The epidemiology of injuries in powerlifting at the London 2012 Paralympic Games: an analysis of 1411 athlete-days

Corresponding author:

Dan Cushman, 590 Wakara Way, Salt Lake City, UT 84108, USA.

Phone: +1-801-213-3476. Fax: +1-801-587-5482.

Email: dan.cushman.work@gmail.com

Authors:

Stuart E Willick[1]

Daniel Cushman[1]

Cheri A. Blauwet[2,3]

Carolyn Emery[4,5]

Nick Webborn[2,6]

Wayne Derman[2,7,8]

Martin Schwellnus[7,8,9]

Jaap Stomphorst[2,10]

Peter Van de Vliet[11]

Affiliations:

[1]University of Utah Orthopaedic Center, Salt Lake City, USA

[2]Medical Committee, International Paralympic Committee, Bonn, Germany

3Department of Physical Medicine and Rehabilitation, Spaulding Rehabilitation Hospital and Brigham and Women's Hospital, Harvard Medical School, Boston, USA

[4]Sport Injury Prevention Research Centre, University of Calgary, Edmonton, Canada

[5]International Olympic Committee (IOC) Research Centre, Calgary, Canada

[6]School of Sport and Service Management, University of Brighton, East Sussex, United Kingdom

[7]Institute for Sport, Exercise Medicine and Lifestyle Research, Faculty of Health Sciences, University of Pretoria, Pretoria, South Africa.

[8]International Olympic Committee (IOC) Research Centre, South Africa

[9]Emeritus Professor, Faculty of Health Sciences, University of Cape Town

[10]Sports Medicine Department, Isala Klinieken, Zwolle, The Netherlands

[11]Health Leisure and Human Performance Research Institute, University of Manitoba, Winnipeg, Canada

ABSTRACT

Sport injury epidemiology has received increased recognition as a field of sport medicine research that can improve the health and safety of athletes. Injuries among Paralympic powerlifters have not previously been systematically studied. The purpose of this prospective cohort study was to characterize injuries among Paralympic powerlifters. Athletes competing in the sport of powerlifting were followed over the 7-day competition period of the 2012 London Paralympic Games. The main outcome measurements were injury incidence rate (IR) (number of injuries per 1000 athlete-days) and injury incidence proportion (IP) (injuries per 100 athletes). A total of 38 injuries among 163 powerlifters were documented. The overall IR was 33.3 injuries/1000 athlete-days (95% CI 24.0 – 42.6) and the overall IP was 23.3 injuries per 100 athletes (95% CI 16.8 – 29.8). The majority of injuries were chronic overuse injuries (61%). The most commonly injured anatomical region was the shoulder/clavicle (32% of all injuries), followed by the chest (13%) and elbow (13%). The information obtained in this study opens the door for future study into the mechanisms and details of injuries into powerlifters with physical impairments.

Key Terms: Bench press, disability, impairment, injury, prevention, international sport, elite athlete, power lifting, weightlifting

What is known about the subject: There have been few prior publications that detailed the types and rates of injuries in Paralympic powerlifters.

What this study adds to existing knowledge: This is the first systematic, prospective study to characterize the rates, types and location of injury in Paralympic powerlifters.

INTRODUCTION

There is an increasing number of athletes with impairments, which provides a medium for sport-related injuries (Blauwet et al. 2014; Fagher et al. 2014). Powerlifting was added to the Paralympic Games program in 1964 (Webborn et al. 2012) and has been contested at the Summer Paralympic Games since that time. Both male and female para-athletes participate in various categories in the sport, including ten weight classes (male and female) and eight impairment categories: impaired muscle power, impaired passive range of movement, limb deficiency, leg length difference, short stature, hypertonia, ataxia, and athetosis (IPC 2015). While the able-bodied version of powerlifting includes the squat, the deadlift, and the bench press (Lavallee et al. 2010), Paralympic powerlifters only participate in the bench press, which consists of athletes lowering a barbell to the chest, holding it motionless, and then pressing it upwards to arms' length until the elbows are in full extension. Athletes are given three attempts, with the winning athlete lifting the largest amount of weight (IPC 2015).

