Injury Trends in Recreational Skiers and Boarders in the 16-Year Period 1996–2012

Arne Ekeland, Andreas Rødven, and Stig Heir

Abstract Introduction: The Norwegian Ski Lift Association has since 1996 conducted a central registration of the injuries occurring in the major Norwegian ski resorts to survey the injury types. The aim of this study was to report injury trends in the period 1996–2012.

Material and methods: The injuries occurring in 7–16 Norwegian ski resorts were recorded by ski patrols during the 16 winter seasons 1996/1997–2011/2012 and related to a series of demographic factors. The number of skiing/boarder days was calculated from sold lift tickets (day cards), but these were only centrally recorded from the 2000/2001 season.

Results: A total of 55127 injured skiers and boarders were recorded. The injury rate dropped from 1.47 to 1.27 injuries per 1000 skier/boarder days ($P < 0.001$), and the skiing/boarding ability increased ($P < 0.001$) in the period 2000–2012. Most of the injuries occurred on groomed slopes, but an increasing number of injuries occurred in terrain parks, from only 4% in the 2000/2002 seasons to 24% in the last two seasons. More serious injuries (fractures and back injuries) were recorded in terrain parks than those occurring at other locations. Many of the injuries were similarly distributed among skiers and boarders, but alpine skiers suffered more lower extremity injuries, especially knee injuries (24%) compared to snowboarders (7%), whereas the reverse was observed for wrist injuries with 22% for snowboarders and 5% for alpine skiers in the last 2-year period ($P < 0.001$). The prevalence of knee injuries among alpine skiers has been about 25% in the period 1996–2012, but wrist injuries among snowboarders dropped from 29 to 22% ($P < 0.001$). The prevalence of knee injuries was twice as high for females (31%) as for males (15%), whereas the reverse was observed for shoulder injuries with 19% for males and 7% for females in the last 2-year period ($P < 0.001$). These differences have been observed during the whole period. Lower leg fracture for alpine skiers <13 years dropped from 20 to 13% in the period ($P < 0.001$), but has remained unchanged with about

A. Ekeland, M.D., Ph.D. (✉) • S. Heir
Orthopaedic Department, Martina Hansens Hospital, Box 823, N-1306 Sandvika, Norway
e-mail: arekelan@online.no

A. Rødven
Norwegian Ski Lift Association, Fridtjofs Nansens vei 19, N-0369 Oslo, Norway

I.S. Scher et al. (eds.), *Snow Sports Trauma and Safety*,
DOI 10.1007/978-3-319-52755-0_1

4% for teenagers and adult skiers. Helmet use by injured skiers/boarders has increased from 11 to 81% in the period, and the prevalence of head injuries has dropped from 19 to 16% ($P < 0.001$).

Conclusion: The injury rate on Norwegian slopes dropped with 14% in the period 2000–2012. The prevalence of back injuries for injured snowboarders increased by 100% from 1996 to 2012, and this may be related to one-third of the injuries occurred in terrain parks at the end of the period. The prevalence of lower leg fracture in alpine children is declined by 35% in the period. Use of helmet by injured skiers/boarders increased from 11 to 81% and the prevalence of head injuries dropped with 16% during the same period.

Keywords Age • Gender • Helmets • Skiing • Skiing trauma • Skiing/boarding ability • Snowboarding • Telemarking • Tibial fractures

1 Introduction

Skiing has been a popular sport in the Nordic countries for more than a century [1], and snowboarding has gained increasing popularity during the last three decades. But skiing and boarding are not without risk, and it is important to perform epidemiological studies to identify risk factors. Most of the studies have been short-term covering 1–2 seasons [2–5], but several good long-term studies have been published from the USA and France [6–9].

The Norwegian Ski Lift Association has a central registry of the injuries occurring at the major Norwegian ski resorts since the season 1996/1997 [10–12]. The purpose of this study is to report the injury trends of skiing and boarding on Norwegian slopes in the 16-year period 1996/97–2011/12.

2 Material and Methods

The injuries occurring on the slopes of 7–16 major Norwegian ski resorts were recorded by ski patrols during the 16 winter seasons 1996/1997–2011/2012. These slopes accounted for about 50% of the ski lift transport in Norway during the registration period. A skiing/boarding injury was defined as an injury sustained by a skier/boarder who was treated by or consulted the ski patrol after a skiing/boarding accident.

The injuries were related to the type of skiing/boarding, the type and site of accident, age, and gender, skiing/boarding ability, use of protective helmet, physician or hospital treatment, and ambulance transport. Regarding skiing ability, the alpine skiers were classified by their performance of turns: expert (short turns), advanced skiers (parallel turns), intermediate skiers (stem turns), and beginners (plow turns) [13, 14]. The skill of snowboarders, telemarkers, and skiboarders was self-estimated.

The number of skier/boarder days was calculated from sold lift tickets (day cards and season cards). The number of day cards was only recorded from the 2000/2001 season and onwards.

The results are presented as injury rates (number of injured skiers/boarders) per 1000 skier/boarder days, mean days between injuries (MDBI), and prevalences (percentage of injured skiers and boarders in various groups). Differences were evaluated by Chi square and 2 × 2-table tests and considered significant when $P < 0.05$.

