Sports injuries and illnesses in the Sochi 2014 Olympic Winter Games

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ABSTRACT

Background Systematic surveillance of injuries and illnesses is the foundation for developing preventive measures in sport.

Aim To analyse the injuries and illnesses that occurred during the XXII Olympic Winter Games, held in Sochi in 2014.

Methods We recorded the daily occurrence (or non-occurrence) of injuries and illnesses (1) through the reporting of all National Olympic Committee (NOC) medical teams and (2) in the polyclinic and medical venues by the Sochi 2014 medical staff.

Results NOC and Sochi 2014 medical staff reported 391 injuries and 249 illnesses among 2780 athletes from 88 NOCs, equalling incidences of 14 injuries and 8.9 illnesses per 100 athletes over an 18-day period of time. Altogether, 12% and 8% of the athletes incurred at least one injury or illness, respectively. The percentage of athletes injured was highest in aerial skiing, snowboard slopestyle, snowboard cross, slopestyle skiing, halfpipe skiing, moguls skiing, alpine skiing, and snowboard halfpipe. Thirty-nine per cent of the injuries were expected to prevent the athlete from participating in competition or training. Women suffered 50% more illnesses than men. The rate of illness was highest in skeleton, short track, curling, cross-country skiing, figure skating, bobsleigh and aerial skiing. A total of 159 illnesses (64%) affected the respiratory system, and the most common cause of illness was infection (n=145, 58%).

Conclusions Overall, 12% of the athletes incurred at least one injury during the games, and 8% an illness, which is similar to prior Olympic Games. The incidence of injuries and illnesses varied substantially between sports.

INTRODUCTION

It is well-established that regular exercise provides a number of significant health benefits, including a reduction in the risk of premature death, as well as non-communicable diseases, such as cardiovascular disease, hypertension, some cancers, obesity and diabetes.1,2 Increasing the exercise loads and entering the realm of elite sports does not seem to diminish these beneficial health effects. The majority of the available data suggest that compared with age-adjusted controls from the general population, elite athletes benefit from a better life expectancy, lower rates of various diseases, as well as lower hospital admission rates.3–7 However, at the same time, elite athletes are exposed to a higher risk of acute and chronic musculoskeletal disorders following their sports participation.8–11 In addition, recent studies have documented that athletes’ risk of sports-related illnesses is almost equally high.12–15

Systematic monitoring of injury and illness trends over long periods of time provides epidemiological data that are invaluable to protect the health of the athletes—one of the main priorities of the International Olympic Committee (IOC).16 A scientific, evidence-based understanding of incidence rates, characteristics, risk factors and associated mechanisms of injuries and illnesses, across different sports and athlete populations, provides the opportunity not only to enhance the treatment given to the injured or ill athlete, but more importantly, to inform the development and assessment of prevention measures.

Some International Sports Federations (IFS) have instituted comprehensive injury and illness surveillance systems longitudinally or in their main events, and published their results.14 15 17–51 For the 2008 Olympic Summer Games in Beijing, the IOC convened for the first time a group of experts to develop an injury surveillance system for multisport events31 32 and in the Vancouver 2010 Olympic Winter Games the surveillance was expanded to also include illnesses, to account for all health aspects of the elite athlete.12 The extended approach became the standard and was repeated with success in the London 2012 Olympic Games.13

The aim of the present paper is to analyse and describe the injury and illness rates and characteristics in the Sochi 2014 Olympic Winter Games. Practical implications and suggestions for further initiatives and research to protect the athletes’ health are provided.
RESULTS
In total, 2780 athletes took part in the Sochi Olympic Games. Of these, 1121 were women (40%) and 1659 men (60%). There were eight double-starters, meaning athletes who participated in two different sports, giving a total of 2788 athletes exposed to injury or illness.

Incidence and distribution of injuries
Among these athletes, we recorded a total of 391 injuries, equaling an overall injury rate of 14 injuries (95% CI 12.6 to 15.4) per 100 participating athletes (table 1). This corresponds to 7.8 injuries and 5 illnesses per 1000 athlete-days. On average, 12% (n=330) of the athletes sustained at least one injury. In addition, there were 43 with two, 2 with three, and 1 athlete with four injuries each, respectively.

