

Comparison and Analysis of Injuries At Ski Resorts in Chongli, China and Japan

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Abstract

Background: *More researches should be needed on injuries at ski resorts in Chongli, one of the sites of the 2022 Winter Olympics.*

Hypothesis: *In Chinese ski resorts, injury accidents should be more frequent, and the injured body parts may be related to the protective clothing*

Methods: *In this retrospective study, injuries at ski resorts in Chongli, China and Japan were analyzed to provide a reference for the ongoing injury prevention work at ski resorts. We collected data [see Additional file 1] on injuries at Wanlong and Fulong Ski Resort in Chongli during the 2017–2018 and 2018–2019 ski seasons. We referred to the ski injury report issued in February 2020 by the Japan Ski Safety Association [see Additional file 2]. The causes of and specific body parts involved in the injuries at both the Chinese and Japanese ski resorts were analyzed.*

Results: *During the 2019–2020 ski season at the Japanese ski resorts, 0.93 injuries occurred per 10,000 skiers, and older skiers constituted a larger proportion of those injured, with 227 (8.6%) aged over 60 years. The knee joint was the most commonly injured body part among both Chinese and Japanese skiers, whereas shoulder joint injury was the most prevalent among snowboarders.*

Conclusion: *The two Chongli ski resorts had a higher injury rate than the Japanese ski resorts. Medical treatment should focus more on older skiers, and helmet use requires urgent promotion*

1 Background

The high injury rate in skiing, one of the most popular winter sports, has limited its development. Studies have reported daily averages of 0.7 to 1.37 injuries per 1000 skiers,^{2, 13, 15} indicative of the fact that skiing is a relatively dangerous sport in which adults participate.⁹ High-level athletes encounter greater risks of injury in competition. Flørenes et al.⁵ noted that 86 (45%) of the 191 acute injuries that occurred among 521 World Cup alpine skiers were sustained during the International Ski Federation Alpine Ski World Cup.

With the approach of the 2022 Winter Olympics, Chongli District, a skiing hot spot in China, is expected to experience an influx of visitors. Moreover, ski resorts will be expecting a higher number of beginner skiers. Ogawa et al.¹¹ examined the relationship between snowboarding injuries and skill level, observing that 86.4% of 19539 injured snowboarders were at an intermediate level or lower. To manage the increasing number of ski injuries, plans have been made for Chongli to recruit more health care personnel and upgrade basic medical equipment. Few studies have investigated ski injuries in Chongli, challenging the ongoing local work on ski injury prevention. Skiing is more popular in Japan, a developed country, than in China. This may explain why the Japanese body of literature on ski injuries dates back longer and is more substantial than the Chinese equivalent. Therefore, Japan's knowledge on ski injury prevention was worthy of reference.

In this study, we analyzed data on injuries at two ski resorts in Chongli, where most of the skiing events at the 2022 Winter Olympics will be staged, during the 2017–2018 and 2018–2019 ski seasons. We also analyzed Japan's ski injury data of February 2020. Moreover, we referred to data on experiences concerning ski injury prevention and specific precautions to improve the ongoing work on ski injury prevention in Chongli.

2 Materials And Methods

The investigation of the ski injuries in China was conducted at the two main ski resorts in Chongli: Fulong Ski Resort and Wanlong Ski Resort. The data on ski injuries in Japan were retrieved from the reports issued by the Japan Ski Safety Association. During ski seasons, medical stations at both of the Chongli ski resorts are staffed by two physicians and one nurse. The nurse records patient information (e.g., name, sex, age, cause and type of injury, and injured body part). The physicians provide emergency and preliminary treatment. Patients with relatively serious injuries, such as fractures, concussions, visceral injuries, and ligament injuries, are immediately transported to the nearest district hospital by a dedicated ambulance for further treatment. The study was approved by the institutional review board. Project Number: M2019456.

