

Characteristics of Helmet or Knit Cap Use in Head Injury of Snowboarders

—Analysis of 1,190 Consecutive Patients—

Osamu FUKUDA, Yutaka HIRASHIMA*, Hideki ORIGASA**, and Shunro ENDO***

Department of Neurosurgery, Saito Memorial Hospital, Minami Uonuma, Niigata;

*Physiological Chemistry, Faculty of Pharmaceutical Sciences, Teikyo University, Kanagawa;

Division of Biostatistics and *Department of Neurosurgery, University of Toyama, Toyama

Abstract

The rate of head injury is 1.86–6 times higher for snowboarding than for skiing. Detailed data about the usefulness of a helmet or knit cap for protecting against serious head injuries have not been reported. The present study evaluated the use of a helmet or knit cap for preventing head injuries. Questionnaire data were collected from 1,190 consecutive patients in a hospital during the 1999/2000–2002/2003 winter seasons at Uonuma ski resort, Niigata, Japan. Patients were divided into the helmet, knit cap, and no cap groups. Upper technical level was highest and jumping as the cause of injury was most frequent in the helmet group. After adjustment for other confounders, there was a significant negative association between the occurrence of serious head injury during snowboarding and female sex (adjusted odds ratio 0.55, 95% confidence interval 0.421–0.718, $p < 0.0001$) and a significant positive association between serious head injury and jumping (adjusted odds ratio 2.25, 95% confidence interval 1.48–3.43, $p = 0.0001$). Among snowboarding maneuvers, only jumping showed a significant negative association between wearing of a helmet or knit cap and the occurrence of serious head injury ($p = 0.036$). Snowboarders who wear helmets might attempt dangerous maneuvers causing injuries. Wearing of a helmet or knit cap protected against serious head injuries on jumping. Every snowboarder should wear a helmet or knit cap on jumping to prevent head injury.

Key words: head injury, snowboard, helmet, knit cap, jump

Introduction

Snowboarding has gained great popularity in Japan, particularly among the younger generation. However, because of its techniques and associated jumping, the rate of head injury is 1.86–6 times higher for snowboarding than for skiing.^{4,15} Snowboarding has only recently been practiced as a winter sport, so there is very little information available regarding the mechanisms and means of protection against head injury. Recently, helmet use was reported to clearly reduce the incidence of head injury in snowboarding.^{13,17} However, the usefulness of helmets in skiing and snowboarding is still controversial.^{7,8,10,11,14,16}

The present study evaluated the efficacy of helmet or knit cap use for protection against serious head injuries, based on 1,190 snowboarders who present-

ed with head injury.

Materials and Methods

This study included 1,190 consecutive patients who experienced head injury during snowboarding and consulted Saito Memorial Hospital between December 1999 and March 2003. This hospital is the only institute of neurosurgery in Minami-uonuma city, located about 200 km northwest of Tokyo, Japan, and center of a famous Japanese winter sports resort area with 34 skiing facilities. Approximately seven million individuals visit this area each winter season. Serious head injury was defined as an incident leading to traumatic amnesia, loss of consciousness, craniofacial fracture, or intracranial lesion.

A questionnaire was prepared for each patient, with inquiries regarding sex, age, level of snowboarding technique, incident slope, use of cap, and related issues. The study was based on the data from all patients' questionnaires. The questionnaire was answered by a related individual, if patients could

not respond to questions. Technical level was divided into five classes, first time, beginner, intermediate, upper, and unknown. Headwear was classified as helmet, knit cap, or no cap. Knit cap is a cap made from knitted cotton, wool, acryl, and other materials. The helmets are small, compact, and light, and are widely sold as sporting goods in Japan. The helmet is made of ABS (acrylonitrile butadiene styrene) resin, etc., in the U.S.A., Germany, France, and elsewhere in accordance with safety standard ASTM2040 (American Society for Testing and Materials 2040), CEN (European Committee for Standardization), and others. Incident slope was classified as flat ground, steep slope, non-steep slope, or jumping stand.

Values are mean \pm standard deviation. Univariate analysis was performed to assess the relationships between headwear and variables. The chi-square test and Kruskal-Wallis test were used for these analyses. After eliminating variables that were closely related, some demographic variables and variables statistically associated with occurrence of head injury were analyzed further using multiple logistic regression analysis. Variables in the final model were selected according to a stepwise method. The odds ratios (ORs) were calculated for interactions of each confounder and occurrence of head injury. Values of $p < 0.05$ were considered significant.