The rate of injury was highest in aerial skiing (48.8 injuries (95% CI 27.9 to 69.7) per 100 athletes), snowboard slopestyle (37.0 (19.4 to 54.5)), snowboard cross (34.4 (19.7 to 49.2)), slopestyle skiing (30.8 (15.7 to 45.8)), halfpipe skiing (25.5 (11.6 to 39.3)), moguls skiing (24.6 (11.7 to 37.4)), alpine skiing (20.7 (15.7 to 25.7)) and snowboard halfpipe (18.2 (7.9 to 28.5)). The injury rates were lowest in Nordic combined, speed skating, biathlon, ski jumping, cross-country skiing, luge and short track (incidence rates ranging from four to nine injuries per 100 athletes).

The injury rates in female (14.9 injuries (95% CI 12.7 to 17.2) per 100 athletes) and male (13.2 (11.4 to 14.9), RR=1.13 (0.93 to 1.38)) athletes were similar (table 2). However, female athletes were at significantly higher risk of injury in slopestyle skiing (RR=3.00 (1.04 to 8.63)), whereas male were at higher risk of injury in ski jumping (7 vs 0 injuries).

Severity, location and type of injuries
While two-thirds of the injuries were estimated to result in no time loss from sport (n=240, 61%), 39% of the injuries (n=151) were expected to prevent the athlete from participating in competition or training. It was estimated that 18% of the injuries (n=69) would result in an absence from sports from 1 to 3 days, 5% (n=21) in an absence from 4 to 7 days, 6% (n=22) in an absence from 8 to 28 days, and 10% (n=39) in an absence for more than 28 days. Information on severity was missing on one injury.

A total of 61 injuries (16%) were classified as severe and entailed an estimated absence from training or competition of more than 1 week (table 1). These injuries were
- 25 ligament sprains/ruptures, of which 23 affected the knee (five in moguls, four in alpine skiing, four in ice hockey; three in aerial skiing, three in ski cross, two in snowboard cross and one in snowboard slopestyle);
- 14 fractures (three fractures to the foot, hand and finger in ice hockey; three clavicle, forearm and wrist fractures in alpine skiing; two ankle and face fractures in slopestyle skiing; two fractures to the pelvis and wrist in snowboard cross; two clavicle and elbow fractures in Nordic combined; one rib fracture in ski cross; and one rib fracture in ski jumping);
- six contusions, haematomas or bruises (four in snowboard and freestyle skiing);
- two muscle strains (in ice hockey to the groin and lower back);
- two tendon ruptures (to the knee in alpine skiing and thigh in bobsleigh);

Injury and illness report form
Our injury and illness record form was identical to the one we used in the 2010 (Vancouver) and 2012 (London) Olympic Games. With respect to injuries, we recorded the following information: accreditation number, sport and event, whether the injury occurred in competition or training, date and time, body part, type, cause and estimated time lost from competition or training. Likewise, we recorded the following information for illnesses: accreditation number, sport and event, date, affected system, main symptom(s), cause and estimated time loss.

We provided instructions on how to complete the form correctly in the instructional booklet. Furthermore, we distributed the injury and illness report forms to all NOCs in the following languages: English, French, Chinese, German, Japanese, Russian and Spanish.

Confidentiality and ethical approval
We utilised the athlete accreditation number to query the IOC athlete database for their age, gender and nationality. We treated all information with strict confidence, and anonymised our medical database at the end of the Games.

The study was approved by the medical research ethics committee of the South-Eastern Norway Regional Health Authority.

Data analysis
We calculated the summary measures of injury and illness incidents (i) according to the formula i=n/e, where n is the number of injuries or illnesses in competition, training or in total during the study period and e the respective number of exposed athletes; with incidence values presented as injuries/illnesses per 100 athletes. We calculated CIs of the risk ratio (RR) of the number of injuries or illnesses between two groups by a simple Poisson model, assuming constant hazard per group. We present injury and illness incidences as means and CIs with 95% CIs. We regarded two-tailed p values ≤0.05 as significant.
two elbow or shoulder dislocations (one each in aerial and slopestyle skiing);
- two lower back muscle cramps or spasms (in biathlon and cross-country skiing);
- one nerve/spinal cord injury to the thoracic spine in ski cross;
- one disc herniation in the lumbar spine in ice hockey;
- one bone bruise injury to the knee in alpine skiing;
- one Achilles tenosynovitis in biathlon; and
- one unclassified injury to the lumbar spine.

Of the 11 reported concussions, three were estimated to lead to more than 7 days of absence (two in halfpipe skiing and one in snowboard slopestyle).