During the 2017–2018 ski season, men and women accounted for 191 and 130 (59.5% and 40.5%), respectively, of the 321 cases of ski injuries that occurred at Fulong Ski Resort (out of 71,000 skier days); the injured individuals were aged between 3 and 60 years, with the mean age (standard deviation) being 27.9 (11.3) years. During the 2018–2019 ski season, 432 cases of ski injuries were reported, for which men and women accounted for 230 and 202 (53.2% and 46.8%), respectively; the injured individuals were aged between 2 and 58 years, with the mean age (standard deviation) being 27.2 (11.1) years.

Men and women accounted for 476 and 279 (63% and 37%), respectively, of the 755 cases of ski injuries that occurred at Wanlong Ski Resort out of 373,000 skier days during the 2018–2019 ski season. The injured individuals were aged between 3 and 73 years, with the mean age (standard deviation) being 32.6 (12.9) years.

Men and women accounted for 1571 and 1073 (59.4% and 40.6%), respectively, of the 2644 cases of ski injuries that occurred at 47 Japanese ski resorts in February 2020.

We sorted the original data from the two Chongli ski resorts on the basis of the classification criteria presented in the injury reports issued by the Japanese ski resorts. Furthermore, we conducted a comparative analysis of the age of the injured individuals at both the Chinese and Japanese ski resorts, the injured body parts, and the cause of injury. We also introduced the injury rate (IR), which represents the number of injury accidents per ski resort per day, to better compare the data of Chongli Ski resort and Ski resort in Japan.

The data were analyzed using Excel software, with the categorical data presented as the number and percentage of cases. Causes of injury and injured body parts (in both the Chinese and Japanese skiers)

were subjected to a chi-squared test using IBM SPSS Statistics for Windows, version 25 (IBM Corp., Armonk, NY, USA). Significance was set at $P < 0.05$.

3 Results

Falls not caused by collisions accounted for 2136 (80.8%) of the 2644 injuries at the Japanese ski resorts. The second most common cause of injury (13.9%) was collisions with other visitors. Falls not caused by collisions accounted for 483 (66.5%) of the 726 injuries at Wanlong Ski Resort during 2018–2019 ski seasons. The second most common cause of injury (31.3%) was collisions with other visitors. More visitors at Wanlong Ski Resort were injured because of collisions with other visitors ($P < 0.001$; Table 1).

Table 1
Causes of ski injury.

Cause of injury	Wanlong Ski Resort		Japanese ski resorts		χ^2	p
	Number (n,%)	Injury Rate (IR)	Number (n,%)	Injury Rate (IR)		
Falls (not caused by collision)	483 (66.5)	2.98	2136 (80.8)	1.56	124.1	0
Collision with other visitors	227 (31.3)	1.4	368 (13.9)	0.27		
Collision with objects	11 (1.5)	0.07	82 (3.1)	0.06		
Other	5 (0.7)	0.03	58 (2.2)	0.04		
Total	726	4.48	2644	1.93		

Among the 2644 injuries at the Japanese ski resorts, 904 cases (34.2%) occurred among individuals aged 21 to 30 years, and individuals aged 11 to 50 years accounted for 79.2% of the total injuries. Among the 1146 injuries at two ski resorts in Chongli during 2017–2018 and 2018–2019 ski seasons, 409 cases (35.7%) occurred among individuals aged 21 to 30, and individuals aged 11 to 50 years constituted 88.4% of the total injuries. The Japanese ski resorts had more older visitors sustaining injuries, with 227 cases of injury (8.6% of the total) sustained by individuals aged over 60 years (Table 2).

Table 2
Age Stratification.

Age	Chongli ski resorts (n, %)	Japanese ski resorts (n, %)
≤10	51(4.5)	93(3.5)
11-20	151(13.2)	479(18.1)
21-30	409(35.7)	904(34.2)
31-40	309(26.9)	410(15.5)
41-50	145(12.6)	301(11.4)
51-60	65(5.7)	230(8.7)
61-70	15(1.3)	151(5.7)
71-80	1(0.1)	63(2.4)
≥80	0(0)	13(0.5)
Total	1146	2644

The body parts most commonly involved in the 1657 skiing accident at the Japanese ski resorts were the knee joint (28.4%), shoulder joint (11.0%), calf (11.0%), head (7.7%), and ankle and toes (7.2%). The body parts most commonly involved in the 469 ski accident at Wanlong Ski Resort were the knee joint (24.9%) and head (16.4%), with a lower likelihood of injury to the shoulder joint (7.4%) and calf (5.0%). Overall, the body parts involved in accident at Wanlong Ski Resort differed considerably from those at the Japanese ski resorts ($P < 0.001$; Table 3).