3 Results

3.1 Injury-Related Factors

Injury rates—A total of 55127 injured skiers and boarders were recorded. The injury rate declined from 1.47 injuries per 1000 skier/boarder days (680 MDBI) in the 2000/2002 seasons to 1.27 injuries per 1000 skier/boarder days (787 MDBI) ($P < 0.001$) in the 2010/2012 seasons (Fig. 1). Fifty-six percent of the injuries required physician or hospital treatment and 15% ambulance transport.

More than half of the injuries occurred during alpine skiing. Snowboarding peaked with 45% of the injuries in the two seasons 2000/2002, declining to 28% of the injuries during the last two seasons. Telemarking injuries dropped from 9 to 2% and skiboarding injuries from 4 to 2% of all injuries in the period (Fig. 2).

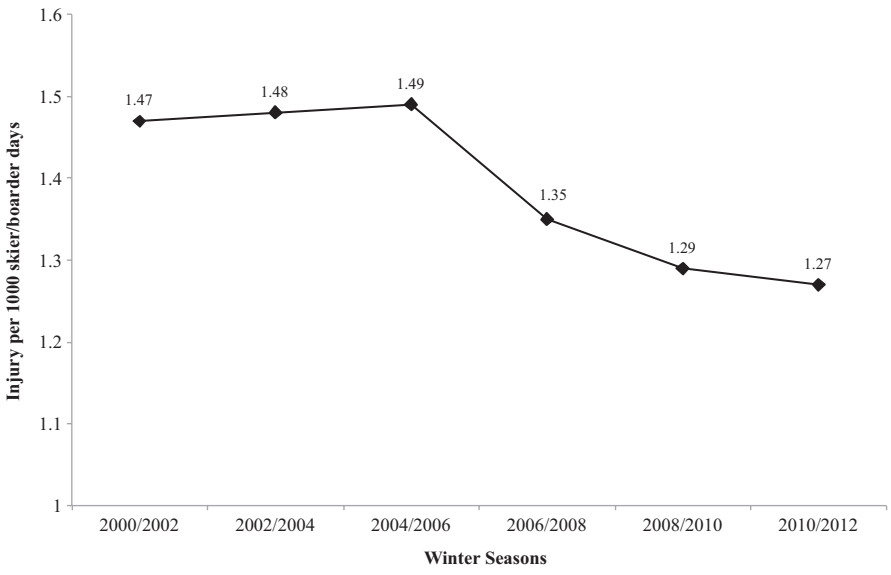

Fig. 1 Injury rates (incidences) for skiers/boarders the seasons 2000/2002–2010/2012. *n* = number of injured skiers/boarders. The population at risk is based on the number of sold day cards for skiers and boarders

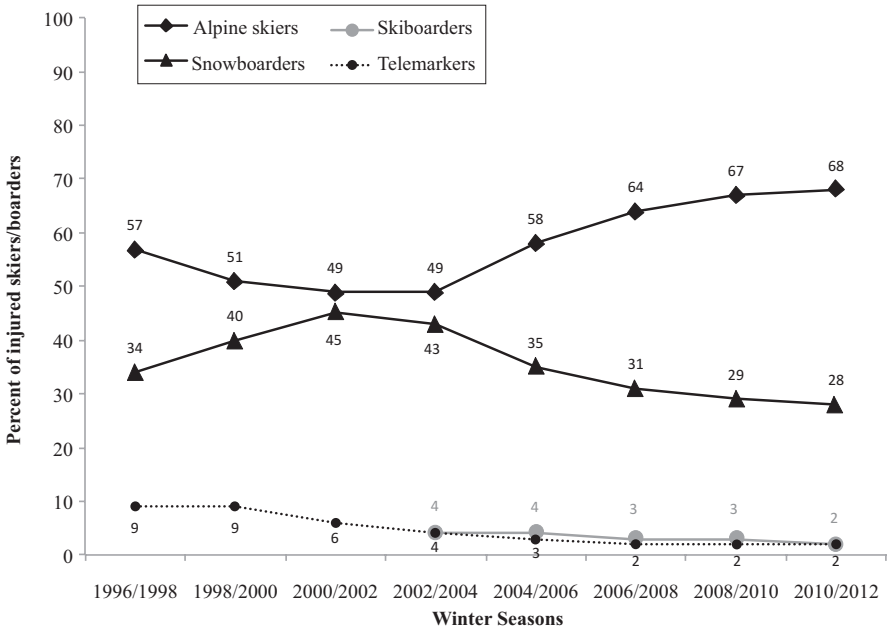

Fig. 2 Prevalences of injured skiers/boarders as percentage of all injured on the slopes the seasons 1996/1997–2010/2012. *n* = number of injured skiers/boarders

Location and type of injury—Many of the injuries were similarly distributed among skiers and boarders, but alpine skiers suffered more lower extremity injuries, especially knee injuries (24%) compared to snowboarders (7%) ($P < 0.001$), whereas the reverse was observed for wrist injuries with 22% for snowboarders and 5% for alpine skiers ($P < 0.001$) in the last 2-year period (Fig. 3). The prevalence of knee injuries among alpine skiers has been about 25% throughout the period, but wrist injuries for snowboarders dropped from 29 to 22% ($P < 0.001$) (Fig. 4). Lower leg fracture was 5.6% for alpine skiers compared to 0.7% for snowboarders ($P < 0.001$) in the 2010/2012 seasons, and this difference has been almost unchanged in the 16-year period. Hand injuries among alpine skiers dropped from 11 to 6% ($P < 0.001$) in the same period (data not shown).