Causes, mechanisms and circumstances of injury
While 81% (n=315) of the injuries were reported to occur acutely, 19% (n=76) were reported to be caused by overuse. The three most commonly reported injury causes/mechanisms were contact with a stationary object (25%), overuse with gradual onset (14%) and non-contact trauma (13%).

Contact with the ground, which includes features built as part of the course, was the most frequent mechanism of injury in ski cross (63%), snowboard slopestyle (59%), snowboard halfpipe (50%), halfpipe skiing (50%), aerial skiing (47%), snowboard slalom (44%), moguls skiing (36%), snowboard cross (33%), and slopestyle skiing (31%), and alpine skiing (26%). Similarly, in ice hockey, contact mechanisms accounted for 77% of the injuries, with contact with another athlete accounting for 40% of the injuries, contact with a moving object accounting for 23% of the injuries, and contact with a stationary object accounting for 13% of the injuries.

Overuse with gradual onset was conversely the most frequent cause of injury in curling (75%), bobsleigh (35%), cross-country skiing (26%) and figure skating (25%). Of all overuse injuries (gradual and sudden onset) occurring in the Games, 75% were recorded with no estimated absence from competition or training.

Of all the injuries, 35% were sustained in competition (8.8 (7.7 to 9.9) injuries per 100 athletes) and 63% during training (4.8 (4.0 to 5.7) injuries per 100 athletes), indicating an 82% higher rate of injury in training (RR=1.82 (1.47 to 2.24)). However, when analysing only the severe injuries, estimated to result in at least 7 days of absence, no difference was found, with competition accounting for 56% of the injuries and training for 42% (RR=0.74 (0.47 to 1.15)). Information on training/competition was missing in 11 injuries.

Injuries in training and in competition differed significantly in characteristics (location, type, mechanism and subsequent time
loss from sport) and in terms of rates in different sports (table 1). The rate of injury was higher in training than in competition in aerial skiing (RR=3.20 (1.17 to 8.74)), alpine skiing (RR=3.20 (1.80 to 5.71)), bobsleigh (RR=6.75 (2.36 to 19.29)), figure skating (RR=8.50 (1.96 to 36.80)) and luge (RR=8.00 (1.00 to 64.00)). When including only injuries estimated to result in at least 7 days of absence, the higher injury rate in training was seen only in alpine skiing (RR=11.0 (1.42 to 85.20)).

Ice hockey was the sole sport in which the competition injury rate was higher than the training injury rate (RR=0.48 (0.25 to 0.83)), a difference which increased when isolating the injuries estimated to result in more than 7 days of absence (RR=0.15 (0.04 to 0.68)).

Incidence and distribution of illnesses

Among the 2788 exposed athletes, a total of 249 illnesses were reported, resulting in an incidence of 8.9 illnesses (95% CI 7.8 to 10.0) per 100 athletes (table 1). On average, 8% (n=229) of the athletes incurred an illness, as there were nine athletes with two illnesses each. Female athletes (10.9 illnesses (9.0 to 12.9) per 100 athletes) were at significantly higher risk of contracting an illness than male athletes (7.3 (6.0 to 8.6), RR=1.5 (1.17 to 1.93)).

Illnesses were reported in a variety of sports. Skeleton was the sport with the highest illness rate (27.7 illnesses (95% CI 12.6 to 42.7) per 100 athletes), followed by short track (14.2 (7.0 to 21.3)), curling (14.0 (6.7 to 21.3)), cross-country skiing (13.8 (9.6 to 18.0)), figure skating (12.1 (6.5 to 17.7)), bobsleigh (11.7 (6.6 to 16.8)) and aerial skiing (11.6 (1.4 to 21.8) (table 1). The illness rates were lowest in snowboard slalom, moguls skiing, ski jumping, snowboard slopestyle, luge, snowboard halfpipe and snowboard cross (incidence rates ranging from 1 to 4 illnesses per 100 athletes).

Affected system, causes and severity of illness

A total of 159 illnesses (64%) affected the respiratory system, and these were most frequently reported in skeleton (21% of the athletes), cross-country skiing (10%), curling (8%), biathlon (8%), bobsleigh (8%), short track (7%) and Nordic combined (7%). The second, third, fourth and fifth most frequently affected systems were the digestive system (n=28, 11%), nervous system (n=13, 5%), skin and subcutaneous tissue (n=12, 5%) and genitourinary system (n=9, 4%), respectively.