Results

Table 1 summarizes the characteristics of all 1,190

patients. Serious head injury occurred in 549 of the 1,190 patients (46.1%). The 1,190 patients were divided into three groups according to the headgear worn at the time of the incident: the helmet group, knit cap group, and no cap group. The intracranial lesions consisted of two cases of cerebral contusions and three of subarachnoid hemorrhage in the helmet group, 19 of subdural hematoma, four of subarachnoid hemorrhage, two of cerebral contusion, and one of intraventricular hemorrhage in the knit cap group, and one of subdural hematoma, one of subarachnoid hemorrhage, and one of cerebral contusion in the no cap group. Surgery was performed for four patients with acute subdural hematoma. Three of the four patients had no cerebral contusion, and the bleeding point of the bridging vein was confirmed during surgery. One of the four patients had mild brain surface contusion, but the bleeding point was not confirmed.

The male/female ratio was highest for the group wearing helmets, followed by the groups wearing no cap and a knit cap ($p = 0.0023$). The age of the helmet group was highest, followed by the knit cap and no cap groups ($p < 0.0001$). The percentage of individuals at the upper technical level was highest in the helmet group, followed by the knit cap and no cap groups ($p < 0.0001$). Head injury on jumping was most frequent in the helmet group, followed by the knit cap and no cap groups ($p < 0.0001$). Serious head injury showed the highest rate in the helmet group, followed by the knit cap and no cap groups ($p = 0.0001$). Craniofacial fracture showed the highest rate in the helmet group, followed by the no cap and

Table 1 Summary of characteristics of 1,190 snowboarding patients

		Number of patients (%)			p Value
		Helmet	Knit cap	No cap	
Total number		92	913	185	
Sex	male	70 (76.1)	570 (62.4)	134 (72.4)	0.0023
	female	22 (23.9)	343 (37.6)	51 (27.6)	
Age, years	mean \pm SD	24.6 \pm 4.04	23.3 \pm 4.08	22.7 \pm 4.80	<0.0001
Technical level	upper	31 (33.7)	117 (12.8)	12 (6.49)	<0.0001
	others	61 (66.3)	796 (87.2)	173 (93.5)	
Slope on injury	jump	56 (60.9)	362 (39.6)	39 (21.1)	<0.0001
	others	36 (39.1)	551 (60.4)	146 (78.9)	
Serious head injury*	positive	59 (64.1)	421 (46.1)	69 (37.3)	0.0001
	Traumatic amnesia	31 (33.7)	247 (27.1)	36 (19.5)	
Loss of consciousness	positive	14 (15.2)	112 (12.3)	21 (11.4)	0.658
Craniofacial fracture	positive	9 (9.8)	36 (3.9)	9 (4.8)	0.036
Intracranial lesion	positive	5 (5.4)	26 (2.8)	3 (1.6)	0.120
Glasgow Coma Scale	15-13	58	414	68	0.620
	12-9	1	0	1	
	8-3	0	7	0	

*Serious head injury was defined as an accident with traumatic amnesia, loss of consciousness, craniofacial fracture, or intracranial lesion. SD: standard deviation.

Table 2 Logistic regression analysis for risk factors for serious head injury with snowboarding using data for 1,190 snowboarders

Variable	Unit	Adjusted OR (95% CI)	p Value
Sex	female	0.550 (0.421–0.718)	<0.0001
Age	5 years	1.02 (0.890–1.17)	0.737
Jump	yes	2.25 (1.48–3.43)	0.0001
Technique	upper	1.17 (0.821–1.68)	0.39
Cap with jump	helmet or knit cap*		0.036
	helmet	0.661** (0.323–1.35)	0.253
	knit cap	0.770** (0.495–1.20)	0.245

*The Wald test was used to evaluate whether wearing a helmet or knit cap had an effect on jumping. **Compared to no cap when jumping. CI: confidence interval, OR: odds ratio.

knit cap groups ($p = 0.036$), but there were no differences in incidence of loss of consciousness or intracranial lesion.

Multiple logistic regression analysis was used to explore independent risk factors for serious head injury (Table 2). After adjustment for other confounders, there was a significant negative association between the occurrence of serious head injury during snowboarding and female sex (adjusted OR 0.55, 95% confidence interval [CI] 0.421–0.718, $p < 0.0001$) and a significant positive association between serious head injury and jumping (adjusted OR 2.25, 95% CI 1.48–3.43, $p = 0.0001$). Although no significant association was observed between helmet or knit cap wearing and the occurrence of serious head injury overall ($p = 0.056$) (data not shown), there was a significant negative association between helmet or knit cap wearing and the occurrence of serious head injury on jumping ($p = 0.036$).

