

**A HIGH INCIDENCE OF INJURY AT THE SOCHI 2014 WINTER PARALYMPIC
GAMES: A PROSPECTIVE COHORT STUDY OF 6564 ATHLETE DAYS**

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Keywords

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What are the new findings?

- This is the first study to document incidence of injury at a Winter Paralympic Games per 1000 athlete days
- Alpine skiing/snowboarding had a significantly higher incidence of injury than any other sport at the Sochi 2014 Winter Paralympic Games
- There was a higher incidence of injury at the Sochi 2014 Winter Paralympic Games, compared to the London 2012 Summer Paralympic Games, as well as compared to the Sochi 2014 Winter Olympic Games
- Injuries to the shoulder were the most common single-joint injury, despite similar incidence of injury between upper and lower body
- Acute injuries occurred at significantly higher incidence than any other type of injury onset

How might this impact on clinical practice in the near future?

- The information in the present study can be used by organisations, coaches and athletes to identify risk factors associated with Winter sports for athletes with impairment
- The identification of these risk factors provides the basis for injury prevention programs at the athlete level as well as the organisational level
- This study has provided a repeatable methodology for the capturing and analysis of the incidence of injury in athletes with an impairment in a Winter Paralympic Games setting, providing the basis for future studies at upcoming Paralympic Games

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ABSTRACT

Objectives: To describe the epidemiology of injuries at the Sochi 2014 Winter Paralympic Games.

Methods: A total of 547 athletes from 45 countries were monitored daily for 12 days during the Sochi 2014 Winter Paralympic Games (6564 athlete days). Daily injury data were obtained from teams with their own medical support (32 teams, 510 athletes) and teams without their own medical support (13 teams, 37 athletes) through electronic data capturing systems.

Results: The total number of injuries reported during the data collection period was 174, with an injury incidence rate (IR) of 26.5 per 1000 athlete days (95% CI 22.7% - 30.8%). There was a significantly higher IR recorded in alpine skiing/snowboarding (IR of 41.1 (95% CI 33.7% - 49.6%) $p=0.0001$) compared to cross country skiing/biathlon, ice sledge hockey or wheelchair curling. Injuries in the shoulder region were the highest single-joint IR (IR of 6.4 (95% CI 4.6% - 8.6%)), although total upper and lower body IR were similar (IR 8.5 vs. 8.4 (95% CI 6.4% - 11.1%)). Furthermore, the IR of acute injuries was significantly higher than other types of injury onset (IR of 17.8 (95% CI 14.7% - 21.4%)).

Conclusion: The results of this study indicate that Paralympic athletes report higher injury incidence than Olympic athletes, as well as higher injury incidence in a Winter Games setting compared to a Summer Games setting. The highest incidence of injury was reported in the alpine skiing/snowboarding sporting category. There was a similar incidence of injury in the upper and lower limb, with the highest single-joint rate of injury reported for the shoulder joint. Thus, the results of this study have identified areas of risk of injury for Paralympic athletes, which can inform injury prevention programs and policy change regarding athlete safety in future Winter Paralympic Games.

INTRODUCTION

Participation in Winter sports for athletes with impairment continues to grow. The first Winter Paralympic Games in Sweden in 1976 hosted 53 athletes competing in two sports, whereas the Sochi 2014 Winter Paralympic Games hosted 547 athletes who competed in six sports.[1;2] This growth has been fostered by the continued development of Paralympic sport in general, including advances in modified sports equipment (e.g. mono skis), adaptive techniques and the evolution of new sports geared toward athletes with an impairment (e.g. para snow board).[3]

The Winter Paralympic Games currently includes six sports (alpine skiing, snowboarding, cross country skiing, biathlon, ice sledge hockey and wheelchair curling). Each sport has been adapted from the able-bodied sport to accommodate for the athletes' impairment type, resulting in specific rule and regulation changes within the sports.[4] The sport of snowboarding was introduced for the first time at the Sochi Games and has been adapted from the able-bodied version of the sport where a group of four athletes proceed down the course at the same time, to a design where a single athlete proceeds down the course at a time, in an effort to provide a seemingly safer experience. Other adaptations have been made for impairments such as visual impairment, cerebral palsy, spinal cord injury and upper and lower limb loss, among others.[3] For example, the use of a sledge and two adapted hockey sticks in ice sledge hockey has been adapted for use by individuals with lower limb impairment. Other examples include the use of a guide skier for visually impaired athletes, and use of a single ski for a single leg amputee or mono ski for an athlete with spinal cord impairment in the sport of alpine skiing.[3]