Infection was the most common cause of illness (n=145, 58%), affecting athletes in mainly the same sports as mentioned above. Of the 159 respiratory illnesses, 118 (74%) were caused by an infection.
One in four illnesses (n=63, 25%) were expected to result in absence from training or competition. Of these, two illnesses (1%) were expected to result in an estimated time loss of more than 7 days (one upper respiratory tract infection; and one illness affecting the nervous system).

**Rate of response, injury and illness per NOC size**

Thirty-four of the 88 NOCs had more than 10 participating athletes. Athletes from these NOCs comprised 2623 of the in total 2779 athletes competing for an NOC, corresponding to 94% (table 3). Throughout the 18 days of the Sochi Games, the 34 NOCs submitted a total of 610 of a maximum of 612 forms (99.7%).

Only 17% of the injuries and 2% of the illnesses were captured by both the NOCs and the Sochi 2014 staff. While 49% of the injuries and 68% of the illnesses were recorded solely by the NOCs, 34% and 30% of the injuries and illnesses, respectively, were recorded only by the Sochi 2014 staff.

Whereas the majority of injured and ill athletes from the larger NOCs were seen internally by the NOC medical staff, athletes from smaller NOCs were to a greater extent relying on diagnosis and treatment from the Sochi 2014 medical staff (table 3).

There was also an inverse relationship between NOC size (measured in number of participating athletes) and the risk of health problems, with athletes from smaller NOCs experiencing higher injury and illness rates (NOCs with <10 athletes: 30.1 (21.5 to 38.7) injuries and 14.1 (8.2 to 20.0) illnesses per 100 athletes versus NOCs with >99 athletes: 10.5 (9.0 to 12.0) injuries and 8.1 (6.8 to 9.4) illnesses per 100 athletes, injury RR=2.87 (2.08 to 4.00), illness RR=1.74 (1.11 to 2.73)).

While the highest injury rates were found in snow sports characterised by aerial manoeuvres and high-speed, namely aerial skiing (49% of all athletes injured), snowboard slopestyle (37%), snowboard cross (34%), slopestyle skiing (31%), halfpipe skiing (26%), moguls skiing (25%), alpine skiing (21%), and snowboard halfpipe (18%), the highest rates of illness were found in ice sports such as skeleton (28%), short track (14%), curling (14%), figure skating (12%), bobsleigh (12%), as well as in cross-country skiing (14%).

**DISCUSSION**

The aim of the present paper was to describe and analyse the injury and illness rates and characteristics in the Sochi 2014 Olympic Games. The main findings of this 18-day long prospective cohort study were that 12% and 8% of all the 2780 athletes suffered from at least one injury or illness, with overall rates of 14 injuries and 8.9 illnesses per 100 athletes, respectively. The magnitude and characteristics of the injuries and illnesses varied substantially between sports and gender.

**Injury rates in the Olympic sports**

The overall rate of injury in the Sochi Games was similar to those in Beijing 2008, Vancouver 2010 and in London 2012 (12% of all athletes injured in Sochi vs 11% in Vancouver and London, and 10% in Beijing). Compared to their Vancouver Winter Games counterparts, higher injury rates were found in the Sochi Games athletes competing in aerial skiing (49% vs 19% of the athletes injured), alpine skiing (21% vs 15%), biathlon (7% vs 1%), cross-country skiing (8% vs 3%), curling (12% vs 4%), luge (8% vs 2%), double slideskiing (25% vs 2%), skeleton (11% vs 6%), snowboard halfpipe (18% vs 13%), and snowboard slalom (14% vs 7%). Conversely, lower injury rates were found among the Sochi Games athletes competing in ice hockey (11% vs 18%), short track (9% vs 18%) and ski cross (14% vs 19%). In general, our findings on the sports-specific injury rates in Sochi are corroborated by a large body of research from the Fédération Internationale de Ski (FIS) World Cup, where snowboard cross and halfpipe,47 aerial and halfpipe skiing and ski cross,42 as well as particularly downhill of the alpine skiing events43 44 have been identified as disciplines with a higher rate of injury.