Injury site—Most of the injuries occurred on groomed slopes, but an increasing number of injuries occurred in terrain parks, from only 4% in the 2000/2002 seasons to 24% in the last two seasons when 35% of the snowboarders and 20% of the alpine skiers ($P < 0.001$) suffered their injury in terrain parks (Fig. 5). Injuries in terrain parks were more serious (more fractures, back injuries, and ambulance transports) than those occurring at other locations (Table 1), and the prevalence of back injuries increased from 6 to 12% for snowboarders ($P < 0.001$) and from 5 to 8% for alpine skiers ($P < 0.001$) in the period (Table 2). Injuries suffered off pist and in ski lifts have been stable during the registration period and accounted for about 10%, respectively 5% of all injuries (Fig. 5).

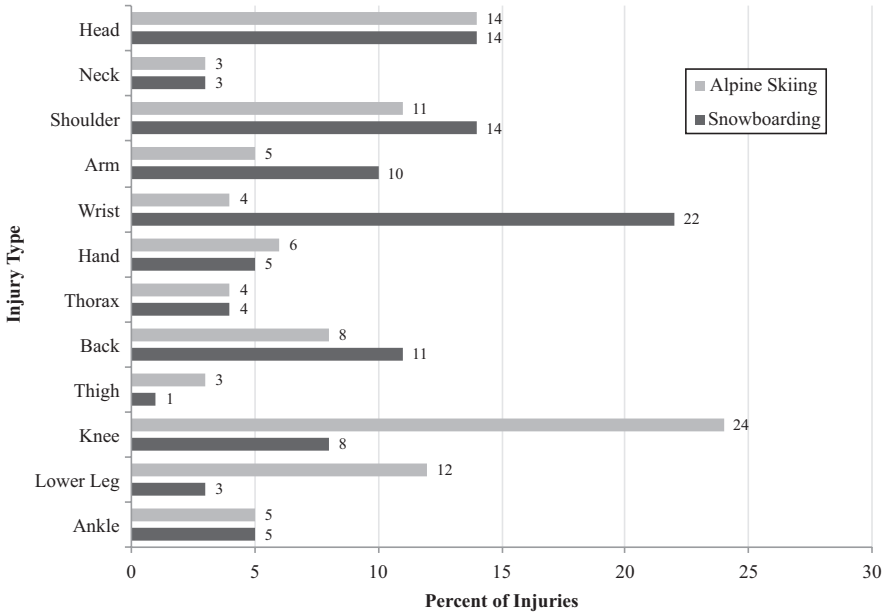

Fig. 3 Type of injuries in alpine skiing and snowboarding the season 2010/2012. *n* = number of injured alpine skiers and snowboarders

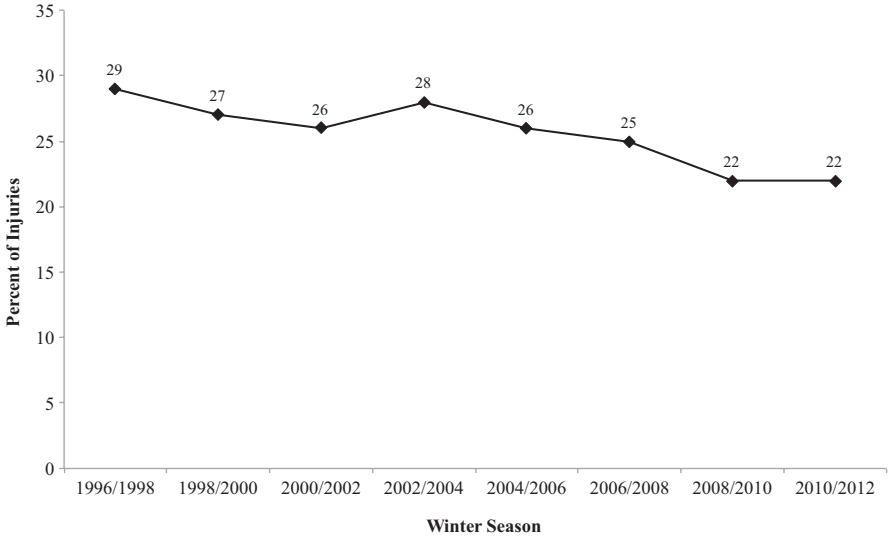

Fig. 4 Prevalence of wrist injuries in snowboarders the seasons 1996/1998–2010/2012. *n* = number of injured snowboarders

