Injury patterns in a large-scale ski resort in the host city of 2022 Winter Olympic Games: a retrospective cross-sectional study

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ABSTRACT

Objectives The aims of the study are to describe the injury patterns among recreational skiers and snowboarders in China and to provide primary data to guide the reconstruction of regional healthcare facilities to deal with the increasing number of participants in snow sports.

Design Retrospective cross-sectional study.

Methods A retrospective study was performed in Wanlong Ski Resort in Chongli, China. Data of all injured skiers and snowboarders treated in the resort clinic during the 2018–2019 season were collected. Patients’ information, including sex, age, equipment, skill level and injured body part, was analysed.

Results A total of 753 sports injuries were recorded. The estimated incidence of injury was 1.98 per 1000 skier days. 453 cases (60.2%) were associated with skiing. The mean age of skiers was older than snowboarders (35.1±14.5 vs 29.0±8.9, p<0.01). Injury not involving others constituted 67.9% of all injuries. The most common injured body part among skiers was lower extremity, contrary to injury in the upper extremity among others constitutes 67.9% of all injuries. The most common injured body part among snowboarders was lower extremity, contrary to injury in the upper extremity among snowboarders. Head and cervical injury was identified in 13.7% of skiers and 13.6% of snowboarders. Head and cervical injury was identified in 13.7% of skiers and 13.6% of snowboarders.

Conclusion The incidence of skiing/snowboarding injury in China was similar to other countries. Injury pattern differed among different sports and causes of injury.

INTRODUCTION

Skiing and snowboarding are popular winter sports worldwide but carry a substantial risk of sports injuries, with reported incidence of 0.5–1.35 injuries per 1000 skier/snowboarder days among recreational skiers/snowboarders1,2 and 6.9 injuries per 1000 runs (or 26.8 injuries per 100 athletes per season)3 among professional alpine skiers in recent years. During the latest Winter Olympic Games in PyeongChang, 12% of athletes incurred at least one injury, equivalent to 12.6 injuries per 100 athletes over a 17-day period.4

Since Beijing was selected to host the 2022 Winter Olympics, the skiing and snowboarding population in China has risen from 8 million in 2015 to 13.2 million in 2018 (WuBin, 2019 China Ski Industry White Book, 2019). Large-scale ski resorts in China are often located in areas remote from major cities, where medical capacity cries for improvement in order to accept and manage large number of winter sports injuries and manage severe injuries.

The aims of this study are to describe the injury patterns among recreational skiers and snowboarders in China by investigating the largest ski resort in the host city of the 2022 Winter Olympic Games and to provide primary data to guide the reconstruction of local hospitals to deal with the increasing number of participants in snow sports.

PATIENTS AND METHODS

Data for this retrospective study were collected from the resort clinic of the Wanlong Ski Resort in Chongli during the 2018–2019 ski season. The Wanlong Ski Resort is a destination ski resort in Northern China which has various terrains and has the largest number of annual visits. The resort clinic is staffed by a registered general practitioner and a nurse and provides primary care to all injured visitors, whether self-presented or sent by patrols. The clinic is also responsible for treating mild injuries, transferring patients to major cities, where medical capacity cries for improvement in order to accept and manage large number of winter sports injuries and manage severe injuries.
local hospitals and carrying out basic life support for life-threatening injuries. The 2018–2019 season in Wanlong Ski Resort lasted for 158 days, from 1 November 2018 to 7 April 2019. A total of 388 606 visits (379 503 skier days) were recorded.

Besides patients’ sex and age information, we also recorded equipment, skill level, date and time of injury, cause of injury, slope difficulty and injured body part. Equipment was classified into skis and snowboards. Special equipment such as cross-country skis and skiboards is rare in China and has not been seen in recorded injured people. Patients were classified according to self-reported years of participation in skiing and snowboarding: beginner (first season), medium (1–5 years), advanced (5–10 years) and expert (≥10 years). Date of injury was divided into weekdays and weekends/holidays according to the Chinese government holiday arrangement. Wanlong Ski Resort’s business hours start from 08:00 to 16:00, so we split the time of injury into four periods of 2 hours each, morning (first 2 hours of business), noon, afternoon and late afternoon (last 2 hours of business). We summarised causes of injury into two types according to the subjective description of the scene of injury: not involving others, defined as falling or crashing without any body contact with others; and involving others, defined as crashing that involves two or more people. Slope difficulty was categorised into beginner trail, medium trail and advanced trail according to the official data of slope inclination angle. Injured body parts were categorised into the following four anatomical body regions: (1) head/cervical, (2) torso, (3) upper extremity and (4) lower extremity. Acromioclavicular joint injuries were classified as upper limb injury, while other clavicle injuries were classified as torso injury. Injuries involving the gluteal region were classified as torso injury.6 Injuries involving the head and cervical region were classified as torso injury. Whether patients have multipart injuries was also recorded, while each injured body part was counted in one of the above groups. The relationship between injured body part and sex, age, equipment and cause of injury was further determined by subgroup analysis.