A change in injury incidence can be the result of changes in the composition of the Olympic Games programme (eg, 12 new events introduced in Sochi), environmental factors, such as weather, snow or ice conditions, venue or track design, competition rules, in equipment or other factors. Changes in injury rates can also follow an increased or reduced awareness among the athletes and their medical staff in recognising and reporting even minor incidents (broad injury and illness definitions applied in IOC surveillance studies). In certain sports, changes may also be attributable to more comprehensive and accurate data reporting by team physicians who over time have been trained as

**Table 3 Response rates, injuries and illnesses in NOCs of different sizes (measured by number of athletes)**

<table>
<thead>
<tr>
<th>NOCs (athletes)</th>
<th>&lt;10</th>
<th>10–49</th>
<th>50–99</th>
<th>&gt;99</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injuries (injuries per 100 athletes)</td>
<td>54 (156)</td>
<td>12 (258)</td>
<td>10 (622)</td>
<td>12 (1743)</td>
<td>88 (2779*)</td>
</tr>
<tr>
<td>Illnesses (illnesses per 100 athletes)</td>
<td>47 (30.1)</td>
<td>67 (26.0)</td>
<td>93 (15.0)</td>
<td>183 (10.5)</td>
<td>3901 (14.0)</td>
</tr>
<tr>
<td>Report forms submitted (%)</td>
<td>22 (14.1)</td>
<td>44 (17.1)</td>
<td>42 (6.8)</td>
<td>141 (8.1)</td>
<td>249 (9.0)</td>
</tr>
<tr>
<td>Recorded by both NOC and OCOG</td>
<td>–</td>
<td>216 (100.0)</td>
<td>178 (98.9)</td>
<td>216 (100)</td>
<td>610 (99.7)</td>
</tr>
<tr>
<td>Injuries</td>
<td>9 (19.1)</td>
<td>11 (16.4)</td>
<td>14 (15.1)</td>
<td>34 (18.6)</td>
<td>68 (17.4)</td>
</tr>
<tr>
<td>Illnesses</td>
<td>1 (4.5)</td>
<td>–</td>
<td>1 (2.4)</td>
<td>2 (1.4)</td>
<td>4 (1.6)</td>
</tr>
<tr>
<td>Recorded only by NOCs</td>
<td>6 (12.8)</td>
<td>27 (40.3)</td>
<td>50 (53.8)</td>
<td>107 (58.5)</td>
<td>191 (49.0)</td>
</tr>
<tr>
<td>Injuries</td>
<td>3 (13.8)</td>
<td>24 (54.5)</td>
<td>31 (73.8)</td>
<td>112 (79.4)</td>
<td>170 (68.3)</td>
</tr>
<tr>
<td>Illnesses</td>
<td>18 (81.8)</td>
<td>20 (45.5)</td>
<td>10 (23.8)</td>
<td>27 (19.1)</td>
<td>75 (30.1)</td>
</tr>
</tbody>
</table>

*1 Independent Olympic Athlete and eight double-starters excluded.
†NOC is missing for 1 injury.
‡Countries with less than 10 athletes were excluded from the response rate analysis.
injury and illness recorders through the implementation of surveillance systems by their own Federation. Also, rate differences (lower or higher) may simply be the result of a natural fluctuation/variability of athlete’s exposure to risk, an observation that emphasises the value of on-going surveillance to monitor trends over time, for example, the effect of venue design, rule or equipment changes in the period between major sports events.

Severity, location and type of injuries
In major sports events, like the Olympic Games, injuries or illnesses of even minor severity and time loss have the potential to be participation-limiting and performance-inhibiting, and thus prevent athletes from reaching their life-time achievement. In the Sochi Games, 61% of the injuries were reported to lead to no absence from competition or training, whereas 39% were estimated to result in time loss of at least 1 day. However, 16% of the injuries were estimated to encompass time loss greater than 7 days. This may indicate a shift from the Vancouver Games, where 23% of the injuries were expected to entail a time loss of at least 1 day, and just 4% a time loss of more than 7 days; however, this is uncertain, as there was a high percentage of missing data on injury severity in Vancouver.12 These results warrant a more extensive recording and detailed analysis of injury risk factors and mechanisms, to improve injury prevention in the future.

The risk of concussion is a recurrent concern in certain sports, and its diagnosis, prevention, treatment and return-to-play guidelines have been addressed in recent consensus meetings.53 54 Eleven concussions were recorded in Sochi (0.4% of the athletes) which is half of the 20 concussions (0.8%) reported in Vancouver. This is higher than the rates reported from the Summer Olympics in London (n=6, 0.06% of athletes) and Beijing (n=12, 0.11%), although these rates are not directly comparable due to the different nature of the sports and events.