Table 3
Body parts commonly involved in ski injuries.

Body part	Wanlong Ski Resort		Japanese ski resorts		χ^2	<i>P</i>
	Number (n,%)	Injury Rate (IR)	Number (n,%)	Injury Rate (IR)		
Knee joint	111 (24.9)	0.69	471 (28.4)	0.35	44.71	0
Shoulder joint	33 (7.0)	0.2	182 (11.0)	0.13		
lower limbs	22 (4.7)	0.14	166 (10.0)	0.12		
Head	73 (15.6)	0.45	128 (7.7)	0.09		
Ankle and toes	36 (7.7)	0.22	119 (7.2)	0.09		
Total	275 (58.6)	1.7	1066 (64.3)	0.78		

Most of the 1847 snowboarding accident at the Japanese ski resorts involved the shoulder joint (17.7%), hands and fingers (15.4%), head (9.6%), elbow (7.0%), and knee joint (6.8%). With regard to the 301 snowboarding accident at Wanlong Ski Resort, the likelihood of injury to the hands and fingers (16.7%) and the shoulder joint (14.0%) was comparable to the results of Japanese ski resorts in the statistical analysis ($P = 0.513$; Table 4).

Table 4
Body parts commonly involved in snowboarding injuries.

Body part	Wanlong Ski Resort		Japanese ski resorts		χ^2	P
	Number (n,%)	Injury Rate (IR)	Number (n,%)	Injury Rate (IR)		
Shoulder joint	41 (13.6)	0.25	327 (17.7)	0.24	3.28	0.513
Hands and fingers	49 (16.3)	0.3	284 (15.4)	0.21		
Head	27 (9.0)	0.17	177 (9.6)	0.13		
Elbow	16 (5.3)	0.1	129 (7.0)	0.09		
Knee joint	23 (7.6)	0.14	126 (6.8)	0.09		
Total	156 (51.8)	0.96	1043 (56.5)	0.77		

Based on injury accident data recorded by Wanlong Ski Resort from 2018 to 2019, the number of injury accidents occurred at various times during business hours was plotted. In general, there is a peak at 11:00 and 14:00 each day, and the number of accidents is the lowest at 13:00, which is similar to the statistical results of Japanese ski resorts. After the opening of the ski resort, the number of accidents increases with the extension of time, which may be related to the increase of fatigue, the increase of the number of people, the increase of environmental complexity and other factors. The peak at 14:00 may be related to the rest period, the ambient temperature, and the number of people at the ski resort (Figure 1).

4 Discussion

Considering the health benefits of skiing and the advances in equipment, the risk–reward ratio of participating in this sport has been optimized.¹ On the basis of data on the ski patrol accidents that occurred at Styrian resorts in Austria during the 2014–2015 ski season, Castellani et al² estimated that the average daily number of injuries per 1000 skiers was 0.7, a slight increase (0.2 cases) over that 7 years prior. The average daily number of injuries per 10000 skiers at the Chongli ski resorts during the 2017–2018 and 2018–2019 ski seasons was 27.9. The corresponding rate at the Japanese ski resorts during the 2019–2020 ski season was 0.93 per 10,000 skiers. Overall, the Chongli ski resorts had a higher rate of injuries.

Most of the ski injuries at Wanlong Ski Resort (66.5%) and the Japanese ski resorts (80.0%) were falls not caused by collisions. However, 31.3% of the injuries at Wanlong Ski Resort resulted from collisions with other skiers, a much higher rate than at the Japanese ski resorts. This may be ascribable to the fact that Wanlong Ski Resort has more traffic. In general, technical errors, excessive speed, or loss of balance can all result in falls. Quinlan et al.¹⁴ noted that skiers who sustained wrist fractures had less experience and more falls, and that the injuries were mainly linked to jumping movements or technical skill level. Similarly, Sakamoto et al.¹⁶ suggested that with regard to injury prevention, both skiers and snowboarders should take extra care when performing jumping movement. Another study⁷ suggested that professional skiers and snowboarders may have a higher risk of serious injury than beginners because they often engage in highly technically challenging movements.