Data regarding injuries for para-athletes participating in powerlifting are scarce. Injuries in powerlifters competing at the Paralympic Games have been mentioned only briefly in two prior reports (Athanasopoulos et al. 2009; Reynolds et al. 1994); both looked at only a subset of all injuries to all athletes. Due to this paucity of data, the first prospective, comprehensive epidemiologic reports of injuries seen in summer Paralympic sports, including powerlifting, were published following the London 2012 Games (Derman et al. 2013; Willick et al. 2013). During the 2012 London Paralympic Games, powerlifters had the second-highest injury incidence rate of all athletes, second to football 5-a-side. Willick et al. (2013) reported 44 injuries in 163

athletes over 2282 athlete-days, giving an injury incidence proportion of 27.0 and an injury incidence rate of 19.3 (95% CI; 14.0 – 25.8) injuries per 1000 athlete-days. This study did not comment on the details of the injuries, including acuity, age groups, sex, body location, or weight groups.

A small body of literature for injuries to able-bodied athletes exists (which also includes injuries related to the squat and deadlift) (Brown et al. 1983; Keogh et al. 2006; Lavallee & Balam 2010; Siewe et al. 2011). In able-bodied powerlifting, incidence rates are reported to be 4.4 injuries per 1,000 hours of training (Keogh et al. 2006) and 2.9 injuries per 1,000 participation hours (Brown & Kimball 1983). The shoulder is the most common location of injury in powerlifters (Keogh et al. 2006; Siewe et al. 2011), particularly in athletes over the age of 40 years (Siewe et al. 2011). During the bench press event, the most common source of pain was the wrist, followed by the arm/shoulder, chest, and head/cervical spine (Siewe et al. 2011). When examining bench press injuries in able-bodied athletes (not necessarily powerlifters), numerous injuries have been reported. These include pectoralis major ruptures (Garrigues et al. 2012; Provencher et al. 2010; Rijnberg et al. 1993), clavicular osteolysis (Lavallee & Balam 2010), triceps tendon ruptures (Lavallee & Balam 2010), and insertional tendinopathy of the pectoralis minor muscle (Bhatia et al. 2007), amongst others (Fritz 2004; Goeser et al. 1990; Heckmann et al. 2008; Jones 1987; Lavallee & Balam 2010; Weiss et al. 1989; Wolfe et al. 1992). For able-bodied powerlifters and body builders, pain reported during the bench press is frequently confined to the area above the abdomen (Siewe et al. 2014; Siewe et al. 2011).

The purpose of this study was to describe the incidence, types and risk factors for injury in powerlifters during the London 2012 Paralympic Games.

MATERIALS AND METHODS

This cohort study was completed as a sub-analysis of a comprehensive injury and illness surveillance study carried out at the London 2012 Paralympic Games. A more complete description of the methodology used for the comprehensive injury and illness surveillance study has been fully described elsewhere (Derman et al. 2013).

Procedures

The Paralympic Injury and Illness Surveillance System was approved by the International Paralympic Committee (IPC). Prior to initiation of the study, ethics board approval was obtained through the University of Brighton in the United Kingdom (FREGS/ES/12/11) and the University of Cape Town Health Sciences Research Ethics Committee in South Africa (HREC/REF 436/2012). Athlete consent to utilize their de-identified medical data for research purposes was obtained at the time of their registration for the Games. A comprehensive database of athlete demographic information was obtained from the IPC, containing the following information: age, sex, sport code, country code, and accreditation number.