Engaging in Winter sports by able-bodied athletes carries a certain risk of injury.[5] This is no different in para-sports. Previous studies conducted on athletes with impairment in a Winter Games setting suggest that these athletes do not have a significantly greater overall risk of injury compared to their able-bodied counterparts.[6-8] However, the functional consequences of injury to an athlete with an underlying physical or visual impairment may be considerably greater than for able-bodied athletes.[2;7]

Previous research conducted by Webborn et al. (2006, 2012) reported an injury proportion (percentage of athletes with an injury) of 9.4% in Salt Lake City (2002), 8.4% in Torino

(2006) and 23.8% in Vancouver (2010).[6;7;7;9] The increased proportion of injury reported in 2010 likely reflected improved participation by team physicians and physical therapists at the time the study was conducted, as well as more vigilant identification of injury and the inclusion of sports-related muscle pain as a selectable diagnosis.[7] The highest proportions of injury were recorded in ice sledge hockey and alpine skiing, with the upper limbs noted as the anatomical area most at risk in both sports.[7] However, it was acknowledged in these studies as well as by other reviews that the definition of injury and other methodological challenges (lack of compliance and the inclusion of minor musculoskeletal complaints that required visits to the physiotherapy and massage departments being included as injuries) should be more clearly defined in future studies.[6;7;10;11]

Understanding injury patterns in Winter para-sports is important, not only for prevention of future injury, but also for the planning of medical services for these events. As an example, the application of recommendations from a previous study's findings has resulted in the introduction of regulatory protective equipment in ice sledge hockey, as well as amendments with regard to safety in training regimens across sports.[7] In addition, previous work has revealed that severe and on occasion life threatening injuries in Games time can occur during training rather than in competition, necessitating appropriate and fully operational emergency medical support services to be in place at all times.[7] Thus, the collection and analysis of data as well as the implementation of the results of epidemiological studies in Winter Paralympic sport are of importance.

The International Paralympic Committee (IPC) adopted a Medical Code in 2011 which "encourages all stakeholders to ensure that sport is practiced in a manner that protects the health of the athlete and minimises the chance of injury...".[4] In order to achieve this goal, the IPC Medical Committee implemented a long-term prospective injury surveillance system to better characterize the risk factors for injury associated with Winter Paralympic sports.

Therefore, the present study aimed to document the incidence of injury at the Sochi 2014 Winter Paralympic Games per 1000 athlete days, using the same web-based electronic platform utilised at the London 2012 Summer Paralympic Games.[12] Overall injury incidence rate, injury incidence rate per sport, type of injury and anatomical area of injury were investigated for the 12 day Games period. The findings of this study were compared to

previous Winter Games, as well as the 2012 London Summer Paralympic Games, which is the only study to date that presents data per 1000 athlete days.

METHODS

The present study was a component of a larger ongoing epidemiological injury and illness surveillance study of both Summer and Winter Paralympic Games. This prospective component of the epidemiology of injury was conducted during the three day pre-competition period and nine day competition period of the Sochi 2014 Winter Paralympic Games. For the purpose of this study, the pre-competition period and competition period were combined and analysed as one 12 day Games period.

Participants

The current study was conducted by the IPC Medical Committee. Before research activities were initiated, ethics board approval was granted by both the University of Brighton (FREGC/ES/12/11) and the University of Cape Town (HREC/REF 436/2012) Research Ethics Committees. At the time of Games registration, informed consent was obtained from all athletes for the use of de-identified medical data gathered during the Games.