Informed consent was waived considering that the study was epidemiological and anonymous.

**Statistical analysis**
All statistical analyses were performed with SPSS V.24.0. Continuous variables were presented as mean and SD, while categorical data were presented as frequency count and percentages. For comparison between subgroups, χ² test was used for categorical variables and Student’s t-test was used for continuous variables. Where there are missing data, the available case was analysed to determine the difference between groups. P<0.05 was considered to indicate statistical significance.

**RESULTS**
During the study period, there were 388 606 visits (379 503 skier days) and 753 cases of injury recorded in Wanlong Ski Resort. The estimated incidence of injury was 1.98 per 1000 skier days.

**Features of injury**
The mean age of injured visitors was 32.5±12.9 years (range 3–73 years). Paediatric patients under 15 years old took up 9.3% while senior patients (over the age of 60) took up 3.0% of all injured population. The number of male patients was twice as female patients. Among the injuries, 453 cases (60.2%) were associated with skiing. Table 1 shows more detailed demographic and sports-related profiles of these injuries.

The 2018–2019 season in Wanlong Ski Resort consisted of 107 weekdays and 51 weekends/holidays according to the Chinese government arrangement. The average daily number of injuries was 3.38 on weekdays and 7.65 on weekends/holidays. A peak of paediatric cases was noted in January and February (figure 1). In a day, the percentage of injury that occurred in the morning, noon, afternoon and late afternoon was 9.7%, 31.6%, 22.0% and 36.7%, respectively.

Accidents not involving other skiers took up 67.9% of all injuries. The most common injured body parts were upper (28.4%) and lower (37.6%) limbs, followed by head and cervical injury (13.1%).

**Injury pattern in subgroups**
The mean age of skiers was 35.1±14.5 years, whereas the mean age of snowboarders was 29.0±8.9 years (p<0.01).
There was no significant difference in the sex profile between skiers and snowboarders. The injured body parts showed different patterns between skiers and snowboarders. More than half of the skier patients sustained lower extremity injuries, while the most common injury among snowboarders was upper extremity injury. Head and cervical injury was identified in 13.7% of skiers and 13.6% of snowboarders. Multipart injury took up 5.3% of injuries among skiers and 3.4% among snowboarders (table 2). The cause of injury was also found to be related to the injured body parts in both skiers and snowboarders. Head injury took up a significantly higher rate in accidents involving others. In skiers, lower extremity injury was the most common injury whether the accidents involved others or not. However, the rate of lower extremity was significantly higher in accidents not involving others (table 3). In snowboarders, head, cervical and torso injuries took up a greater portion in accidents involving others (table 4). The correlation between age, sex, skill level and injured body parts was not significant (online supplemental tables 1–6).

**DISCUSSION**

We found that the incidence of sports injury in the Chinese recreational skiing and snowboarding population was 1.98 per 1000 skier days, which was comparable with the reported incidence of 0.5–3.7 per 1000 skier days in European and North American countries in recent years. According to government report, the total number of visits in ski resorts in Chongli hit nearly one million in the 2018–2019 ski season, which means an estimated number of 2000 sports injuries in one season if such finding is extrapolated to the whole region. Therefore, a better understanding of injury pattern in Chinese population will guide the reform of local healthcare facilities to deal with the increasing number of participants in snow sports.

