

Injuries and illnesses in athletes with Spinal Cord Injury during the 2012 London Summer Paralympic Games

**A dissertation prepared by THOMAS FREDERIK SWART
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List of abbreviations

ANS (Autonomic nervous system)

CI (Confidence interval)

CP (Cerebral palsy)

IOC (International Olympic committee)

IP (Incidence proportion) % of athletes with injury or illness

IPC (International Paralympic committee)

IR (Incidence Rate) number of injuries or illnesses/1000 athlete days

LOCOG (London Organizing Committee of the Olympic and Paralympic Games)

LP (Limb deficiency)

SCI (Spinal Cord Injury)

VI (Visual impairment)

UTI (Urinary tract infections)

Abstract

Background:

The Summer Paralympics have grown from participation of a mere 16 athletes at the 1948 Stoke-Mandeville Games, to a large multi-code event of 4176 athletes competing in 20 different sporting codes at the 2012 London Summer Paralympic Games. Unlike able-bodied athletes, Paralympic athletes represent a heterogenous group of people with a varied degree of physical-, mental- and physiological impairment. Despite the growth in the Paralympic sport, limited research exists describing injury and illness in Paralympic athletes. For athletes with impairment to perform optimally and not to jeopardise their health, studies should identify and eventually address risk factors for both injury and illness.

Aim:

The main aim of this study was to determine the incidence and nature of illnesses and injuries in a cohort of athletes with spinal cord injury (SCI) during the 3-day pre-competition and 11-day competition period at the 2012 London Summer Paralympic Games. This knowledge could provide an initial framework for future research regarding injury- and illness prevention strategies in athletes with SCI.

Methods:

This study was a component of the large prospective cohort study which was conducted over the 14-day period of the London 2012 Summer Paralympic Games, coordinated by the Medical Committee of the International Paralympic Committee (IPC). The data were collected at the London 2012 Summer Paralympic Games during the 3-day pre-competition and 11-day competition periods.

Three data sources were used. Firstly, the IPC provided a comprehensive athlete database that contains accreditation number, country code, sports code (20 sports), gender and age. The second data source was the medical encounters of

staff that provided care to their own teams. At the London 2012 Summer Paralympic Games, a novel system (WEB-IIS) was used to collect data via desktop computer interface, tablet or smart phone. The third data source was from an electronic medical data capture system (EMDCS) (ATOS, France) where the medical staff of the Local Organizing Committee of the London Summer Paralympic Games (LOCOG) were requested to enter all medical encounters, at both the Paralympic Village polyclinic and at the sports venues wherever the athlete reported for care. A standardized form was used for this purpose. After comparing all the data, a total of 3009 athletes, of which 709 were athletes with SCI formed part of this study.

The Incidence Rate (IR) for illnesses and injuries in athletes with SCI was calculated as the number of illnesses and injuries per 1000 athlete days and was compared to a group of all other Paralympic athletes with injury and illness (who had other impairments).

Results:

There were significantly more upper limb injuries in athletes with SCI ($p=0.0001$), with an IR of 6.4 injuries / 1000 athlete days (95% CI 4.6 - 8.9). The IR for all the other athletes were 4.4 injuries / 1000 athlete days (95% CI 3.4 - 5.8). For lower limb injuries, the IR for athletes with SCI was significantly lower ($p=0.0001$) at 1.4 injuries / 1000 athlete days (95% CI 0.8 - 2.5) compared to an average IR of 4.2 injuries / 1000 athlete days (95% CI 3.3-5.4) for all other athletes participating at the 2012 London Paralympic Games.

Athletes with SCI had a significantly higher IR for illness than the group of all other athletes ($p=0.0004$). The IR for illness in athletes with SCI was 15.4 illnesses / 1000 athlete days (95% CI 11.8-20.1), whereas the average for all other athletes were 11.0 illnesses / 1000 athlete days (95% CI 8.7-14.1). The IR for skin- and genito-urinary illness were significantly greater in athletes with SCI ($p=0.0001$), with an IR of 3.9 illnesses / 1000 athlete days (95% CI 2.5-6.2) for skin illness and 2.3 /1000 athlete days (95% CI 1.8-4.6) for genito-urinary illness. The IR in skin illness for all other athletes were 1.8 illnesses / 1000 athlete days

(95% CI 1.1-2.7) and genito-urinary illness, were 0.5 illnesses / 1000 athlete days (95% CI 0.3-0.8).