Causes, mechanisms and circumstances of injury
The causes, mechanisms and circumstances of injuries in competition and training differed significantly between the different sports. With 63% of the injuries occurring during training and only 35% in competition, the findings differ from those in the Vancouver Games, where the distribution was relatively even (54% vs 46%, respectively).12

It can, however, be hypothesised that winter sports athletes suffer a slightly higher proportion of injuries in training, whereas their summer sports counterparts sustain more injuries in competition, but more data is needed to confirm this.13 22 36–38 42 47 52 Ice hockey was the only sport on the Sochi Olympic programme in which the majority of injuries occurred in competition, an effect which was even greater when including only the injuries estimated to result in more than 7 days of time loss. These results correspond with earlier epidemiological findings.55–59

The majority of injuries in Sochi were reported to be acute, whereas overuse injuries with either a gradual or sudden onset accounted for about one-fifth of the injuries. Similar distributions have been reported from the summer and winter Olympic Games previously.12 13 52; however, these numbers should be interpreted with caution, due to the current limitations in the recording of overuse injuries.60–63

Illness risk during the Olympics
The rate of illness in the Sochi Games was similar to those reported in the Vancouver Games and London Games (8% of all athletes affected in Sochi vs 7% in Vancouver and London).12 13 Also consistent with the Vancouver and London data is the difference in the incidence of illnesses between female and male athletes, with female athletes in Sochi contracting 50% more illnesses than male athletes. The same disproportion has previously been reported in the 2009 athletics17 and aquatics world championships, but not in the 2011 athletics world championships,18 in the 1994–2009 US Open tennis championships,64 or in the Summer Paralympic Games.14

The high incidence of respiratory infections mirrors data from other elite sport events.7 14 15 22 37–39 64–66 Predominant risk factors are mechanical and dehydration stresses generated within the airways and the level of airborne pollutants, irritants and allergens inhaled by the athlete under high ventilatory exercise conditions.16 Earlier it has been reported that airway hyper-responsiveness/asthma is one of the most common chronic medical conditions in winter and summer elite sports, especially among endurance athletes.71 Team physicians can anticipate that athletes travelling intercontinentally are at higher risk of illness,67 but that these illnesses can be mitigated through careful planning and diagnostic work prior to the Games.12

Methodological considerations
In studies on sports injury, it is usually recommended to express incidences using a measure of time exposed to risk as the denominator.14 15 35 73 74 However, considering the inherent complexity and size of the Olympic Games, this was not feasible in the present study. Instead, we expressed the incidence of injury or illnesses by means of absolute risk: the number of new cases per 100 registered athletes. This approach erroneously assumes that the frequencies and lengths of exposure are identical in all sports and that the number of athletes at risk in each NOC is constant throughout the Games, and interpretation of differences in injury incidences or patterns should therefore be made with caution.

In the current study we defined injuries and illnesses as new or recurring injuries or illnesses receiving medical attention, regardless of the consequences with respect to absence from competition or training. By using such a definition, predominantly the moderate and severe acute injuries will be recorded. The less serious injuries may be overlooked, since such injuries do not always require medical attention,75 76 albeit our results show that the majority of reported injuries were not estimated to involve any absence from the sport. In the Olympic Games, all athletes can get healthcare through the athletes’ village poly-clinic and the venue medical clinics. However, the availability, size and quality of the NOCs own medical teams vary between countries, meaning that not all athletes benefit from identical healthcare, which may bias the injury and illness recording.

Throughout the 18 days of data collection in the Olympic Games, we collected 99.7% of all the NOC injury and illness report forms. This is the highest NOC response rate to date in the Olympic Games injury and illness surveillance, a result which can be attributed to favourably disposed NOC medical staff, an informational meeting with all NOCs the day before the Games’ opening, the preparation of report forms in seven languages and an instructional booklet on how to fill in the forms, and a dedicated and increasingly experienced research team which conducted frequent follow-up visits to boost NOCs’ compliance. However, although the NOC response rate was...
excellent, we did not test the accuracy and internal validity of their reported data. Thus, we cannot evaluate the extent to which the NOC data match the actual circumstances of the occurred injury or illness. Furthermore, it has been documented earlier in professional alpine skiing and male elite football that prospective injury surveillance by team medical staff underestimates the incidence of injuries and time-loss injuries. Our results support these findings, as the NOC medical teams failed to report 34% and 30% of the total reported injuries and illnesses, respectively.