Discussion

Interestingly, we found that female sex was associated negatively and jumping was associated positively with the occurrence of serious head injury. This may be due to a difference in the participation in dangerous activity like jumping between the two sexes.^{1,9)} An increase in spinal injuries has been reported in advanced snowboarders attempting dangerous maneuvers,⁶⁾ and is consistent with links between jumping and spinal injuries in snowboarders.^{18,21)} Higher proportion of head injuries in association with higher ability has also been reported for both male skiers and snowboarders under age 18 years.⁵⁾ We emphasize that snowboarders performing dangerous maneuvers such as jumping causing high energy injuries should wear a helmet or knit

cap.

Although helmet use by skiers and snowboarders is increasingly encouraged, recommendations are generally based on data from helmet studies for these sports.¹³⁾ Wearing a helmet is effective for preventing head injuries in skiers and snowboarders.^{13,17)} We obtained the same finding. Head wear including a helmet or knit cap protected against serious head injuries on jumping, but whether helmet use prevents injuries in snowboarders is still controversial. Helmets may increase cervical spine injury⁸⁾ and the incidence and the severity of injuries.⁷⁾ Helmets may also restrict sight and hearing, and contribute to an increase in collisions.¹⁰⁾

The present study suggests that snowboarders who wear a helmet tend to attempt dangerous maneuvers causing injuries. We speculate that snowboarders wearing a helmet might be more likely to suffer from serious head injuries. This paradox may be one of factors which confound the judgment as to whether a helmet is effective for protecting against head injury during snowboarding. We could not define the efficacy of helmet or knit cap use in falls, only in jumping. We speculate that head wear is effective for protection against high energy injury in snowboarding.

Determination of optimum helmet design is clearly very important.¹²⁾ Clearly there is a risk for neck or other injuries in skiers or snowboarders wearing a helmet that is too large or heavy.³⁾ The findings that helmets are harmless and valuable in reducing severe head injuries in other sports including bicycling,²⁰⁾ ice hockey,¹⁹⁾ and football²⁾ indicate that further study is needed of alpine recreational helmet design and efficacy in minimizing the effects of similar impact injuries.

The present hospital-based study using a questionnaire examined whether use of a helmet or knit cap is effective in protecting against serious head injuries, using data obtained from 1,190 consecutive snowboarders after adjustment for many confounding factors. The results demonstrate that snowboarders who wear helmets might attempt dangerous maneuvers such as jumping causing high energy injuries and head wear including a helmet or knit cap protected against such serious head injuries. Every snowboarder should wear a helmet or knit cap on jumping to prevent serious head injury.

Acknowledgment

This study was presented in part at the 64th annual meeting of the Japan Neurosurgical Society, Yokohama, Japan, October 5–7, 2005.