Injury data were gathered via two sources. First, a database was populated from the electronic medical data capture system (EMDCS) (ATOS, France) utilized at all athlete medical stations operated by the London Organizing Committee for the Olympic and Paralympic Games (LOCOG). LOCOG medical staff entered all injury

encounters when an athlete presented to a medical station with a complaint consistent with the pre-determined definition of injury (see below). A second database was populated by medical staff providing care for their own teams utilizing a novel web-based injury and illness surveillance system (WEB-IISS) that was developed specifically for the purposes of this study and is described in greater detail elsewhere (Derman et al. 2013). Utilization of the WEB-IISS allowed for the gathering of more detailed clinical information regarding injury compared with the EMDCS alone. Following the Games, the various databases were cleaned and merged. Once this process was complete, all personally identifiable information was removed from the final database so that no athlete could be individually identified.

The injury incidence rate (IR) was defined as the number of injuries per 1000 athlete-competition days. Further detail regarding the calculation of athlete-days has been described (Derman et al. 2013). The injury incidence proportion (IP) was defined as the percentage of athletes reporting an injury, calculated as the number of injuries per 100 athletes (%).

Injury Definitions

For the purposes of the comprehensive study, our classification of injury, previously described by Derman et al. (2013), was ‘any newly acquired injury as well as exacerbations of preexisting injury that occurred during training and/or competition of the 14 day pre-competition and competition period of the London 2012 Paralympic Games.’ For the purposes of this powerlifting-specific injury analysis, we analyzed injuries reported only during the seven day competition period. An acute traumatic injury was considered ‘an injury that was caused by an acute precipitating traumatic

event.' An acute on chronic injury was considered 'an acute injury in an athlete with symptoms of a chronic injury in the same anatomical area.' Finally, a chronic (overuse) injury was considered 'an injury that developed over days, weeks or months and was not associated with any acute precipitating event.'

Statistical Analysis

We recorded both the total number of athletes with injuries and the total number of injuries. An athlete could report more than one injury over the 7-day powerlifting competition period of the Games. Injury incidence rate (IR) and incidence proportion (IP) (95% CI) were estimated. In addition, IR and IP by injury type (chronic vs acute) were estimated. The total sample was analyzed, as well as sub-group analyses by event discipline, impairment type, weight class, sex, and age. Between group differences by sex and age were examined based on incidence rate ratios (IRR; 95% CI). Chi square testing was performed to compare group proportions.

RESULTS

Overall injury incidence rate and incidence proportion

There were a total of 163 athletes who participated in seven days of powerlifting competition, accounting for 1141 athlete-competition days of exposure. The 163 powerlifters represented 56 countries and 39.9% of the powerlifters were female. A total of 38 injuries were sustained by 38 different athletes. Table 1 demonstrates the injury IRs, IPs, and IRRs for these athletes. The overall injury IR was 33.3 injuries/1000 athlete-days (95% CI; 24.0 – 42.6) and the overall IP was 23.3 injuries per 100 athletes (95% CI; 16.8 – 29.8).

Associations with injury (sex, age)

There were no significant differences between male and female powerlifters [IRR=1.14 (95% CI; 0.56-2.38)]. Compared with the oldest age group (ages 35-67) the highest IR was in the 26-34 year-old age group [IRR=1.55 (95% CI; 0.73-3.41)] followed by the youngest age group (ages 13-25) [IRR=1.31 (95% CI; 0.41-3.69)] but these differences were not statistically significant (Table 1).

Onset of injury (acute vs. chronic)

With regard to onset of injury, 60.5% of the reported injuries were chronic overuse injuries, 26.3% were acute-on-chronic, and only 13.2% were acute traumatic in nature (Table 1). When comparing the IR of the chronic overuse injuries combined with the acute on chronic injuries (28.9 per 1,000 athlete days) with the acute traumatic injuries that occurred in the absence of pre-existing pathology (4.4 per 1,000 athlete-days), all of the cumulative overuse injuries were significantly more common (IRR=6.6 CI 2.6-16.9).