The current study utilised the web-based injury and illness surveillance system (WEB-IISS) which was successfully implemented at the London 2012 Paralympic Games. The WEB-IISS was utilised for data collection by teams with their own medical support staff. For athletes who did not have accompanying medical staff, injury data were captured via the ATOS system supplied to the medical staff employed by the Sochi Organising Committees of the Olympic and Paralympic Games (SOCOG). Complete details of data sources, data collection, data input and analysis can be found in the previous literature.[13] Specific fields were adapted within the WEB-IISS with regard to Winter sports, which included certain aspects of each athlete's classification within the sports they competed in (lower limb impairment, minimally impaired, sitting class, standing class and visual impairment) as well as the factors contributing to injury.

To promote participation in the study, introductory information was sent via email to all National Paralympic Committees (NPC) and attending Chief Medical Officers (CMO) of the teams participating in the Games (N = 45). Detailed information regarding the study was

provided to the team physicians of all delegations, as well as all SOCOG medical staff (for countries who did not have their own medical staff), at the pre-competition medical briefing. Participation and compliance from teams with medical staff was incentivised by the provision of a tablet computer for data entry to each participating country that had more than 10 athletes competing at the Games. The remainder of the countries with accompanying medical staff reported their data via laptop computers within the Paralympic Village.

Definition of injury

The general definition accepted for reporting injury was noted as any athlete experiencing an injury that required medical attention, regardless of the consequences with respect to absence from competition or training.[13] An injury was specifically defined as “any newly acquired injury as well as exacerbations of pre-existing injury that occurred during training and/or competition of the Games period of the Sochi 2014 Winter Paralympic Games”. Acute, acute on chronic and chronic injuries were logged. An acute injury was defined as “an injury that was caused by an acute precipitating traumatic event”. An acute on chronic injury was defined as “an acute injury in an athlete with symptoms of a chronic injury in the same anatomical area”. A chronic (overuse) injury was defined as “an injury that developed over days, weeks or months and was not associated with any acute precipitating event”. [13]

Calculation of athlete days

Teams without their own medical support

Exposure data in terms of athlete days for countries without their own medical support (13 teams, 37 athletes) was made on the assumption that the total number of athletes, as published in the IPC athlete database, was static for the duration of the Games. The total athlete days were calculated as follows: total period days (pre-competition and competition 12 day period) x daily team size (for each day).

Teams with their own medical support

The CMO of each team with their own medical staff (32 teams, 510 athletes) was requested to capture their daily team size (number of athletes that were under the care of the medical team) as well as registering any new injury. An analysis of this exposure data revealed that there was a negligible variance (~ 0.5%) between this reported daily number of athletes in each delegation and the total number of athletes as published in the IPC athlete database.

Therefore, total athlete days for each country were also calculated as described for teams without their own medical support.

Calculation of the injury incidence rate and injury proportion

Injury incidence rate (IR) was calculated as injuries per 1000 athlete days. The number of athlete days was reported separately by sport, age group and sex. The IR per 1000 athlete days was reported for all injury types, onset of injury as well as injuries in different anatomical areas. The proportion of athletes with an injury refers to the percentage of athletes reporting an injury and was calculated as the number of athletes with an injury over the total number of athletes competing in the relevant sub group.

Statistical analysis of the data

Data were in the form of counts (i.e. the number of injuries each athlete reported). Athletes could participate in more than one sport and/or more than one event. Some athletes incurred multiple injuries during the 12 days, thus the outcome variable was the number of injuries each athlete reported. Standard descriptive statistical analyses were reported, including number of athletes participating in the various sports (combining alpine skiing with snowboarding and cross country skiing with biathlon) by age (14-25 years, 26-34 years and 35-63 years) and sex (male or female), number of reported injuries, number and proportion of athletes with an injury. Generalized linear Poisson regression modelling was used to model the number of reported injuries overall, as well as the number of injuries for three anatomical areas (upper limb, lower limb and head/face/neck) and for three types of injuries (acute onset, chronic overuse, and acute on chronic) and were corrected for overdispersion and including the independent variables of interest. Results were reported as injury incidence rates per 1000 athlete days (including 95% confidence intervals). Results for overall injury rates were reported by sex, age group, type of sport.