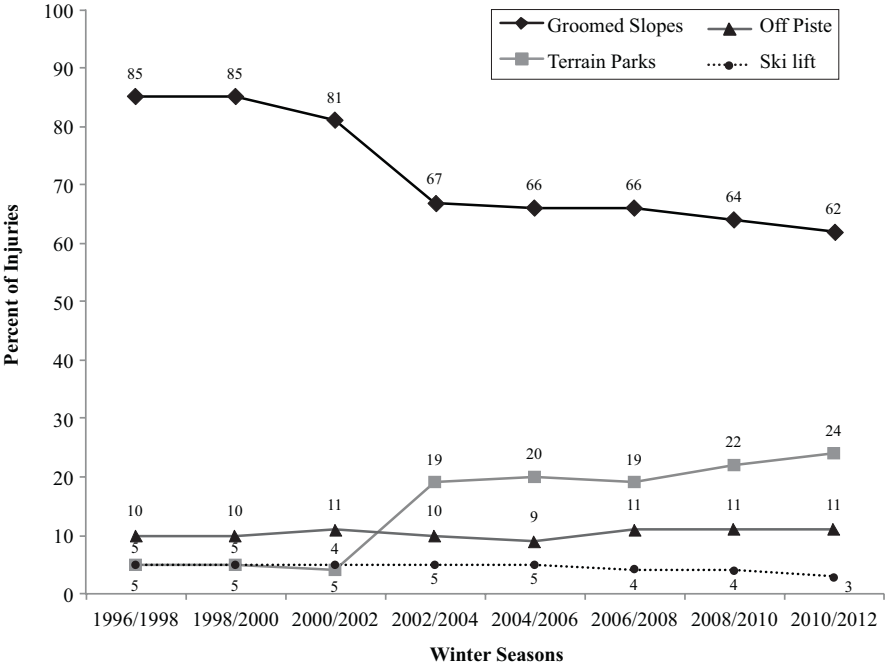

Fig. 5 Site of injury for injured skiers/boarders the seasons 1996/1997–2010/2012. *n* = number of injured skiers/boarders

Table 1 Serious injuries in terrain parks and other slopes the seasons 2010/2012

Injury type	Terrain parks *n* = 1803 (%)	Other slopes *n* = 5758 (%)	Significant differences
Fractures	30	6	$P < 0.001$
Back injuries	18	8	$P < 0.001$
Ambulance transport	30	25	$P < 0.001$

n = number of injuries

Table 2 Back injuries among alpine skiers and snowboarders in the seasons 1996/1998 and 2010/2012

Skiing/ snowboarding seasons	1996/1998 *n* = 2221/1319 (%)	2010/2012 *n* = 5792/2354 (%)	Significant differences
Alpine skiers	5.1	7.8	$P < 0.001$
Snowboarders	5.8	11.5	$P < 0.001$

n = number of injuries among alpine skiers/snowboarders

3.2 Skier-Related Factors

Age—Twenty percent of the injured skiers/boarders were children <13 years, 38% adolescents 13–19 years and 42% adults >19 years. The prevalence of lower leg fracture was related to age and dropped from 20 to 13% for alpine skiers <13 years during the observation period ($P < 0.001$), but remained almost unchanged and about 4% for teenagers and adult skiers (Fig. 6).

Gender—Forty percent of the injured skiers/boarders were females and 60% males. Knee injuries were related to gender, and the prevalence was twice as high for females as for males throughout the period (Fig. 7), whereas the reverse was observed for shoulder injuries (Fig. 8).

Skiing/boarding ability—The skiing/boarding ability increased significantly ($P < 0.001$) during the 12-year period 2000–2012 (Table 3), and the ability for snowboarders increased in the period 1996–2012 ($P < 0.001$). (Table 4). In the 2010/2012 seasons, alpine skiers <13 years suffering lower leg fracture had a significant lower skiing ability than alpine skiers in the same age group suffering other injuries ($P < 0.001$) (Table 5). The ability of the latter increased significantly ($P < 0.001$) from the 1996/1998 to the 2010/2012 seasons (Table 5).

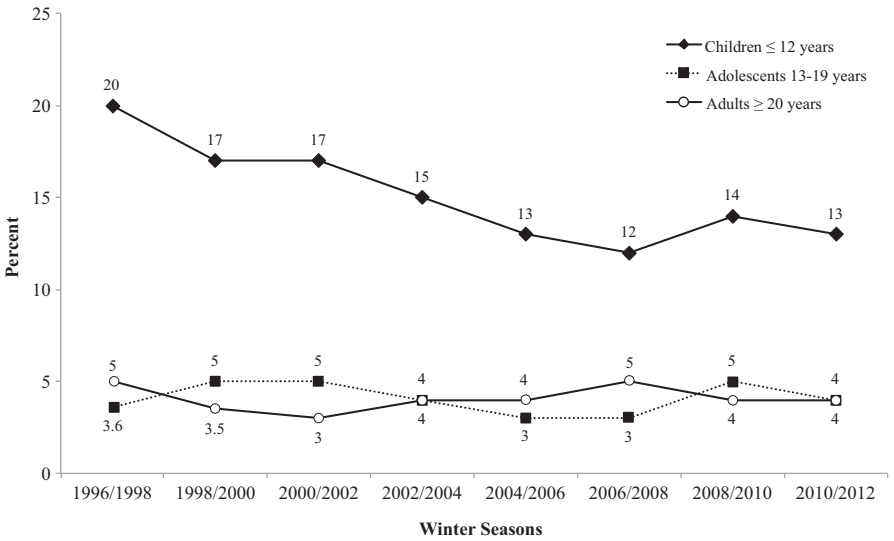

Fig. 6 Prevalence of lower leg fractures in injured alpine skiers during the seasons 1996/1998–2010/2012 recorded for children, adolescents, and adults. *n* = number of skiers with lower leg fracture