Summary:

The results of this study present an insight into injuries and illnesses in athletes with SCI. Athletes with SCI injury have a greater incidence rate of upper limb injuries and a lower incidence of lower limb injuries, than other Paralympic athletes. Total-, skin- and genito-urinary illnesses were also significantly greater in athletes with SCI compared to other Paralympic athletes.

For clinicians caring for athletes with SCI, the results indicate that more attention should be given to the prevention of upper limb injuries and specifically skin- and genito-urinary illnesses.

Key words:

Spinal cord injured athletes, Summer Paralympic Games, illness, injury, genito-urinary illness

Chapter 1

1.1 Introduction and scope of the thesis

The benefit of sport for people with and without disability has been well established. During the mid 1940's Sir Ludwig Guttmann introduced sport as an essential part of the rehabilitation of the management of patients with spinal cord injuries ⁽¹⁾. He described the effects of sport on the rehabilitation of patients with paraplegia and tetraplegia. He stressed that sporting activities not only enabled patients to overcome boredom but also promoted the development of physical and cardio-respiratory endurance. Guttmann claimed that sport promoted self-discipline, a competitive spirit and comradeship. It was also invaluable in promoting health, physical strength, endurance, social integration and physiological well-being ^(1,2,3).

His efforts led directly to the establishment of the Stoke-Mandeville Games in 1948, where a mere 16 wheel-chair athletes competed ⁽¹⁾. This was a very modest beginning for what is now the Paralympics Games, in which 4,176 athletes from 164 delegations participated during the 2012 London Paralympics ⁽⁴⁾.

Competing in the Olympic Games or a major international championship event has become the goal for many athletes. It involves hours of dedication, training, personal sacrifice in preparation, not only for the athletes but also for coaches, family, friends and supporters. For the best personal result, an athlete should be in peak physical condition without injury or illness that might hamper his/her performance.

In the pursuit of free and fair competition the International Paralympic Committee states in the IPC Medical code (enforced since 01 January 2013) that all stakeholders should take measures to ensure that sport is practiced in a manner that protects the health of the athlete ⁽⁵⁾. This vision is also in line with the Olympic Charter which requires the International Olympic Committee (IOC) to encourage and support measures protecting the health of athletes ⁽⁶⁾.

Illness and injury surveillance form an integral part of the development of preventative programs ^(7,8,9). Studies using the unique and comprehensive illness and injury data collection at the 2012 London Paralympic Summer games have shown that the risk for injury and illness in Paralympic athletes are similar to those of other athletes participating in elite competitions ^(4,8). However, the profiles of illness and injuries in the Paralympic athletes were quite different from the able-bodied athletes. Indeed, upper limb injuries and non-respiratory illnesses were shown to be more prevalent in elite Paralympic athletes ^(4,7,8,9). In contrast, Derman et al (2016) has shown in recent studies at the 2014 Sochi Winter Paralympic Games that athletes had a higher incidence rate (IR) of injury ⁽¹⁰⁾ and illness ⁽¹¹⁾ than Olympic athletes participating at the Summer and Winter Olympics. The IR for injuries and illness in Paralympic athletes at the 2014 Sochi Paralympic Games was also higher than that observed at the 2012 London Summer Paralympic Games ^(10,11).

Besides unique sporting codes for Paralympic athletes, there is also a vast difference in physical, physiological and psychological attributes of Paralympic athletes compared to a more uniform population in able-bodied sport ⁽⁷⁾. Each group of Paralympic athletes present their own unique challenges. Athletes with spinal cord injury (SCI), for example, experience obvious physical restrictions due to the loss of movement ⁽⁷⁾. However, sensory- and autonomic deficits can often be more challenging to their health and well-being. Athletes with limb deficiency, also have some physical restrictions, but to a much lesser degree. Their sensory and autonomic function is generally intact and more comparable to that of able-bodied athletes. The Paralympic games is therefore a gathering of athletes with a variety of pre-existing medical conditions. For Paralympic athletes to ultimately benefit from epidemiological studies, specific sub-groups need to be evaluated to identify possible risk factors for injury and illness.