The largest proportion of injuries at both the Chinese and Japanese ski resorts (35.7% and 34.2%, respectively) occurred among individuals aged between 21 and 30 years. However, significantly more injuries at the Japanese ski resorts were sustained by older individuals, with 227 cases (8.6%) in individuals aged over 60 years. This may be attributable to both societal aging and the high popularity of skiing in Japan. In a study by Patrick et al,¹² injuries were found to be more likely to occur among skiers and snowboarders aged between 46 and 55 years, had never received professional training, or used rental gear. Girardi et al⁶ indicated that skiers aged 60 years and older have a higher injury severity score (ISS). In another study, a difference in age between snowboarders and skiers with severe injury (defined as an ISS higher than 15) was observed. Specifically, the severely injured skiers and snowboarders were aged 38 and 20 years, respectively, on average.⁴

Studies^{12,17} have noted that the knee joint is one of the most common sites of ski injuries; this is in line with the present results that knee joint injuries accounted for 24.9% and 28.4% of the ski injuries at the resorts in China and Japan, respectively. In a study by Sakamoto et al,¹⁶ calf fractures comprised 39.6% of the fractures sustained in skiing accidents. In another study, skiers had a higher rate of knee joint injury, femoral fractures, and calf fractures than snowboarders, as well as a higher level of injury severity (ISS > 9).¹⁰ In short, skiers were more likely to sustain lower limb injuries.

In a case–control study, the injury rate of snowboarders fluctuated over time but was still higher than that of skiers.⁸ Wrist, shoulder joint, and ankle injuries were more common among snowboarders, whereas knee joint and ligament injuries were more prevalent among skiers.^{8,18} In the present study, shoulder joint injuries were common (17.7%) among snowboarders at the Japanese ski resorts, whereas injuries to the hands and fingers (16.7%) were more common among those at Wanlong Ski Resort, consistent with the literature. Maat et al.¹⁰ observed that concussions and lower limb fractures were more common among snowboarders than skiers. The direction of falls may determine the body parts injured. In a descriptive epidemiological study of 1918 cases of upper extremity injuries sustained in snowboarding falls, wrist fractures and elbow dislocations (68.1% and 63.5%, respectively) were more likely to occur in backward falls. As for forward falls, shoulder joint dislocations (68.9%) and upper arm fractures (60.7%) were the most common injuries.¹⁹

In the Japanese ski resorts, the rate of helmet use among injured skiers increased from 43.2% in the 2018–2019 ski season to 48.2% in the 2019–2020 ski season, and that among injured snowboarders increased from 22.9–24.4%. Although the rate of helmet use among Japanese skiers approached 50%, it is not comparable to that of the American and European skiers (approximately 80%). No record of helmet use was found at the two Chongli ski resorts. Follow-up studies involving the collection of statistics on the observed increase in both ski and snowboarding injuries are necessary. Severe injuries are common in both skiing and snowboarding; therefore, precautions (e.g., wearing helmets and the provision of information on injury prevention) must be taken.³

Our study still had some limitations. First, the data of the Japanese ski resorts merely focused on the February, 2020. Second, compared with the 47 ski resorts in Japan, we didn't have enough ski resorts to collect data, which might have negative effects on results. However, the study was the few ones that study ski injuries between China and Japan.

5 Conclusion

Overall, the injury rate was slightly higher at the ski resorts in Chongli than at those in Japan. To manage the expected high influx of skiers to Chongli ski resorts and reduce the rate and severity of injury, the knowledge and experience of the Japanese ski resorts should be used as a reference.