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

References

- 1) Bridges EJ, Rouah F, Johnston KM: Snowblading injuries in Eastern Canada. *Br J Sports Med* 37: 511-515, 2003
- 2) Cantu RC: Head injuries in sport. *Br J Sports Med* 30: 289-296, 1996
- 3) Deibert MC, Aronsson DD, Johnson RJ, Ettlinger CF, Shealy JE: Skiing injuries in children, adolescents, and adult. *J Bone Joint Surg Am* 80: 25-32, 1998
- 4) Fukuda O, Takaba M, Saito T, Endo S: Head injuries in snowboarders compared with head injuries in skiers. A prospective analysis of 1076 patients from 1994 to 1999 in Niigata, Japan. *Am J Sports Med* 29: 437-440, 2001
- 5) Hagel BE, Meeuwisse WH, Mohtadi NGH, Fick GH: Skiing and snowboarding injuries in the children and adolescents of Southern Alberta. *Clin J Sport Med* 9: 9-17, 1999
- 6) Hagel BE, Pless IB, Platt RW: Trends in emergency department reported head and neck injuries among skiers and snowboarders. *Can J Public Health* 94: 458-462, 2003
- 7) Hunter RE: Skiing injuries. *Am J Sports Med* 27: 381-389, 1999
- 8) Konrad CJ, Fieber TS, Schuepfer GK, Gerber HR: Are fractures of the base of the skull influenced by the mass of the protective helmet? A retrospective study in fatally injured motorcyclists. *J Trauma* 41: 854-858, 1996
- 9) Levy AS, Hawkes AP, Hemminger LM, Knight S: An analysis of head injuries among skiers and snowboarders. *J Trauma* 53: 695-704, 2002
- 10) Levy AS, Smith RH: Neurologic injuries in skiers and snowboarders. *Semin Neurol* 20: 233-245, 2000
- 11) Machold W, Kwasny O, Gassler P, Kolonja A, Reddy B, Bauer E, Lehr S: Risk of injury through snowboarding. *J Trauma* 48: 1109-1114, 2000
- 12) Macnab AJ, Cadman R: Demographics of alpine skiing and snowboarding injuries: lessons for prevention programs. *Inj Prev* 2: 286-289, 1996
- 13) Macnab AJ, Smith T, Gagnon FA, Macnab M: Effect of helmet wear on the incidence of head/face and cervical spine injuries in young skiers and snowboarders. *Inj Prev* 8: 324-327, 2002
- 14) Nagaguchi H, Fujimaki T, Ueki K, Takahashi M, Yoshida H, Kirino T: Snowboard head injury: prospective study in Chino, Nagano, for two seasons from 1995 to 1997. *J Trauma* 46: 1066-1069, 1999
- 15) Nagaguchi H, Tsutsumi K: Mechanisms of snowboarding-related severe head injury: shear strain induced by the opposite-edge phenomenon. *J Neurosurg* 97: 542-548, 2002
- 16) Sacco DE, Sartorelli DH, Vane DW: Evaluation of alpine skiing and snowboarding injury in a north-eastern state. *J Trauma* 44: 654-659, 1998
- 17) Sulheim S, Holme I, Ekeland A, Bahr R: Helmet use and risk of head injuries in alpine skiers and snowboarders. *JAMA* 295: 919-924, 2006
- 18) Tarazi F, Dvorak MF, Wing PC: Spinal injuries in skiers and snowboarders. *Am J Sports Med* 27: 177-180, 1999
- 19) Tator CH: Neck injuries in ice hockey: a recent, unsolved problem with many contributing factors. *Clin Sports Med* 6: 101-114, 1987
- 20) Weiss BD: Bicycle-related head injuries. *Clin Sports Med* 13: 99-112, 1994
- 21) Yamakawa H, Murase S, Sakai H, Iwama T, Katada M, Niikawa S, Sumi Y, Nishimura Y, Sakai N: Spinal injuries in snowboarders: risk of jumping as an integral part of snowboarding. *J Trauma* 50: 1101-1105, 2001

Address reprint requests to: Osamu Fukuda, M.D., Department of Neurosurgery, Saito Memorial Hospital, 478-2 Kakenoue, Minami Uonuma, Niigata 949-6602, Japan.
e-mail: fufu@seagreen.ocn.ne.jp

Commentary

Snowboarding has become a popular sport in the mountain resorts. And for the younger generation raised on skateboards, the transition for fun and excitement to the snowboard has arrived in a big way. Unfortunately, head injuries are more common than for skiing. The younger male person who has little fear in challenging jumps with or without a helmet is more likely to make a bad landing and to have a serious injury. All we can do is warn and educate these snowboarders.

Thomas B. DUCKER, M.D., F.A.C.S.
Department of Neurosurgery
Johns Hopkins University
Annapolis, Maryland, U.S.A.

After Prof. Wen ta Chiu, from an epidemiological analysis, had reported significantly lower mortality rates for motorcyclists after the introduction of compulsory helmets in Taiwan, the obvious protective effect of helmets in sports with frequent head injuries became "evidence based." This important report by Fukuda et al. constitutes further significant support to the idea that protection of the brain is by far more effective than treatment of head injury. The results of this analysis are quite reassuring: Snowboarders, who engage in jumping have an overall increased risk of suffering a head injury, but they can certainly protect their brains. It has become common practice to use safety ski bindings, which release the boot when the skier falls to protect the legs. As society as a whole pays for the expense of severe head injury there should be some incentive, e.g. reduced accident insurance rates, based on this study to encourage protection of the head. The authors deserve our respect to draw our attention to this effect with this sound study.

Raimund FIRSCHING, M.D., L.R.C.P., M.R.C.S.
Klinik für Neurochirurgie
Otto-von-Guericke-Universität
Magdeburg, Germany