During the London 2012 Paralympic Summer Games, athletes with SCI participated in 16 of the 20 Paralympic sporting codes. To our knowledge no studies to date have comprehensively described injuries and illnesses in this

group of athletes with SCI with specific focus on age, gender, sports category, severity and type of illness and injury.

The main aim of this study was to determine the incidence and nature of the illnesses and injuries in the cohort of athletes with SCI during the 3-day pre-competition and 11-day competition period at the 2012 London Paralympics. This knowledge will hopefully provide an initial framework for future research and clinical practice regarding injury- and illness prevention strategies in athletes with SCI.

Chapter 2

Literature review: Injuries and illnesses in athletes with spinal cord injury

1. Introduction: Medical challenges of athletes with Spinal Cord Injury (SCI) at the Paralympic games

SCI is the result of damage to the spinal cord at any level. More than 80% of SCI are due to a traumatic incident. Trauma is most commonly due to motor vehicle accidents, violence (gun shots and stabbings) and sport related injuries. Other causes for SCI include tumours, infections and arterio-venous malformations.

The level at which the spinal cord is damaged determines functionality in terms of the effect on motor control / power, sensation and the autonomic nervous system. SCI causes either tetraplegia (quadriplegia) where the upper- and lower limbs and trunk are affected, or paraplegia where the upper limbs are spared with only the lower limbs and possibly the trunk affected. In addition, SCI can either be complete or incomplete. In incomplete injury, there is preservation of some sensory and/or motor function below the neurological level of injury that includes the lowest sacral segments S4-S5 and with complete injuries there is an absence of sensory and motor function below the neurological level of injury, including the lowest sacral segments (S4-S5).⁽¹²⁾

In addition to motor- and sensory deficit, SCI can also damage the autonomic nervous system (ANS). This can affect the cardiovascular and respiratory system, bladder and bowel function as well as thermoregulation. The degree of autonomic dysfunction is independent from the motor injury, sensory loss or complete vs incomplete lesions in SCI^(13,14).

Another way to classify SCI are the terms *high* or *low* level SCI. Researchers differ in their definition of high and low level SCI, but the most widely accepted is that an injury above T6 level be regarded as a high level SCI due to the effect on the autonomic nervous system (ANS). A high level SCI affecting the ANS results in a restricted potential for improvement in cardiac output and maximal oxygen uptake ^(7,13). This can have a negative effect on performance compared to other athletes.

Autonomic dysreflexia is a trait unique to athletes with a high level SCI (T6 or above). To elicit autonomic dysreflexia, athletes with a high SCI and autonomic dysfunction, should experience an acute painful stimulus below the level of the spinal lesion ⁽¹³⁾. This results in an uncontrolled sympathetic discharge and subsequent cardiovascular responses that not only can enhance physical performance, but also pose a serious risk to health. Paralympic athletes, who know that they might develop autonomic dysreflexia, sometimes voluntarily induce it before or during the event to enhance their performance ^(7,13). These voluntary techniques used include fracture of toes, sitting on the scrotum and blocking of a urinary catheter. This practice, referred to as boosting, improves middle-distance wheelchair racing performance by about 10% in elite athletes with tetraplegia. However, autonomic dysreflexia can become a medical emergency resulting in a serious cardiovascular event or stroke ^(7,13,14).

Compared to other athletes, athletes with SCI do not have the protection that pressure, temperature, and pain sensation provide due to an insensate skin below the level of spinal injury. Friction related to repetitive movements of sports, or humid environments (rowing, sailing, or wheelchair using activities), can result in pressure sores, particularly in tissue over bony prominences ⁽⁷⁾.

Thermoregulation is also negatively affected in athletes with SCI due to the loss of temperature sensation, reduced sweating capacity and vaso-motor control at the level below the spinal lesion. These athletes are therefore at greater risk for thermal injury (hyper- and hypothermia), especially in extreme environmental conditions ^(14,15).