The same result demonstrates how recording data both among NOC medical staff and in the organising committee’s medical stations is absolutely vital to the scientific quality of the surveillance study. A mere 17% of the injuries and 2% of the illnesses were captured by both recorder groups. Our study also shows that in particular athletes from smaller NOCs benefit from diagnosis and treatment from the local organising committee’s medical staff, whereas the majority of athletes from larger NOCs are seen by their own NOC medical staff. More importantly, we identified an inverse relationship between NOC size and the risk of health problems, with athletes from the smallest NOCs experiencing an almost threefold injury rate and twofold illness rate compared with the largest NOCs. It is difficult not to see this finding in light of distinct differences in resources available to the NOC. Large delegations usually come from countries with well-developed exercise physiology and sports medicine communities, and are generally able to offer their athletes more comprehensive healthcare and closer medical follow-up in the lead up to and during the Games, potentially giving them a competitive advantage.

Practical implications

The epidemiology of injuries in the Sochi and Vancouver Olympic Games and the FIS World Cup has demonstrated a high risk of severe injuries in many of the snowboarding and freestyle skiing events. Likewise, in recreational freestyle skiing and snowboarding, it has been found that the rate of severe injuries, in the form of spine and head injuries, is double inside terrain parks compared with outside. Furthermore, it has recently been demonstrated that a preponderance of the injuries occur in jumps, kickers and the halfpipe, in other words, in features that facilitate aerial manoeuvres. In order to mitigate the risk of these injuries, we need more refined data on their sport-specific risk factors and mechanisms. Our data, although crude, show that a large proportion of the injuries are caused by contact with the ground (or other stationary objects attached to it). It has been shown that the magnitude of impact risk can be characterised by the equivalent fall height, a measure of jumper impact velocity normal to the slope. By employing jump design algorithms taking the equivalent fall height into account, the landing impact from aerial manoeuvres and thus the risk of injury can be minimised.

The IOC is currently developing a customised electronic medical record (EMR) for the Rio 2016 Games and beyond to replace the medical encounter system used by the local organising committees since the Barcelona 1992 Games. The implementation of the EMR will not only improve the healthcare provision in the Olympic and Paralympic Games, but also provide a number of new opportunities for recording of injuries and illnesses in a confidential manner. With time, NOC physicians and physiotherapists will be able to record their daily injury and illness data, feeding into the same EMR database, possibly rendering the IOC paper record forms obsolete. Data privacy will evidently be of high importance, with data accessible strictly to authorised users. In the long term, our aim is to invite NOCs to use the same EMR in their daily medical follow-up of their athletes in between the Games. An electronic injury and illness surveillance will also facilitate advances in the quality and usefulness of the data that we capture. For example, one will be able to record risk factors and mechanisms that are specific to each sport and event, which will significantly improve our ability to subsequently ideate and tailor injury prevention initiatives.

The continuously accumulating evidence that injury and illness rates vary substantially between sports demonstrates the need for tailoring preventive measures to the specific context of each sport. Sport bodies such as the IOC, International Paralympic Committee (IPC), IFs and NOCs have the responsibility to protect the health of their athletes. The Olympic Movement Medical Code encourages all stakeholders to take measures to ensure that sport is practised with minimal risks of physical injury and illness or psychological harm. For IFs, a critical component of this responsibility is the implementation of a scientifically sound injury and illness surveillance system in all major events. Some sports federations, such as FIFA (Fédération Internationale de Football Association), FINA (Fédération Internationale de Natation), FIS, FIVB (Fédération Internationale de Volleyball), IAAF (International Association of Athletics Federations), IIHF (International Ice Hockey Federation), WR (World Rugby) and UEFA (Union of European Football Associations) have put increasing effort into working systematically and scientifically to protect their athletes’ health. We encourage other IFs and sports organisations to follow their example.

CONCLUSION

In summary, 12% of the athletes incurred an injury and 8% suffered from at least one illness during the Sochi Olympic Winter Games. The incidences and characteristics of injuries and illnesses in training and competition varied substantially between sports and gender. Future initiatives will include the recording of sport-specific injury and illness risk factors and mechanisms, to better inform the development of tailored prevention measures targeting the athlete at risk.

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