RESULTS

Participants

All countries present at the Sochi 2014 Winter Paralympic Games chose to participate in the study. During the Games period, a total of 45 NPCs, including 547 athletes over 6564 athlete days were monitored. Teams with their own medical support staff comprised a total of 6096

athlete days (32 countries, 508 athletes), whilst teams without medical support staff comprised a total of 468 athlete days (13 countries, 39 athletes).

Table 1: Number of athletes participating in each sport (all athletes, males and females, age groups of combined males and females)

Sport	All athletes	Males	Females	Age 13-25	Age 26-34	Age 35-63
All	547	418	129	172	198	177
Alpine skiing /snowboarding	219	163	56	75	88	56
Cross country skiing/biathlon	149	95	54	60	49	40
Ice sledge hockey	129	129	0	34	53	42
Wheelchair curling	50	31	19	3	8	39

Incidence of injuries by sport

Table 2 presents the total number of injuries as well as injuries reported in four categories of sports. The total number of injuries recorded in all sports was 174 injuries in 134 athletes. Of all athletes participating at the Games, 24.5% reported an injury, with an IR of 26.5 injuries per 1000 athlete days (95% CI 22.7% – 30.8%). The highest total number of injuries as well as the highest reported IR were in the sports of alpine skiing/snowboarding (108 injuries in 81 athletes, IR of 41.1 (95% CI 33.7% – 49.6%)). This was significantly higher than the average IR for the other sports (IR of 15.5 (95% CI 11.3% - 21.3%) p<0.0001). The second highest IR was in the sport of ice sledge hockey (IR of 26.5 (95% CI 19.0% – 35.9%)), followed by wheelchair curling (IR of 16.7 (95% CI 8.0% – 30.7%)) and cross country skiing/biathlon (IR of 8.4 (95% CI 4.7% – 13.8%)).

Table 2: Incidence of injury by sport (total number of injuries, number of athletes with an injury, total number of athletes competing, total number of athlete days, proportion of athletes with an injury, injury incidence rates per athlete days)

Sport	Total number of injuries	Number of athletes with an injury	Total number of athletes competing	Total number of athlete days	Proportion of athletes with an injury	Injury incidence rate #injuries/1000 athlete days (95% CI)
All	174	134	547	6564	24.5	26.5 (22.7-30.8)
Alpine skiing /Snowboarding	108	81	219	2628	37.0	41.1 (33.7-49.6)*
Cross country skiing /biathlon	15	15	149	1788	10.1	8.4 (4.7-13.8)

Ice sledge hockey	41	31	129	1548	24.0	26.5 (19.0-35.9)
Wheelchair curling	10	7	50	600	14.0	16.7 (8.0-30.7)

*Significantly different from all other sports (p=0.0001)

Incidence of injuries by sex and age group

A comparison of the IR for three tertiles of age approached significance (p=0.06), with the highest IR noted in athletes in the highest age tertile (Table 3). There was no significant difference in IR between sexes.

Table 3: Incidence of injury by sex and age group (total number of injuries, number of athletes with an injury, total number of athletes competing, total number of athlete days, proportion of athletes with an injury, injury rates per athlete days)

Sex/Age group	Total number of injuries	number of athletes with an injury	total number of athletes competing	total number of athlete days	Proportion of athletes with an injury	injury rate #injuries/1000 athlete days (95% CI)
All	174	134	547	6564	24.5	26.5 (22.7-30.8)
Female	40	31	129	1548	24.0	25.8 (18.5-35.2)
Male	134	103	418	5016	24.6	26.7 (22.4-31.6)
Age 13 - 25	45	38	172	2064	22.1	21.8 (15.9-29.2)
Age 26 - 34	62	47	198	2376	23.7	26.1 (20.0-33.5)
Age 35 – 63	67	49	177	2124	27.7	31.5 (24.4-40.1)

Incidence of injuries for anatomical area

The region of the body most affected by injury was the upper limb, with 56 injuries occurring in 35 athletes (IR of 8.5 (95% CI 6.4% - 11.1%) Table 4). Of these injuries, 42 occurred in the shoulder (IR of 6.4 (95% CI 4.6% – 8.6%)). A similar incidence of injury was observed in lower limb with 55 injuries in 45 athletes (IR of 8.4 (95% CI 6.3% – 10.9%)). Of these, the knee was the most affected joint in the lower limb (25 injuries, IR of 3.8 (95% CI 2.5% – 5.6%)). A total of 31 injuries were recorded in 26 athletes in the anatomical areas of the head, face and neck with an IR of 4.7 (95% CI 3.2% – 6.7%). The CI of the IR of injuries to the head, face and neck indicated that the upper and lower limb were higher than all other anatomical regions.

