a similar fashion but was able to right himself and continue descent off the ramp into the vicinity of a warm-up hut where he collapsed and died immediately. Postmortem examination revealed a transverse (1.8 by 0.2 cm) circumferential laceration in the first portion of the ascending aorta, resulting in 350 ml of intrapericardial hemorrhage and cardiac tamponade, considered responsible for death. Toxicological examination was negative for the presence of alcohol and illicit drugs.

#### *Case 5*

This 60-year-old housewife, an experienced skier and a native of Utah, was skiing on a day when the snow was uniformly covered with exceedingly smooth, hard ice. While skiing at moderate speed near the higher elevations of the resort, she lost control, skidded in a turn, and collided with a tree on the edge of the trail. Postmortem examination revealed a triangular laceration of the scalp, which extended from the forehead to the occipital region and was associated with extensive right periorbital ecchymosis. Internal examination revealed extensive fractures of the calvarium and base of the skull with underlying laceration of the cerebrum and subdural, subarachnoid, and intracerebral hemorrhage. Death was attributed to the cranio-cerebral injuries. Toxicological examination was negative for the presence of alcohol or illicit drugs.

#### *Case 6*

This 26-year-old male ski instructor, in the company of two other instructors, was caught in a snow avalanche and buried. The body was recovered 65 min after the slide. Postmortem examination revealed multiple abrasions on the exterior of the face and

neck, severe pulmonary edema, and congestion consistent with the reported findings of suffocation by inhaled snow and water. Toxicological examination was negative for the presence of alcohol or illicit drugs.

### Discussion

Of the six individuals who died of accidental causes during this 5-year period, two were classified as advanced skiers. Both of these individuals suffered their fatal injuries as a result of skiing out of control. In one instance this was attributed to speed and the intervention of a medium-size jump off a mogul which caused the skier to leave the trail. In the second instance, environmental conditions (an icy surface) resulted in the skier's being unable to effect a change of direction and therefore colliding with a fixed object, in this instance also a tree at the side of the trail. Of interest is the fact that two individuals, both middle-aged, without significant underlying disease, suffered injuries as a result of forward falls on the trail. Both were intermediate skiers. Another skier of intermediate ability apparently veered out of control into an unmarked area where an environmental hazard resulted in injury when he dropped 9 ft (2.7 m) to a stream bed and landed among many large boulders. The last individual, an extremely advanced skier, was buried in an avalanche from which he was not recovered until slightly more than 1 h later. He died from the consequences of suffocation together with inhalation of snow and water.

There was a single death of apparent natural causes during actual skiing in these areas during this period. This individual, a 53-year-old male with a well-established history of atherosclerotic heart disease who had been hospitalized on one previous occasion for myocardial infarction, also had a long-standing history of diabetes mellitus. The terminal episode was characteristic of acute myocardial ischemia, with severe pain in the precordium radiating into the arm. The deceased collapsed and, in spite of helicopter evacuation, was dead on arrival at a university hospital 14 min later. Postmortem examination was not conducted. Death was attributed to atherosclerotic heart disease, the diagnosis being established by earlier history.

Table 4 presents three additional deaths among this ski population that were not considered related to participation in the sport.

TABLE 4—*Summary of non-ski-related fatalities.*

Deceased	Cause of Death
14-year-old female student	interstitial myocarditis
42-year-old male telephone worker	atherosclerotic heart disease (previous history)
23-year-old male resort worker	suicide by gunshot

### Case 7

This 14-year-old student from New England was on an extended ski vacation with her parents. Two days prior to her death she had a temperature of 102°F (39°C) and complained of vomiting and diarrhea which was believed to be "a touch of flu." Prior to this time she had engaged in vigorous skiing without complaint either prior to her departure from home or during her vacation. On the day of her death she complained of acute chest pain and collapsed. A physician-friend on the scene indicated that within 30 s she went into cardiac arrest. Mouth to mouth resuscitation was administered together with oxygen therapy for 3 h, to no avail. Postmortem examination revealed acute diffuse

interstitial myocarditis. Microbiology studies, both bacterial and viral, were negative. There was no evidence of injury. No other members of the skiing party became ill. There were no known episodes of "flu" in the area at the time.

#### *Case 8*

This 42-year-old male with a well-established history of atherosclerotic heart disease was found deceased by a waitress in the bar. He was sitting on one seat with his feet elevated on the adjoining seat and had consumed approximately a half of a glass of beer. He had skied only the latter part of the day. His occupation was telephone repairman. After one clinical episode of myocardial infarction and several episodes of angina pectoris the family physician had advised less severe exertion than in the past. He died 105 min after the lifts ceased operating on the day of his death.

#### *Case 9*

This 23-year-old male, who worked in one of the resorts as a dishwasher, often became depressed after losing all of his earnings during habitual gambling parties. On the day of his death he was found with a contact entrance gunshot wound in the temple. The gun was in close proximity. His death was considered to be an intentional act. Toxicological examination was negative for the presence of illicit drugs.

#### **Summary**

A 5-year study of a busy ski population in Utah revealed a total at-risk period of approximately 3.5 million skier-days. While the morbidity (fractures, strains, sprains, and occasionally more severe injuries) associated with skiing is well recognized and considered by most physicians concerned to be distributed somewhat unevenly within the various skills of skiing, the authors have identified an exceedingly low mortality among the same population. Six individuals died as a result of injuries directly attributable to skiing. Three of these were considered to be advanced skiers and three were of intermediate skill. In three instances the environment was considered to play a role in the accident. Two of these victims were skiing out of control, one as a result of ice-covered snow and one as a result of speed in combination with a small jump. The third victim was crushed in an avalanche. One accident was completely unexplained, the skier having skied without apparent attempt at checking or change of course into a nonrecreational area. The two remaining skiers of intermediate skill both suffered injuries incident to falling forward with considerable force onto a relatively flat, hard snow surface.

Notwithstanding the intense and sometimes prolonged exertion at relatively high altitudes (9400 to 11 000 ft or 2.9 to 3.3 km), only one skier with a previous history of atherosclerotic heart disease died while skiing. One additional middle-aged skier with similar history died at the conclusion of the day. There were two additional non-ski-related fatalities, one a 14-year-old student with interstitial myocarditis and the second, a 23-year-old male resort worker with a history of habitual gambling who committed suicide by gunshot wound.

#### *Acknowledgments*

The authors are indebted to the owners and managers of the five major ski areas adjoining Salt Lake City for the resort-use estimates, making possible the information provided in Table 1.



**Reference**

[1] Scharff, R., Ed., *Ski Magazine's Encyclopedia of Skiing*, Harper & Row, New York, 1970.

James T. Weston, M.D.  
School of Medicine  
The University of New Mexico  
Albuquerque, N. Mex. 87131