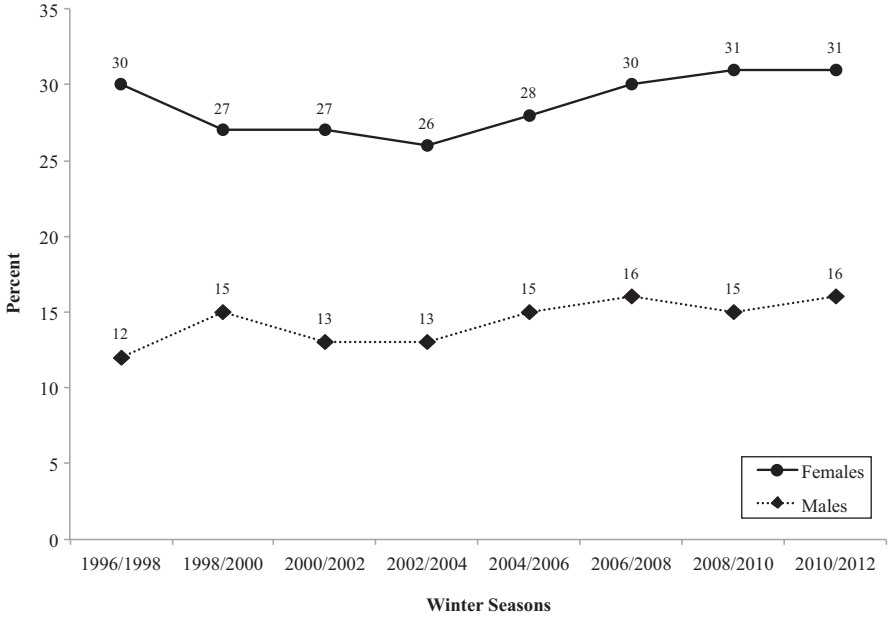

Fig. 7 Prevalence of knee injuries in injured female and male skiers/boarders during the season 1996/1998–2010/2012. *n* = number of skiers/boarders with knee injury

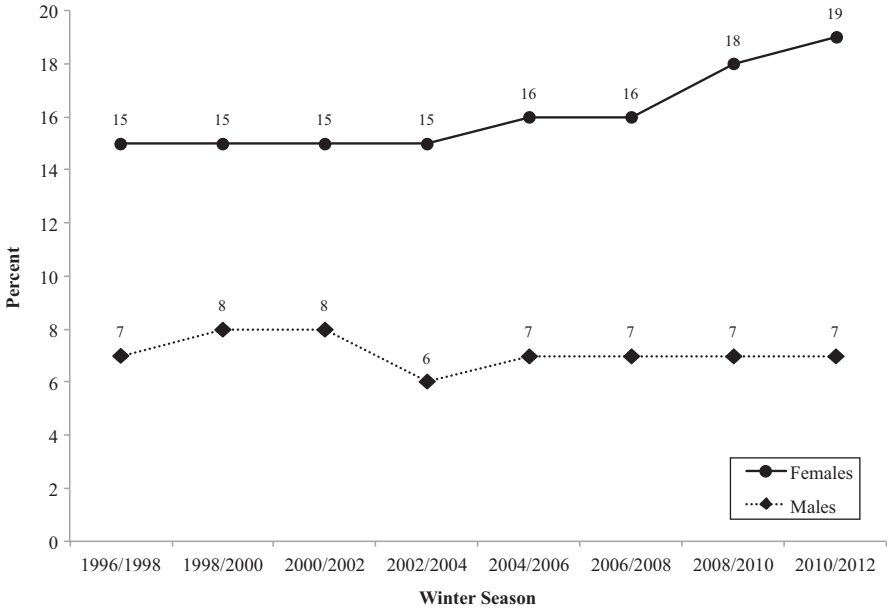

Fig. 8 Prevalence of shoulder injuries in injured female and male skiers/boarders during the seasons 1996/1998–2010/2012. *n* = number of skiers/boarders with shoulder injury

Table 3 Skiing/boarding ability in the seasons 2000/2002 and 2010/2012

Skiing ability	2000/2002 season* $n = 6138$ (%)	2010/2012 season* $n = 7695$ (%)
Expert	14	16
Advanced	28	32
Intermediate	31	31
Beginner	27	20

n = number of injured skiers/boarders
*Significant higher ability for injured skiers/boarders in the 2010/2012 season compared to the 2000/2012 season ($P < 0.001$)

Table 4 Snowboarding ability for injured snowboarders in the seasons 1996/1998 and 2010/2012

Skiing ability	1996/1998 seasons* $n = 1224$ (%)	2010/2012 seasons* $n = 2063$ (%)
Expert	14	16
Advanced	28	35
Intermediate	28	30
Beginner	30	20

n = number of injured alpine skiers and snowboarders
*Significant higher ability for injured snowboarders in the 2010/2012 season compared to the 1996/1998 season ($P < 0.001$)

Table 5 Skiing ability for alpine skiers <13 years with lower leg fracture the seasons 2010/2012 and injured alpine skiers <13 years with other injuries the seasons 2010/2012 and 1996/1998

Skiing ability	2010/2012 seasons Skiers <13 years with lower leg fracture* $n = 154$ (%)	2010/2012 seasons Skiers <13 years with other injuries*# $n = 999$ (%)	1996/1998 seasons Skiers <13 years with other injuries# $n = 336$ (%)
Expert	2	10	2
Advanced	15	27	20
Intermediate	29	35	36
Beginner	54	28	42

n = number of injured alpine skiers
*Significant lower skiing ability in children with lower leg fracture compared to children with other skiing injuries ($P < 0.001$). #Significant higher skiing ability of alpine skiers with other injuries in the 2010/2012 compared to the 1996/1998 seasons