Athletes with SCI's eligibility to participate in the Paralympic games is based on the athletes' impairment of muscle power. These athletes have the longest history of classification for participation in the Paralympic Games, dating back to the first Stokes-Mandeville Games in 1948. The initial classification was medically driven, but has evolved over the years to allow for fair competition amongst all participants. The International Paralympic Committee (IPC) Classification Code is the core document that harmonises policies and procedures and sets principles for classification that must be applied by all International Federations. Each Federation is responsible to set out its own classification system based on the IPC Classification Code ⁽⁵⁾. For athletes with SCI motor function, power forms the basis of classification. Although autonomic dysfunction has been recognised as possible factor in performance, it has not yet been added to any classification system ^(5,12).

During the 2012 London Paralympics SCI athletes competed in 16 of the 20 possible sporting codes. Classification systems to participate in the different sporting codes varies from simplistic to quite complex. The simplest is Powerlifting, which is open to all athletes with a physical disability and is classified by weight alone. In stark contrast to this, athletics (track and field) and swimming consist of multiple classifications in which athletes with similar abilities can compete against each other.

2. Epidemiology of injury in athletes with SCI

To date there are no specific epidemiological studies evaluating injuries in athletes with SCI. However, there are some studies describing injuries in the entire group of Paralympic athletes.

The largest study published on Paralympic athletes, by Willick et al (2013) on the 2012 London Paralympics ⁽⁴⁾, involved 3565 athletes from 160 countries, evaluated over a period of 14 days (3 pre-competition days and 11 competition days). Willick et al (2013), showed an IR of 12.7 injuries / 1000 athlete days where 51.5 % were acute injuries. Similar injury rates were found between male

and female para-athletes. Higher injury rates were found in older athletes and in certain sporting codes. Shoulder injuries were the most common injuries (17.7%) and combined upper limb injuries accounted for 41% of all injuries. The latter finding was the only major difference in comparing injuries in this group of athletes with similar epidemiological studies in able-bodied athletes. A reason postulated for this was that a significant proportion of athletes at the Paralympic games utilize wheelchairs.

Other studies on the summer Paralympic Games reported the overall percentage of injured athletes between 17-90% across all sports ^(4,7). In the Paralympic Winter Games (2002, 2006, 2010 and 2014) there has been a gradual increase in the incidence proportion (IP) of injuries in athletes, from 9.4 % in Salt Lake City (2002) to 24.5% in Sochi (2014) ⁽¹⁰⁾. The IR for injuries at the Sochi Games were 26.5 injuries / 1000 athlete days. IRs in different sporting codes also varied significantly. There was a significantly higher IR recorded in alpine skiing/snowboarding (IR of 41.1 injuries / 1000 athlete days) compared to cross-country skiing/biathlon, ice sledge hockey or wheelchair curling ⁽¹⁰⁾.

Gawroński et al (2013) studied the Polish Paralympic team at the 2008 Beijing and 2012 London Paralympics ⁽¹⁶⁾. The team consisted of similar number of athletes with 91 athletes in Beijing and 100 athletes in London. The IR for total injuries was found to be significantly greater in Beijing (IR of 29 injuries / 1000 athlete days) than in London (IR of 15 injuries / 1000 athlete days). The main finding of this study was that the more stringent medical care guidelines implemented by the team management before the London 2012 Paralympic Games, may have had a direct impact on the improved results achieved by the Polish athletes at the 2012 Games.

In wheelchair sports, athletes with SCI form between 50-65% of the participants ⁽¹⁷⁾. In a review on injuries in Paralympic athletes, Fagher and Lexell (2014) found that the different rate denominators and definitions of injury cause inconsistencies in the reported data, making any comparisons between studies difficult. However, it was shown that upper extremity injuries (especially shoulder injuries) were the most common injuries in wheelchair athletes. In the 25 journal

publications included in the review, only 3 studies included the age range of the athletes studied, presenting another limitation in the available research. Only one study showed a significantly higher proportion of injuries in athletes aged 21-30 years ⁽¹⁷⁾.

3. Epidemiology of illness in athletes with SCI

There are fewer studies on illness than injury in Paralympic athletes at international competitions ^(8,9), where research studies indicate that up to 50% of medical consultations in these settings are for illness ^(8,9,18).