Table 4: Incidence of injury by each anatomical area (total number of injuries, number of athletes with an injury, proportion of athletes with an injury, injury incidence rates per athlete days)

Anatomical area	Total number of injuries	Number of athletes with an injury	Proportion of athletes with an injury	Injury incidence rate #injuries/1000 athlete days (95% CI)
All	174	134	24.5	26.5 (22.7-30.8)
<i>Upper Limb</i>	56	47	8.6	8.5 (6.4-11.1)
Shoulder/Arm/Elbow	42	37	6.8	6.4 (4.6-8.6)
Wrist/Hand/Finger	14	12	2.2	2.1 (1.2-3.6)
<i>Lower Limb</i>	55	49	9.0	8.4 (6.3-10.9)
Knee	25	23	4.2	3.8 (2.5-5.6)
Ankle/Foot/Toe	12	12	2.2	1.8 (0.9-3.2)
Lower Leg	7	6	1.1	1.1 (0.4-2.2)
Thigh/Stump	6	6	1.1	0.9 (0.3-2.0)
Hip/Groin/Pelvis	5	5	0.9	0.8 (0.2-1.8)
Head/Face/Neck	31	26	4.8	4.7 (3.2-6.7)
Spine	19	18	3.3	2.9 (1.7-4.5)
Chest/Trunk/Abdomen	7	6	1.1	1.1 (0.4-2.2)
Other	5	5	0.9	0.8 (0.2-1.8)

Incidence of injuries for onset

Table 5 presents the number and rate of injuries classified as acute injury, acute on chronic injury and chronic injury. The highest number of reported injuries were acute (117 injuries in 93 athletes, IR of 17.8 (95% CI 14.7% – 21.4%)) followed by chronic (32 injuries in 27 athletes, IR of 4.9 (95% CI 3.3% – 6.9%)) and acute on chronic (25 injuries in 23 athletes, IR of 3.8 (95% CI 2.5% – 5.6%)). The IR of acute injuries was significantly higher than all other types of injury onset (95% CIs do not overlap).

Table 5: Incidence of injury by onset (total number of injuries, number of athletes with an injury, proportion of athletes with an injury, injury incidence rates per athlete days)

Type of injury	Total number of injuries	Number of athletes with an injury	Proportion of athletes with an injury	Injury incidence rate #injuries/1000
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				athlete days (95% CI)
All	174	134	24.5	26.5 (22.7-30.8)
Acute	117	93	17.0	17.8 (14.7-21.4)*
Acute on chronic	25	23	4.2	3.8 (2.5-5.6)
Chronic overuse	32	27	4.9	4.9 (3.3-6.9)

*Significantly different from all other types of injury onset (according to 95% CIs)

Time loss as a result of injury

Of the injuries reported during the 12-day Games period, 20.1% resulted in more than one day of exclusion from training or competition, whilst 79.9% resulted in no time loss from training or competition.

DISCUSSION

The aim of the present study was to document the incidence of injury at the Sochi 2014 Winter Paralympic Games in four categories of sports.

This study was the first to document injuries per 1000 athlete days at an international, multi-sport event such as the Winter Paralympic Games, providing the first reliable data for the incidence of injury at such a competition. Whilst previous studies recording data at prior Paralympic Games have noted the proportion of athletes with an injury, these studies were somewhat limited by low reporting rates for minor injuries, lack of exposure data, lack of a web-based data collection system and lack of a consistent definition of injury.[6;7] Building on this prior work, the current study is the first to present data on both the incidence of injury per 1000 athlete days as well as the proportion of athletes with an injury at a Winter para-sport competition.