- First, the volume of skiers should be maintained at a reasonable level. As mentioned, at Wanlong Ski Resort, 31.3% of the visitors were injured in collisions with others.
- Second, as mentioned, older individuals constituted a larger proportion of skiers injured at the Japanese resorts, with those aged 60 years or older accounting for 227 cases (8.6% of the total). Given that skiers aged 60 years and older are more prone to severe injury, staff members at ski resort medical stations are advised to place injured skiers in this age group under observation for a longer period of time and transfer them to higher-level hospitals in a timely manner if necessary.
- Third, the usage of helmets should be encouraged to prevent the severe injury.

Declarations

Ethics approval and consent to participate

The study protocol was established, according to the ethical guidelines of the Helsinki Declaration and was approved by Peking University Third Hospital Medical Science Research Ethics Committee. Project Number: M2019456.

Consent for publication

Not applicable.

Availability of data and materials

The datasets supporting the conclusions of this article are included within its additional file.

Competing interests

The authors certify that there is no competing interests with any financial organization regarding the material discussed in the manuscript.

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Authors' Contribution

XM carried out the data analysis, collected the data and drafted the manuscript. JL carried out the data analysis and edited the manuscript. YY carried out the design of study, collected the data and helped to draft the manuscript. SGA collected the data. YA conceived of the study, and participated in its design. All authors have read and approved the content of the manuscript

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Figures

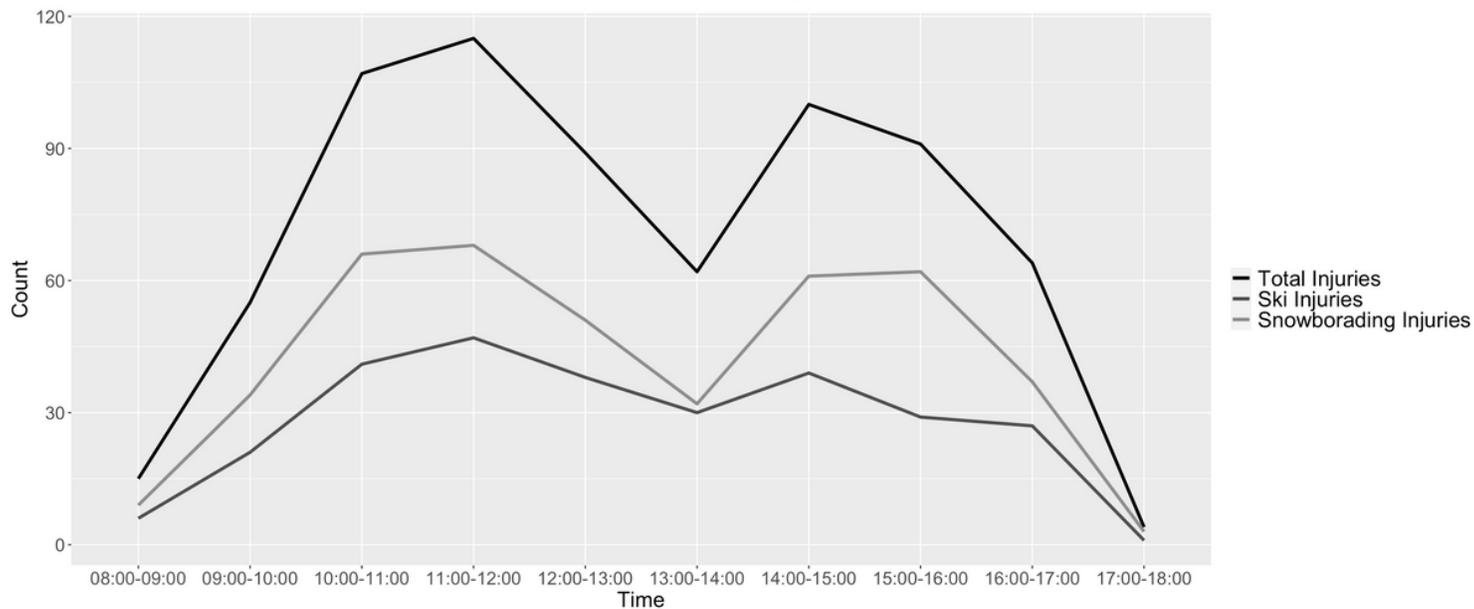


Figure 1

Number of injuries that occur during ski resort business hours

Supplementary Files

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