The IPs for illness in able-bodied athletes have ranged between 6.7% - 75% of athletes studied at international competitions, but the lack of consensus in the reporting patterns of medical conditions have made comparisons difficult ^(8,9,18). Only a few studies exist where illness rates have been reported as a rate of illness per 1000 athlete days. In able bodied single code sports, the IR for illness has been reported as 7.7 in World Cup football, 10.9 in Confederations Cup football and 2.7 in Rugby Union ⁽⁸⁾.

Engbretsen et al ⁽¹⁸⁾ showed in their study of the Summer Olympic Games in London 2012 that the IP for illness was 7%, with substantial variability during training and in competition periods, between sporting codes as well as gender. Women experienced an 60 % greater incidence of illness than men. This finding has also been reported in other events including the 2009 World Athletic Championships, 2009 World Swimming Championships as well as the 2010 Vancouver Winter Olympics. It was however not the case in the 2011 World Athletics Championships and the US Open Tennis Tournament (1994-2009) ⁽¹⁸⁾, where there was no difference in the IP for illness between men and women.

Respiratory illness is the most common ailment from which athletes in elite sport suffer. ^(4,7,8,18,19). During the 2012 Summer Olympic Games it represented 41% of illnesses, followed by gastro intestinal tract illness (16%) and skin and subcutaneous tissue illness (11%) ⁽¹⁸⁾.

Schwellnus et al (2013) showed no difference in the IR for illness among all the athletes during the pre-competition and competition periods in the 2012 London Summer Paralympic Games. The overall IR for illness was 13.2 illnesses / 1000 athlete days. IP was the highest for respiratory illness (27.4%), skin was 18.3% and gastro-intestinal 14.5%. Interestingly, genito-urinary illness was 8.3%, which is much higher than that documented in studies for able bodied athletes. The IR of illness was significantly higher in athletics, but no difference was found between males and females and in different age groups ⁽⁹⁾.

Gawroński et al (2013) also reported in their study of Polish Paralympic athletes in the 2008 Beijing and 2012 London Paralympics, that respiratory illness was the most common condition from which athletes suffered (IR 15.2 and 18.1 respectively) ⁽¹⁵⁾. They also reported a high IR for illness of 49.2 illnesses / 1000 athlete days in Beijing and 31.3 illnesses / 1000 athlete days in London. At both events, athletes with SCI had the highest IR for illness. There were also differences in IR in the various sporting codes and type of disability, but this was not uniform between the 2008 and 2012 events.

Derman et al (2016) ⁽¹¹⁾ studied illnesses in athletes at the 2014 Sochi Winter Paralympic games. The IR for illnesses was 18.7 illnesses / 1000 athlete days. IR of the different sporting codes varied with wheelchair curling showing the highest IR of 20.0 illnesses / 1000 athlete days. Illnesses in the respiratory system (IR 5.6), eye and adnexa (IR 2.7) and digestive system (IR 2.4) were the most common. Older athletes (35–63 years) had a significantly higher IR of 22.6 illnesses / 1000 athlete days compared to an IR of 12.6 illnesses / 1000 athlete days in younger athletes (14–25 years) ($p=0.049$).

4. Conclusion

The International Paralympic Committee stated in the IPC Medical code (enforce since 01 January 2013) that all stakeholders should take measures to ensure that sport is practiced in a manner that protects the health of the athlete ⁽⁵⁾. The IPC has already acted by banning the use of “boosting” to protect athletes with a

high level SCI, from potential ill-health effects ^(5,7). This vision is in line with the Olympic Charter stating that one of the main roles of the International Olympic Committee (IOC) is to encourage and support measures protecting the health of athletes ⁽⁶⁾. For this to be implemented, proper illness- and injury surveillance should form an integral part of the development of preventative programs ^(4,7,8,9,18).

For both injury and illness research, there is a lack of consensus in definition of a reportable injury/illness, unconfirmed medical diagnoses, generally small sample sizes and a lack of exposure data. This severely limits the possibility of comparing different studies.

Studies using the unique and comprehensive illness and injury data collection at the 2012 London Paralympic Games, have shown that that the risk for injury and illness in Paralympics athletes are similar to those of other athletes participating in elite competitions ^(4,8,9). However, at the 2014 Sochi Winter Paralympic Games it was greater ^(10,11). The profiles of illness and injuries in the Paralympic athletes were different from the able-bodied athletes. Indeed, upper limb injuries and non-respiratory illnesses were shown to be more prevalent in elite Paralympic athletes ^(4,7,8).