3.3 Equipment-Related Factors

Helmet—The use of helmet by injured skiers/boarders increased from 11 to 81% in the period, and the prevalence of head injuries dropped from 19 to 16% ($P < 0.001$) (Fig. 9). In the 2010/2012 seasons, 15.8% of the skiers/boarders wearing helmet suffered a head injury compared to 16.9% of those without helmet. More skiers/boarders

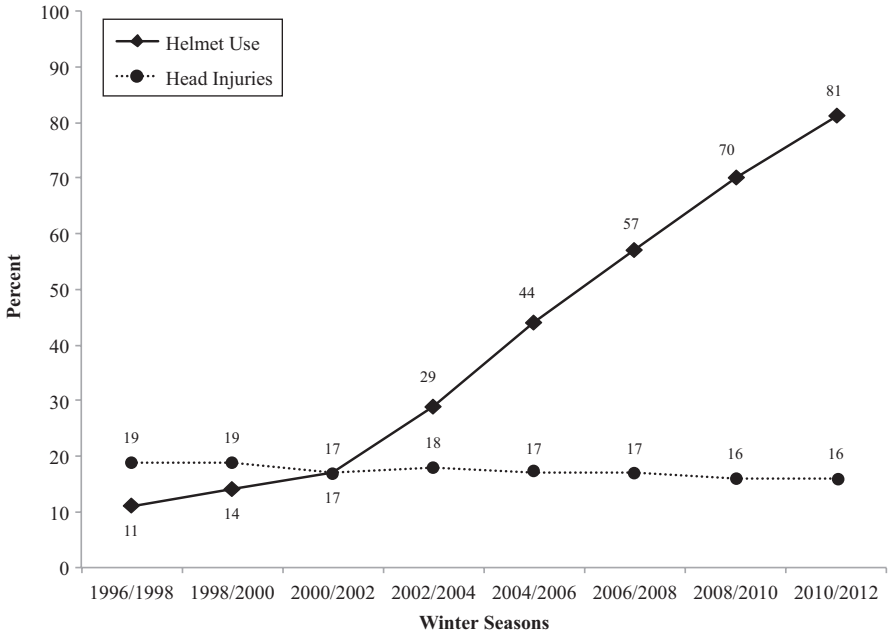

Fig. 9 Use of helmet and prevalence of head injuries in injured skiers/boarders during the seasons 1996/1998–2010/2012. *n* = number of injured skiers/boarders

Table 6 Head injury severity with and without helmet the 2010/2012 seasons

Head injury	With helmet *n* = 943 (%)	With helmet *n* = 234 (%)	Pianificant difference
Direct to hospital	5	13	$P < 0.001$
To physician	54	63	$P = 0.026$

n = number of skiers/boarders with head injury

without helmet needed transport direct to hospital or physician than those with helmet (Table 6). The prevalence of neck injury has been about 3% and similar for skiers/boarders with and without helmet throughout the study.

Wrist guard—Only 4% of injured snowboarders used wrist guards.

4 Discussion

The injury rate decreased by 14% during the period 2000–2012. The number of sold day cards was not recorded before 2000, only the number of lift transports. The injury rate is significantly related to skiing ability [8, 9, 15, 16], and the ability on the slopes increased significantly for skiers/boarders during the period (Table 3).

This may partly explain the reduced injury rate at the end of the period. Also Shealy et al. [9] report a reduction of the injury rate in a ski patrol study from 14 American ski resorts in the period 2000–2010, where the injury rate was 2.6 per skier visit in 2000 and 2.5 in 2010. Kim et al. [7] found a decrease in injury rate for alpine skiers, but not for snowboarders in the period 1988–2006 in a study from Vermont, USA. Laporte et al. [8] found an overall decrease in injury rate from 2.7 to 2.43 injuries per 1000 skier/boarder days during the period 2005–2010 in a study from 32 French ski resorts. The injury rate for alpine skiers remained stable in the period, whereas that of snowboarders declined after 2006.

Most of the injuries occurred during alpine skiing, whereas snowboarding peaked with 45% of the injuries on the slopes in the 2000/2002 seasons (Fig. 2). This is not related to differences in risk for alpine skiing and snowboarding, but to the size of the population of skiers and boarders on the slope. The popularity of alpine skiing increased after the carving skis were introduced in the late 1990, with a corresponding sales reduction of snowboards. The popularity of telemark skiing has also gradually decreased during the registration period. Skiboards were introduced in 2002 but did not gain popularity with low sales of the equipment. Also Kim et al. [7] report that snowboarders peaked with 34% of the population on the slopes in 2000/2001 and then dropped to 20% the last years of their study that ended in 2006.

Alpine skiers suffer mainly knee injuries whereas snowboarders suffer mainly wrist injuries. This is in agreement with several other reports [7, 9, 17]. The prevalence of knee injuries in alpine skiers remained almost the same during the period as also reported by Kim et al. [7] and Shealy et al. [9], but the prevalence of wrist injuries in snowboarders decreased (Fig. 4). Beginners were significantly overrepresented among snowboarders with wrist injuries [7, 8, 12]. Snowboarding ability increased significantly during the period with less beginners on the slopes (Table 4), and this may be a possible explanation for the reduced prevalence of wrist injuries at the end of the period. This finding is in accordance with that of Laporte et al. [8] from France whereas both Kim et al. [7] and Shealy et al. [9] found an increase of wrist injuries over time in the USA. The two latter studies do not report if the snowboarding ability changed in the recorded period.