The mean age of injured visitors was 32.5±12.9 years (range 3–73 years). Of the injured population, 9.3% were younger than 15 years old. In China, students’ winter vacation lasts for about 4 weeks around the Chinese New Year. We found that sports injury among teenagers peaked in January and February and constituted nearly 15% of all injuries that occurred in these 2 months. The incidence of ski injury was reported higher in teenagers than in adults. As more young people participate in these activities, an increase in paediatric patients with snow sports injuries will be seen in the future.
and female skiers and snowboarders. Girardi et al found a difference in terms of injured body parts between male and female skiers. However, there was no significant difference in terms of injured body parts between male and female skiers and snowboarders.14 Many studies reported that snowboarders in China, which implied the fact that the rate of crash accident was extremely high on medium trails (see online supplemental table 7). Yet no available studies provide conclusive evidence on the influencing factors of the rate of self-inflicted and crash injuries.17

The cause of injury was also found to be related to injured body parts among both skiers and snowboarders. Head injury took up a significantly more portion in accidents involving others. Sports-specific injuries, such as shoulder injury in snowboarding and knee injury in skiing,7 were more frequent in accidents not involving others. These findings can be attributed to different injury mechanisms, with non-contact injury often causing ligament and tendon tear, and contact injury causing bony injury and concussion.18

From an epidemiological view, the present study provides strategies that can guide the restructure of local hospitals and unload the burden during the winter season. First, establish a paediatric orthopaedic department to cope with paediatric patients, who took up nearly 10% of the whole injury population, especially the surge during the winter vacation in China. Second, establish a department of neurosurgery and a department of oral and maxillofacial surgery to deal with head and face injuries, which took up 13% of all injuries. Third, rearrange the worktime schedule according to the time-related ‘tide’ of winter sports injury to increase effectiveness with limited manpower. For example, during the winter season, weekends can be set as work days and another two weekdays as rest days to cope with the traumatic cases in weekends, which are twice as many as in weekdays. Fourth, intensive care units are crucial in managing severe injuries as the population at higher risk for severe injuries including snowboarders, of higher skill level and of young participants is growing bigger. Fifth, build up communication and cooperation network with nearby ski resorts to allow access to critical patient information in advance and guide prehospital care. Although the present study did not provide information about injury severity and number of patients who needed transfer and further treatment,

### Table 3: Relationship between cause of injury and injured body part in skiers

| Injury | Injury not involving others, n (%) | Injury involving others, n (%) | P value |
|--------|----------------------------------|-------------------------------|---------|
|        | (n=291)                          | (n=126)                       |         |
| Head and cervical | 21 (7.2) | 36 (28.6) | <0.01 |
| Torso  | 54 (18.6)                        | 29 (23.0)                     |         |
| Upper extremity | 53 (18.2) | 26 (20.6) |       |
| Lower extremity | 172 (59.1) | 50 (49.7) |       |
| Multipart injury | 9 (3.1) | 13 (10.3) |       |

### Table 4: Relationship between cause of injury and injured body part in snowboarders

| Injury | Injury not involving others, n (%) | Injury involving others, n (%) | P value |
|--------|----------------------------------|-------------------------------|---------|
|        | (n=197)                          | (n=68)                        |         |
| Head and cervical | 17 (8.6) | 19 (27.9) | <0.01 |
| Torso  | 39 (19.8)                        | 24 (35.3)                     |         |
| Upper extremity | 107 (54.3) | 18 (26.5) |       |
| Lower extremity | 37 (18.8) | 13 (19.1) |       |
| Multipart injury | 3 (1.5) | 6 (8.8) |       |
based on existing literature up to 60% of injured skiers and snowboarders seen in resort clinics require transfer to hospitals. To date, the local hospital in Chongli has reinforced its orthopaedics and sports medicine department by seeking cooperation with higher level hospitals in Beijing. An evidence-based restructuring of local hospitals may increase accessibility to healthcare among injured skiers and snowboarders in nearby ski resorts.

Several limitations exist in this study. First, severity of injury and accurate diagnosis were not recorded and patients were not followed up for prognosis. Second, although medical providers in the ski resort collected injury cases as thorough as possible, there were still patients who went to local or tertiary hospitals directly or did not receive any type of medical help for mild injuries. In this case, the incidence of injury may be underestimated. Additionally, data on injury severity and number of patients who needed transfer were incomplete, so we were unable to estimate the burden in local hospitals during the skiing season. We are currently conducting a large-scale survey on the demographics of Chinese winter sports participants and a prospective research of winter sports injury in the skiing population in China to fill the gap. The effectiveness of hospital restructuring will be reported as well.

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Contributors  NC designed the study, carried out the data analysis and drafted the manuscript. YY carried out the design of patient information registration chart and helped draft the manuscript. YJ helped to connect with relevant staff in Wanlong Ski Resort and revise the manuscript. YA conceived of the study and participated in its design.

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