Adaptive Sports Injury Epidemiology

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Abstract: The benefit of sport for athletes with impairments is well established. However, sport participation is not without risk. The existing literature informs us that injury patterns are sport and disability specific. Further research is needed to study injuries in this population.

Key Words: impairment, injury, Paralympics, veterans, adaptive, sports

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There are many benefits to participation in adaptive sport. As detailed elsewhere in this issue, sports participation has a positive impact on cardiovascular fitness, self-efficacy, and self-perceived quality of life,[1] as well as a positive association with employment.[2] Despite the many benefits of adaptive sport, there are also risks associated with participation. The aim of this article is to review the available literature on injury epidemiology in adaptive sports in order to gain a better understanding of the risks involved in sports participation for athletes with impairment.

INJURY EPIDEMIOLOGY IN ADAPTIVE SPORTS

When reviewing the available literature, the most robust data with regard to the injury and illness in adaptive sports come from the Paralympic games, generally considered the pinnacle of para-sport competition. However, even this dataset is smaller in scope when compared with injury and illness epidemiology of able-bodied athletes.[3–6] For example, a simple search on Google Scholar returns about 7000 entries for "Paralympic injury," whereas "Olympic injury" has almost 60,000 articles. A search on Scopus for "Paralympic" provides just over 1000 references but "Olympic" returns almost 14,000 entries. The first systematic review of sports injury in disability sport published in 2016 identified a limited number of prospective studies, variability in the quality of the available literature, and inconsistency in injury definitions across studies.[7] Earlier studies examining wheelchair athletes reported descriptions of injuries, but lacked scientific rigor, often using only self-reports.[8,9]

Within the subset of athletes with disabilities, veterans make up a significant percentage of the North American population (www.teamusa.org/US-Paralympics/Resources/Military/Military-Athletes, www.legion.org/news/241414/veterans-big-part-us-paralympic-team). At the elite level, there are many US veterans competing at the Paralympic games, as shown in Table 1. Some of the events available to veterans at the recreational level include the Valor Games, the National Veterans Wheelchair Games (NVWG), the International Invictus Games, and the Warrior games. There is a Ski Spectacular held in Breckenridge, Colorado every year as well as Summer and Winter Sports Clinics (www.va.gov/adaptivesports). In addition, The Golden Age Games has adaptive classes (www.va.gov/opa/speceven/gag/index.asp). Despite the existence of these games, there is a paucity of published data describing the rate of injury at a veteran-specific event.

METHODS

We performed a literature search to investigate the incidence of injury in adaptive sports. Using scientific databases, including Google Scholar, Scopus, Mendeley, PubMed, and QxMD, we searched relevant literature with the following key terms: wounded warrior, veteran, injury, illness, National Veteran's Wheelchair Games, Paralympic, and Valor Games.

Injury at the Paralympic Games

In order to better understand the epidemiology of injury at the Paralympics, it should be highlighted that the Paralympics have grown considerably in size, scope, visibility, and competitiveness. Many sports have been added since the first Paralympics in 1960, as shown in Table 2. The number of athletes at the Paralympic Games has increased as well. The First Paralympic Games had 400 athletes with spinal cord injuries from 23 countries. By comparison, the most recent Summer Games held in Rio de Janeiro in 2016 had over 4000 athletes with a variety of impairments from 160 countries.

The complex classification system of Paralympic sport also needs to be taken into account when reviewing the available literature in adaptive sports injury epidemiology. For example, the most recent Winter Games consisted of 6 sports: alpine skiing, cross-country skiing, snowboard, biathlon, para ice hockey, and wheelchair curling. The sport of Alpine skiing contained 30 medal events, 15 for men and 15 for women. There were 5 disciplines within the broad sport category of alpine skiing: downhill, slalom, giant slalom, super-G, and combined. Further, there were 3 competition categories within each of these disciplines: standing, sitting, or visually impaired. Injury patterns in the literature are specific to sporting event and to disability of the athlete. Injury pattern data may be limited in some sports due to these complex classification systems and level of disability.