Anatomical location of injuries

Table 2 provides data by anatomic locations of injuries. The shoulder/clavicle was the most commonly injured area (31.6% of all injuries), followed by elbow and chest (each 13.2% of all injuries), upper arm and foot and ankle (each 7.9% of all injuries), and cervical spine (5.3%). Of the injuries for which the body location was specified, 87.1% involved the upper body [IR=23.7 injuries/1000 athlete-days (95% CI 15.5 – 31.8)].

Injuries in different weight classes

Table 3 describes the number of injuries by sex and weight class. There was a statistically significant difference in injury incidence proportion among lighter athletes compared with heavier athletes ($\chi^2 = 6.0$, $p = 0.01$). For all athletes competing in the weight classes of 75 kg and under, the injury incidence proportion was 17.3%, compared with 34.6% for all athletes competing in the weight classes over 75kg.

DISCUSSION

The data presented in this study represent the first prospective epidemiological study describing injuries in the sport of powerlifting in elite para-athletes. The main findings of this study are 1) that the overall injury incidence rate in these athletes was 33.3 per 1000 athlete-competition days and the overall injury incidence proportion was 23.3 per 100 athletes, 2) there was no difference in IR between male and female athletes, 3) there was no difference in IR by age categories, 4) most injuries were chronic /overuse injuries, and 5) the most common anatomical area injured was the upper limb, in particular the shoulder/clavicle.

Available literature is scarce for powerlifting injuries in athletes with impairments. Athanasopoulos et al. (2009) showed that powerlifting injuries were among the most commonly seen injuries by physiotherapists at the 2004 Athens Paralympic Games, although no attempt was made to obtain exposure data. Willick et al. (2013) demonstrated an IR of 19.3 injuries/1000 athlete-days over the 14 days, including non-competition and competition period, of the London 2012 Paralympic Games from the same cohort, however this did not include any additional analyses of the powerlifting injuries. This lower overall IR, compared with our value of 33.3

injuries/1000 athlete competition-days, indicates that the competition period of the Games saw the majority of powerlifting injuries. In other words, because the exposure was halved (7 athlete-competition days, as opposed to 14 athlete days) and most of the injuries occurred during the competition period, our IR appears much higher. Powerlifting injuries have also been studied in the able-bodied population (Brown & Kimball 1983; Keogh et al. 2006; Lavallee & Balam 2010; Siewe et al. 2011).

Shoulder pain and elbow pain have been identified to be more common in master class athletes (veteran athletes over the age of 40 years old) in able-bodied powerlifting (Siewe et al. 2011). Given that performance declines in a linear fashion in able-bodied powerlifters after the age of 40 (Anton et al. 2004), one could suspect an increase in injuries in the older Paralympians. Our data did not support this trend, however. Possible explanations include differences in training techniques between older able-bodied and para-athletes, a potentially higher volume of daily use of a para-athlete's upper extremities leading to injury across the age-span, or an increased focus on only one event, as opposed to the three required of able-bodied powerlifters. As more injury data are collected, additional information regarding these subtle findings may be elucidated.

In this athlete population, the shoulder/clavicle was the most frequently injured anatomical region, which one would expect given the large amount of force centered on the shoulder girdle complex during the bench press (Siewe et al. 2011). Although able-bodied powerlifters also must squat and deadlift, the shoulder is still the most commonly injured area of the body (Keogh et al. 2006; Siewe et al. 2011). Additionally, pain complaints were predominantly confined to the area above the

waist, similar to able-bodied bench pressing (Siewe et al. 2014; Siewe et al. 2011). Of note, three foot and ankle injuries were seen in the Paralympic powerlifters, which may have occurred in the competition period however not during the competition itself; for example, in transit to and from competition or in the athlete village. Given the importance of the shoulder in activities in daily living for persons with impairment, particularly those who ambulate by wheelchair, further study is needed to help prevent these injuries. Powerlifting training program design, scapular stabilizer strengthening, and training schedule (such as training around activities of daily living) should all be examined as methods of decreasing these injuries.