Higher incidence of injury in Paralympic athletes compared to Olympic athletes

The first important finding of this study was that there were similar injury proportions (percentage athletes injured) at the Sochi 2014 Winter Paralympic Games compared to those reported at the Vancouver 2010 Winter Paralympic Games (24.4% for Sochi and 23.8% for Vancouver) indicating a high risk for injury and consequently a high proportion of injuries sustained in a Winter Games setting.[7] Interestingly, only 9% of all athletes were reported to have experienced an injury at the Salt Lake City 2002 Winter Paralympic Games.

However, injuries were likely under-reported due to limitations of data collection at that time.[6] It is important to note that the incidence of injury recorded in the present Paralympic study (IR of 26.5 (95% CI 22.7% - 30.8%)) was three times the incidence of injury recorded at the Sochi 2014 Winter Olympic Games (IR of 7.8) indicating a higher risk of injury in athletes with impairment compared to their able-bodied counterparts at a similar competition.[5] This finding is in contrast to previous research which states that injury profiles are similar between able-bodied athletes and athletes with impairment.[6-8]

Higher incidence of injury in a Winter Games setting

The second important finding was that the incidence of injury (per 1000 athlete days) at the Sochi Games was higher than the London 2012 Summer Paralympic Games.[7] Indeed, twice the rate of injury was documented at the Sochi Games compared to the London Games (IR of 26.5 vs. 12.7). The difference observed between the Winter and Summer Games IR may be the result of the nature of high risk sports in which athletes compete in the Winter Games setting,[14] the inclusion of para-snowboarding at the Sochi Games,[15] or environmental factors associated with the Sochi Games.[16] This is indicated by the relatively lower IR of sports other than alpine skiing/snowboarding at the Sochi Games (IR of 16.8 (95% CI 13.0% - 21.3%)). High risk collision sports seen in the Winter Paralympic Games including ice sledge hockey and the alpine events clearly have a higher risk for musculoskeletal injury than some of the non-contact sports played in the Summer Games setting.[2;13] Importantly, the warm climate at the Sochi Games may have contributed substantially to environmental conditions placing athletes at higher risk for musculoskeletal injury. Temperatures recorded during daytime competition often reached 18° Celsius, and night time temperatures did not always fall below freezing, which is imperative for firm snow packing.[16] As a result, it has been suggested that the adverse snow conditions resulted in rescheduling of events and a very high DNF (did not finish) rate and also possibly the high rate of injury present in the high velocity events such as alpine skiing/snowboarding.[16]

Incidences of injury between four sporting categories

The third important finding of this study is related to the comparison of IRs in the four different categories of sport. The highest IR was reported in alpine skiing/snowboarding (IR of 41.4 (95% CI 33.7% - 49.6%)), the second highest in ice sledge hockey (IR of 26.5 (95% CI 19.0% - 35.9%)) and third highest in wheelchair curling (IR of 16.7 (95% CI 8.0% - 30.7%)), whilst the Nordic events of cross country skiing/biathlon had the lowest IR with 8.4

per 1000 athlete days (95% CI 4.7% – 13.8%). As argued above, the high IR in alpine skiing/snowboarding may be partially attributed to poor weather and snow conditions.[16] However, there was a higher IR observed in wheelchair curling compared to cross country skiing/biathlon, which is a novel finding. As alpine skiing has traditionally high IRs and wheelchair curling has traditionally low IRs, the nature and onset of these injuries need to be further analysed in order to gain further insight into these injury incidence rates.