The prevalence of knee injuries was twice as high in females as in males, whereas the reverse was observed for shoulder injuries. These findings were observed throughout the 16-year registration period (Figs. 7 and 8), and have also been reported by others [17–20]. This significant gender difference is observed both in alpine skiing, snowboarding, telemark skiing, and skiboarding, and in each of the four skiing/boarding ability groups: expert, advanced, intermediate, and beginner [12]. It may be due to anatomical sex differences and related to differences in strength and elasticity of ligament and muscles, but so far we have no convincing explanation for these observations.

The prevalence of lower leg fracture in alpine skiers was significantly higher for children than for older skiers (Fig. 6), as reported previously [21, 22]. The risk for lower leg fracture in alpine skiers decreased significantly in the 1970 and 1980, probably due to better boots and release bindings, and better binding setting and adjustment in the ski shops, levelling out to a lower plateau from the 1990 [6]. This has not

been observed to the same degree in children where the prevalence of lower leg fracture decreased from 20% in the 1996/1998 seasons reaching a plateau of 12–13% from the 2006/2008 seasons. Alpine skiers <13 years with lower leg fracture have a significant lower skiing ability than skiers <13 years with other injuries, and the skiing ability of the latter increased significantly during the registration period (Table 5). This may partly explain the reduction of lower leg fracture for children in the period, together with better boots and bindings with correct adjustment and setting, and less use of second-hand equipment [23]. Also Greenwald and Laporte [22] have reported beginners to be overrepresented among skiers with lower leg fracture.

Use of a protective helmet increased from 11 to 81% in the period, but the prevalence of head injury only dropped from 19 to 16% (Fig. 9). Helmet offers protection against head injuries [24–26], but the reduction of the head injury prevalence of three percentage points or 16% after an increase of helmet use of 60 percentage points or more than seven times is less than expected and in agreement with the findings of Sulheim et al. [27]. But the injuries suffered by skiers/boarders without helmet were probably more serious as more of them required transport direct to hospital or physician than those suffered by skiers/boarders with helmet (Table 6). Skiers/boarders with helmet suffering head injuries had a higher ability than all injured skiers/boarders with helmet [12]. This may indicate that they ski faster on the slope and may have a sensation seeking behavior [25, 28]. The prevalence of neck injuries has been similar for skiers/boarders with and without helmet throughout the study. Thus, the use of helmet does not increase the risk for neck injuries, as also reported by Cusimano and Kwok [26].

Most of the injuries occurred on groomed slopes, where most of the skiing/boarding population was located. Terrain parks started to appear in the ski resorts around 2000, and since then an increasing share of the injuries occur in terrain parks (Fig. 5). More fractures and back injuries occurred in terrain parks than in other slopes and more injuries from the parks required ambulance transport (Table 1), suggesting the injuries in terrain parks to be more serious. It is difficult to record the injury rate in terrain parks. Laporte et al. [8] reported an increased rate compared to the overall injury rate, whereas Shealy et al. [9] found no evidence for an increased injury rate in terrain parks.

The strength of this study is the high number of injuries recorded in the largest Norwegian ski resorts by the same method during 16 successive ski seasons. The limitation is the lack of a control material of uninjured skiers/boarders from the same period. In the 2001/2002 season, we were able to collect a representative control material enabling us to perform a case-control study with calculation of injury rates and injury risk for different groups of skiers/boarders [5, 16]. Another limitation is that the diagnoses have been made by ski patrols, and some conditions like fractures may have been over diagnosed. The prevalence of the different injuries has, however been quite consistent during the 16-year period. We therefore think that any weakness of diagnostic accuracy by the ski patrols may partly be compensated by the high number of injured skiers/boarders in the material. The ski patrol may also pick up some minor injuries not needing medical attention.

5 Conclusion

The injury rate on Norwegian slopes dropped 14% during the period 2000–2012, possibly due to an increase of the skiing/boarding ability. The prevalence of wrist injuries in snowboarders was also reduced, whereas the boarding ability increased. The prevalence of back injuries in snowboarders increased by 100% from 1996 to 2012, and this may be related to one-third of the injuries occurred in terrain parks at the end of the period. The prevalence of knee injuries was twice as high in females compared to males, whereas the reverse was observed for shoulder injuries throughout the period. The prevalence of lower leg fracture in children dropped by 35% at the end of the period, whereas the skiing ability of children with other injuries increased. The use of helmet increased more than seven times among injured skiers/boarders to 81%, and the prevalence of head injuries dropped with 16% at the end of the 16-year period.