Injury surveillance at the Paralympics started in 2002 at the Salt Lake City Winter Games with a standardized medical encounter form. Data collection and compliance by each team's medical personnel continued to improve over time. Injury data were collected for 3 consecutive winter games (Table 3). In 2012, an online exposure form was added. Exposure data are critical in sports injury epidemiology,

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TABLE 1. Percentage of Total Paralympic Athletes Who are Veterans

Veterans in the Paralympics	
2014 Sochi Winter Games	22.5% (18/80) of the US Paralympic team (www.teamusa.org/US-Paralympics/Resources/Military/Military-Athletes)
2016 Rio Summer Games	11.8% (34/289) of the US Paralympic team (www.teamusa.org/US-Paralympics/Resources/Military/Military-Athletes)
2018 PyeongChang Winter Games	24.3% (18/74) of US Paralympic team (www.legion.org/news/241414/veterans-big-part-us-paralympic-team)

allowing for an accurate representation of the amount of potential chances an athlete has for injury. Before 2012, the injury data collected allowed for calculation of incidence proportions (IPs). With exposure data, incidence rates (IRs) could also be calculated. Furthermore in 2012, the summer games were added to the injury and illness surveillance project.[13] The summer games are larger than the winter games in terms of the number of participants, as well as the number of events, as shown in Table 4. This makes data capture more challenging and explains why the injury and illness surveillance project started with the smaller winter games.

Several patterns have emerged from the Paralympic injury and illness surveillance project. First, there are similar rates of injury and illness for male and female participants. Second, there is a consistently high rate of injury seen in football 5-a-side during the summer games[14,18,20] and alpine skiing and snowboarding during the winter games.[10,12,16] Third, there was a high rate of injuries seen at the Sochi 2014 Paralympic Games. In fact, the overall IR of 26.5 injuries per 1000 athlete-days[16] was 3 times greater than the overall IR of 7.8 injuries per 1000 athlete-days at the Sochi Olympic Games.[5] This is thought to be at least in part due to poor snow quality and poor course conditions created by warm weather. Fourth, the respiratory system is the most common system affected by illness.[15,17,19] When looking at the distribution of illness across physiological systems, the highest IR was reported in the respiratory system for all 3 Paralympic games where incident rates were reported (2012, 2014, 2016 Games).[15,17,19] Fifth, the shoulder is the most commonly injured joint, and rates of shoulder injury vary depending on type of sport.[12,20,21]

The sixth pattern to emerge from the Paralympic injury and illness surveillance project relates to age. Injury and illness rates increase with age, although this is not statistically significant in every study. There was a significantly lower ($P = 0.049$) illness IR [12.6, 95% confidence interval (CI): 7.9-20.1] in the youngest age group (age: 14 to 25 y) at the Sochi Paralympic games as compared with the older age group (age: 35 to 63 y, illness IR: 22.6, 95% CI: 16-31.9).[17] At the Rio de Janeiro 2016 Paralympic Games there was a significantly higher ($P < 0.01$) illness IR (11.8, 95% CI: 10.3-13.4) in the oldest age group (age: 35 to 75 y) when compared with other age groups (age: 12 to 25 y, illness IR: 8.8, 95% CI: 7.4-10.5 and age: 26 to 34 y, illness IR: 9.0, 95% CI: 7.8-10.5).[19]

TABLE 2. Sports Included in Paralympic Events

First Paralympics, 1960, Rome (Ninth Annual International Stoke Mandeville Games)	Rio de Janeiro Summer 2016	PyeongChang Winter 2018
Archery	Archery	Alpine skiing
Athletics	Athletics	Cross-country skiing
Dartchery	Boccia	Snowboard
Snooker	Canoe	Biathlon
Swimming	Cycling	Para ice hockey
Table tennis	Equestrian	Wheelchair curling
Wheelchair basketball	Football 5-a-side	
Wheelchair fencing	Football 7-a-side	
	Goalball	
	Judo	
	Powerlifting	
	Rowing	
	Sailing	
	Shooting	
	Sitting volleyball	
	Swimming	
	Table tennis	
	Triathlon	
	Wheelchair basketball	
	Wheelchair fencing	
	Wheelchair rugby	
	Wheelchair tennis	