Although the majority of injuries seen across all sports during the London 2012 Paralympic Games were acute in nature (Derman et al. 2013), the majority of the powerlifting injuries were chronic or acute on chronic. The repetitive nature of a single motion at high forces likely contributes to these injuries. The higher injury rate among athletes in the heaviest weight classes, who are lifting the greatest weights of all the powerlifters, supports the hypothesis that repetitive application of very high loads places the musculoskeletal system at risk of overload. It should be noted that able-bodied elite weightlifters tend to demonstrate more acute injuries than chronic (Calhoon et al. 1999; Keogh et al. 2006; Lavallee & Balam 2010), though this is not a direct comparison, as weightlifting is a different sport with a larger variety of lifting techniques with more ballistic patterns movements (e.g. clean and jerk) compared with the Paralympic bench press. Additionally, many Paralympic powerlifters rely on their upper extremities for daily mobility (ex: pushing a wheelchair and/or wheelchair transfers) in addition to sport-specific activities, which could potentially increase the likelihood for chronic overuse injuries.

This study has strengths and several limitations. The main strengths of this study include that this is the largest study to date evaluating a Paralympic athlete population, injuries were diagnosed by physicians, and there was a high response rate from participating countries (Willick et al. 2013). One primary limitation includes a possible measurement bias (underestimation of injury IR) given that data collection was dependent upon medical personnel entering in a daily report of injuries. The research team went to extensive efforts to maximize participation in the study on the part of LOCOG and team medical personnel in order to improve the quantity and quality of injury data, but could not ensure that 100% of all injuries were captured. Additionally, despite improvements in data collection methodology, the specific type of injuries were not recorded – for example, rotator cuff tendinopathy, acromioclavicular joint separation, deltoid muscle strain, or clavicular fracture – which would all be documented as a shoulder/clavicle injury in this study. The clinical documentation system that has been in place at the Games does not allow for more specific information regarding the nature of injuries, mechanisms of injuries and pre-disposing factors for injuries. We plan on better categorizing injury type and athlete classification for future studies. We chose to confine exposure to the competition period, as we felt this was the crucial period for injuries in this sport, but this may show relatively higher incidence rates when compared to a longer exposure period, such as including the pre-competition period. There were a relatively low number of injuries overall, thus continued surveillance over multiple games will help to improve accurate characterization these injuries. Also, it has proven challenging to analyze injuries by athlete classification or specific impairment type given that this type of data is not available via our current data collection tools. This information

would be useful when designing injury prevention strategies, as it is known that injury types are specific for the athlete's sport and impairment type. Future studies utilizing more comprehensive data collection methodologies may help to elaborate the specific etiology of these injuries, thus enabling prevention measures.

In conclusion, this cohort study demonstrated a significant burden of injury in powerlifters competing at the 2012 London Paralympic Games. Most injuries were chronic overuse injuries and the most commonly injured anatomical region was the shoulder/clavicle. Sex and age group were not associated with injury risk. Further research is needed to identify mechanisms of injury and to develop and evaluate strategies for injury prevention in future training plans and competitions.

PERSPECTIVES

Individuals with impairments are participating in recreational and competitive sports in increasing numbers and realizing many social and physical benefits. However, sports participation carries a risk of injury. Some of these injuries may have greater functional consequences for individuals with impairments compared with the functional impact of similar injuries on individuals without physical impairments. In order to protect the short and long term health of the athletes, the International Paralympic Committee conducted the first comprehensive, prospective study of injury and illness at the summer Paralympic Games in London, 2012. The data revealed a high rate of chronic upper limb overuse injuries among Paralympic powerlifters. Further work is needed to try and decrease these injuries, which if left untreated, could potentially have significant negative impacts on the individuals' ability to participate in future sports and daily activities.

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