Similar incidence of upper and lower limb injuries

The fourth important finding of this study was the anatomical location of injuries sustained by athletes at the Games. The shoulder joint was the single joint most affected by musculoskeletal injury (IR of 6.4 (95% CI 4.6% - 8.6%)), and the second highest joint affected by injury was the knee (IR of 3.8 (95% CI 2.5% - 5.6%)). It is of interest that similar IRs were observed in the upper limb and lower limb anatomical areas (IR of 8.5 for upper and 8.4 for lower (95% CI 6.4% - 11.1% for the upper limb and 95% CI 6.3% - 10.9% for the lower limb)), which is in contrast to the data gathered in a Summer Games setting.[13] Injuries reported at the London Games constituted a high ratio of upper limb to lower limb injuries.[13] This may be the result of the different load on the shoulder complex and related joints whilst competing in Summer sports, which may not be present in Winter sports.[17-20] The similarity between the upper and lower body IR in the present study may reflect the sports in which the athletes take part, where wheelchairs are not used, despite reliance on the upper body for propulsion. Whilst wheelchair curling utilises adapted wheelchairs, the sport is neither a high velocity nor high load sport for the upper limbs of the athletes involved. It is of interest that the anatomical region of head, face and neck (IR of 4.7 (95% CI 3.2% - 6.7%)) was observed to have higher rate of injury compared to that documented in the London study (IR of 0.3 (95% CI 0.2% - 0.5%))[13]. This finding supports the anecdotal reports of higher numbers of concussions and facial fractures reported in a preliminary commentary on injury at the Sochi Games.[16] This is important, as medical staff at future Winter Paralympic Games should be prepared for injuries in this anatomical area, and provide suitable prevention programs in the Games setting.[21]

Acute injuries most common at the Sochi Winter Paralympic Games

A final important finding of the current study was that the majority of the injuries at the Sochi Games were reported as acute injuries (67.2%). This finding is similar to that in the Summer setting, where the majority of injuries recorded were classified as acute injuries (51.5%).[13]

The finding of the current study is also in contrast to previous Winter Paralympic Games, where 40.8% of injuries reported at the Vancouver Games were classified as acute traumatic injuries, compared to the 57.5% of injuries reported as chronic overuse injuries.[7] As discussed above, the traumatic nature of injuries recorded at the Sochi Games is perhaps expected, given the higher velocity at which the sports are conducted in a Winter Games setting (compared to a Summer Games setting), as well as the adverse snow conditions experienced at the Sochi Winter Games.[6;7;14;16;21;22]

Limitations of the study

There were several limitations of the present study that require further investigation in the future. There is an assumption that all of the NPC delegations had athletes present and 'at risk' for the whole 12-day Games period. Furthermore, whilst injuries have been presented in a similar manner in previously published papers, and while the issues of collecting exposure data in such environments are often difficult, there could be a small limitation to the exact determination of 'athlete days'. Data were recorded utilizing two electronic sources, which will be addressed through integration of the sources in future studies of the epidemiology of injury at Paralympic Games. The relatively small total number of injuries and injured athletes does not allow for complex multivariate analysis, which might identify further risk factors for injuries in a Winter Paralympic Games setting, which cannot be identified by the statistics completed in the current study. Particularly, future studies should analyse larger data sets to investigate snowboarding and alpine skiing separately. Further, data should be analysed to investigate the relationships between sports, onset of injury, location of injury as well as whether the injury occurred during training, pre-competition or competition phases of the total Games period. These analyses would allow for the identification and discussion of mechanisms of injury, which the current study, due to small numbers, cannot achieve. This study has however provided the framework for repeatable studies at future Winter Paralympic Games, where these in-depth analyses are possible. Longitudinal data collection as well as the growth of the Winter Paralympic Games more broadly may provide further opportunities in this area.

In summary, this study successfully documented the incidence of injuries sustained at the Sochi 2014 Winter Paralympic Games per 1000 athlete exposure days, whilst also providing information regarding the onset and anatomical area of injury. This study has built on the data gathering techniques of previous studies,[13] resulting in a repeatable data collection

method that can be used longitudinally to investigate the epidemiology of injury at future Winter Paralympic Games. It was found that there was a similar proportion of injuries at the Sochi Games compared to previous Winter Paralympic Games, but that there was a higher IR in these Paralympic athletes compared to their able-bodied counterparts at the Sochi 2014 Olympic Games. There was a higher incidence of injury documented at this competition compared to the London 2012 Summer Paralympic Games, which is the only other study to report injuries per 1000 athlete days. The sports of alpine skiing/snowboarding were found to have a particularly high incidence of injury, and injuries in the shoulder region were the highest single-joint IR, although total upper and lower body incidence of injury were similar. Furthermore, acute injuries were more prevalent in this edition of the Winter Paralympic Games. The results of the current study can be used to inform injury prevention programs and safety policy changes in future editions of the Winter Paralympic Games.

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