Injury at the NVWG

To our best knowledge, no study has been published on the injury and illness rates at a recreational event involving wounded warriors or adaptive Veteran athletes. The first formal study investigating injury and illness epidemiology at a NVWG event is pending publication. We performed a retrospective chart review of the medical information collected during the week of the 26th Annual NVWG (June 27 to July 2, 2016) held in Salt Lake City, Utah. Data were in the form of counts for age, sex, impairment type, chief complaint, diagnosis, treatment. Encounters were then classified into 7 categories based on chief complaint and frequency was calculated: Bowel (4.9%), bladder (7.1%), skin and soft tissue (26.1%), need for medical supplies (16%), musculoskeletal injury (17.9%), other medical illness (19%), and follow-up of previously documented problem (9%). The most common chief complaint was related to skin and soft tissue (wounds, abrasions, bruises, and lacerations). Repeat presentations by the same athlete were common. Moreover, higher proportions of athletes presenting for care were seen in athletes with spinal cord injury (IP: 37.7%, 95% CI: 32.5%-42.9%) and multiple sclerosis (IP: 41.5%, 95% CI: 28.2%-54.8%) as compared with athletes with amputation and traumatic brain injury.

TABLE 3. Injury IP for All Athletes at the Paralympic Games

Games	Injury IP
2002 Winter Salt Lake City[10]	9.40%
2004 Summer Athens	NA
2006 Winter Torino[11]	8.40%
2008 Summer Beijing	NA
2010 Winter Vancouver[12]	11%-23.8%

IP indicates incidence proportion; NA, not available.

TABLE 4. Summary of Published Data for Last 3 Paralympic Games

Games	Exposure	No. Participants (% Data Capture)	Athlete-time at Risk	Total Injuries	Injury IP	Injury IR Per 1000 Athlete-days	Total Illnesses	Illness IP	Illness IR Per 1000 Athlete-days
2012 Summer London[14,15]	14 d* 20 sports	3565 athletes (84%) 160 countries (98%)	49,910 athlete-days	633 total injuries in 539 athletes	15.1%	12.7 (95% CI: 11.7%-13.7%)	657 total illnesses in 505 athletes	14.2% (95% CI: 13.0-15.3%)	13.2 (95% CI: 12.2-14.2)
2014 Winter Sochi[16,17]	12 d† 6 sports	547 athletes (100%) 45 countries (100%)	6564 athlete-days	174 total injuries in 134 athletes	24.5%	26.5 (95% CI: 22.7%-30.8%)	123 total illnesses in 95 athletes	17.4%	18.7 (95% CI: 15.1%-23.2%)
2016 Summer Rio de Janeiro[18,19]	14 d* 22 sports	3657 athletes (83.5%) 78 countries (48.8%)	51,198 athlete-days	510 total injuries in 441 athletes	12.1%	10.0 (95% CI: 9.1-10.9)	511 total illnesses in 454 athletes	12.4%	10.0 (95% CI: 9.2-10.9)

*Total competition period of 14 days includes 3-day precompetition period and 11-day competition period.
†Total competition period of 12 days includes 3-day pre-competition period and 9-day competition period.
CI indicates confidence interval; IP, incidence proportion; IR, incidence rate.

CONCLUSIONS

Competitions such as the Paralympic Games and NVWG are some of the largest sporting events available for athletes with impairments. The most comprehensive data for injury and illness in adaptive sports come from the literature on the Paralympic Games owing to the Paralympic Injury and Illness Surveillance Project. Several patterns have emerged from this dataset, including similar injury and illness rates when comparing male to female participants. When considering sporting event, the highest rates of injury are seen in alpine skiing, snowboarding, and football 5-a-side. The most common physiological system affected by illness is the respiratory system, and the most common anatomic location affected by injury is the shoulder joint. Finally, injury and illness rates have positive correlations with age.

Although significant progress has been made in obtaining quality data at the level of the Paralympic Games, data at other adaptive sporting events can still benefit from improved data collection. There is limited injury epidemiology data arising from Veteran-specific recreational events such as the NVWG. High-quality exposure data, such as time in competition, days in competition, or number of games, is a key marker for identifying injury risk information. With high-quality injury and illness surveillance data, better information is gained to allow for future studies to reduce further injuries and illnesses.

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