References

1. Ekeland A, Larsen SR, Tuxen AG, Nygaard P (1989) Organization of skiing safety in Norway. In: Johnson RJ, Mote CD, Binet MH (eds) Skiing trauma and safety, vol 7. ASTM STP 1022, Philadelphia, pp 342–353
2. Hagel BE, Meeuwisse WH, Mohtadi NG, Fick GH (1999) Skiing and snowboarding injuries in children and aldolescents of southern Alberta. Clin J Sport Med 9(1):9–17
3. Langren M, Salvaraj S (2004) Increased injury risk among first-day skiers, snowboarders and skiboarders. Am J Sports Med 32:96–103
4. Ogawa H, Sumi H, Sumi Y, Shimizu K (2010) Skill level-specific differences in snowboarding related injuries. Am J Sports Med 38(3):532–537
5. Sulheim S, Holme I, Rødven A, Ekeland A, Bahr R (2011) Risk factors for injuries in alpine skiing, telemark skiing and snowboarding—case-control study. Br J Sports Med 45(16): 1303–1309
6. Johnson RJ, Ettlinger CF, Shealy JE (2009) Update on injury trends in alpine skiing. In: Johnson RJ, Shealy JE, Langren M (eds) Skiing trauma and safety, vol 17. ASTM STP 1510, Philadelphia, pp 11–22
7. Kim S, Endres NK, Johnson RJ, Ettlinger CF, Shealy JE (2012) Snowboarding injuries. Trends over time and comparisons with alpine skiing injuries. Am J Sports Med 40(4):770–776
8. Laporte JD, Bajolle L, Lamy D, Delay JB (2012) Winter sport injuries in France over two decades. In: Johnson RJ, Shealy JE, Greenwald RM, Scher IS (eds) Skiing trauma and safety, vol 19. ASTM STP 1553, Philadelphia, pp 201–215
9. 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 STP 1582, Philadelphia, pp 93–111
10. Ekeland A, Rødven A (2000) Injuries in alpine skiing, telemarking and snowboarding. In: Johnson RJ, Zucco P, Shealy JE (eds) Skiing trauma and safety, vol 13. ASTM STP 1397, Philadelphia, pp 87–94
11. Ekeland A, Rødven A (2006) Injuries in Norwegian ski resorts 2002–2004. In: Johnson RJ, Shealy JE, Yamagishi T (eds) Skiing trauma and safety, vol 16. ASTM STP 1474, Philadelphia, pp 1–7
12. Ekeland A, Rødven A (2012) Injuries in alpine skiing, telemarking, snowboarding and skiboarding related to gender and ability. In: Johnson RJ, Shealy JE, Greenwald RM, Scher IS (eds) Skiing trauma and safety, vol 19. ASTM STP 1553, Philadelphia, pp 216–227

13. Ekeland A, Holtmoen Å, Lystad H (1993) Lower extremity equipment-related injuries in alpine recreational skiers. Am J Sports Med 21(2):201–205
14. Sulheim S, Bahr R, Ekeland A (2007) Self-estimation of ability among skiers and snowboarders in alpine skiing resorts. Knee Surg Sports Traumatol Arthrosc 15:665–670
15. Shealy JE (1982) Two-year statistical analysis of skiing injuries at 13 selected aereas in the USA. In: Hauser W, Karlsson J, Magi M (eds) Skiing trauma and skiing safety IV. Publication series of TUEV-edition, Munich, pp 207–216
16. Ekeland A, Sulheim S, Rødven A (2005) Injury rates and injury types in alpine skiing, telemarking and snowboarding. In: Johnson RJ, Shealy JE, Ahlbäumer MG (eds) Skiing trauma and safety, vol 15. ASTM STP 1464, Philadelphia, pp 31–39
17. Zacharopopoulos AN, Smyrnis A, Vlastos I, Zafairiou C (2015) Skiing injuries in Greece: a six year case-control study. In: Johnson RJ, Shealy JE, Greenwald RM (eds) Skiing trauma and safety, vol 20. ASTM STP 1582, Philadelphia, pp 122–137
18. Greenwald RM, France EP, Rosenberg TD, Toelcke T (1996) Significant gender differences in alpine skiing injuries: a five year study. In: Mote CD, Johnson RJ, Hauser W, Schaff PS (eds) Skiing trauma and safety, vol 10. ASTM STP 1266, Philadelphia, pp 36–44
19. Shealy JE, Ettlinger CF (1996) Gender related injury pattern in skiing. In: Mote CD, Johnson RJ, Hauser W, Schaff PS (eds) Skiing trauma and safety, vol 10. ASTM STP 1266, Philadelphia, pp 45–57
20. Cadman R, Macnab AJ (1996) Age and gender: two epidemiological factors in skiing and snowboarding injury. In: Mote CD, Johnson RJ, Hauser W, Schaff PS (eds) Skiing trauma and safety, vol 10. ASTM STP 1266, Philadelphia, pp 58–65
21. Deibert MC, Aronsson DD, Johnson RJ, Ettlinger CF, Shealy JE (1998) Skiing injuries in children, aldolescents and adults. J Bone Joint Surg Am 80(1):25–32
22. Greenwald RM, Laporte JD (2009) Effect of age and experience on lower leg fractures in alpine sports. In: Johnson RJ, Shealy JE, Langren M (eds) Skiing trauma and safety, vol 17. ASTM STP 1510, Philadelphia, pp 3–10
23. Ekeland A, Nordsletten L (1994) Equipment-related injuries in skiing. Recommandations. Sports Med 17:283–287
24. Hagel BE, Pless IB, Goulet V, Platt RW, Robitaille Y (2005) Effectiveness of helmets in skiers and snowboarders: case-control and case crossover study. BMJ 330:281
25. 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
26. Cusimano MD, Kwok J (2010) The effectiveness of helmet wear in skiers and snowboarders: a systematic review. Br J Sports Med 44(11):781–786
27. Sulheim S, Ekeland A, Holme I, Bahr R (2017) Helmet use and risk of head injuries in alpine skiers and snowboarders: changes after an interval of one decade. Br J Sports Med. 51:44–50]
28. Shealy JE, Johnson RJ, Ettlinger CF (2006) On piste fatalities in recreational snow sports in the U.S. In: Johnson RJ, Shealy JE, Yamagishi T (eds) Skiing trauma and safety, vol 16. ASTM STP 1474, Philadelphia, pp 27–34