Besides unique sporting codes for Paralympic athletes, there is also a vast difference in physical, physiological and psychological attributes of these athletes compared to a more uniform population in able-bodied sport. Not only do athletes with SCI have physical restrictions due to loss of movement, but also have sensory, thermoregulatory and autonomic deficits that challenge their health and well-being ^(7,13,14,15). This potentially changes their risk profile for both injuries and illness. For this group of athletes and indeed other Paralympic athletes to ultimately benefit from epidemiological studies, specific sub-groups need to be evaluated to identify possible specific risk factors for injury and illness.

To date athletes with SCI have not been studied as a group and compared to the other impairment classes participating at the Summer Paralympic Games. The present study aims to address this limitation in the existing literature.

Chapter 3

3.1 Aim of the study

The main aim of this study was to determine the incidence and nature of the injuries and illnesses in a cohort of athletes with spinal cord injury (SCI) during the 3 day pre-competition and 11-day competition period at the 2012 London Summer Paralympic Games. This knowledge will provide an initial framework for future research regarding injury- and illness prevention strategies in athletes with SCI.

For injuries, the aim was to determine the incidence rate (IR) of all injuries reported; investigate body areas mostly affected and evaluate independent co-factors', including gender, age and sport, effect on IR of injury. For illness, the aim was to determine the incidence rate (IR) of illness; investigate the systems most frequently affected; evaluate factors associated with IR (gender, age and sport) and identify possible risk-factors. In this study we are presenting the data comparing athletes with SCI with the Average of all the other athletes.

3.2 Method

3.2.1 Study design

This study was a sub-component of the large prospective cohort study conducted over the 14-day period of the London 2012 Summer Paralympic Games and coordinated through the Medical Committee of the IPC. The data were collected at the London 2012 Summer Paralympic Games during the 3-day pre-competition and 11-day competition periods. This study has received ethical approval from the Faculty of Health Science Ethics Committee (344/2015).

3.2.2 Database

Information was obtained using three data sources. Firstly, the IPC provided a comprehensive athlete database that contained accreditation number, country code, sports code (20 sports), gender and age.

The second data source was the medical encounter database derived from medical staff that provided care to their own teams. At the London 2012 Paralympic games, a novel system (WEB---IIS) was used to collect data via desktop computer interface, tablet or smart phone. This system was developed to provide easy access for users to capture data. Some features included; personalized login and password for designated team medical staff to ensure accurate reporting and security, automated email reminders if staff did not update the records for the day and administrator access to facilitate daily computation of data collected and analysis of team compliance. The procedure has been well described in other studies ^(4,8,9).

The third data source was from an electronic medical data capture system (EMDCS) (ATOS, France) where the medical staff of the Local Organizing Committee (LOCOG) of the London 2012 Summer Paralympic Games were requested to enter all medical encounters, at both the Paralympic Village polyclinic and at the sports venues wherever the athlete reported for care. A standardized form was used for this purpose.

3.2.3 Inclusion and exclusion criteria

All medical encounters whereby Paralympic athletes presented with any injuries or illnesses were included in the analysis. In this study, 'injury' was defined as any sport-related musculoskeletal or neurological complaint prompting an athlete to seek medical attention, regardless of whether or not the complaint resulted in lost time from training or competition. 'Acute traumatic injury' included any musculoskeletal or neurological complaint that started at a single, identifiable point in time (e.g. due to a collision, fall or acute tissue overload). 'Acute on chronic injury' included any musculoskeletal or neurological complaint that an athlete had prior to the Games, with subsequent exacerbation of the same

symptoms during the study period. 'Chronic (overuse) injury' included any injury that did not have an identifiable acute or traumatic onset and was due to repetitive overload of soft tissue or bone.

A medical illness was defined as 'any newly acquired illness as well as exacerbations of pre-existing illness that occurred during training or competition, and during or immediately before the London 2012 Summer Paralympic Games'.

Data was only collected for injury and illness and the data did not include any information about specific sensory and autonomic deficits in the athletes with SCI studied.

3.3.4 Incidence Rate of Illness and Injuries

The Incidence Rate (IR) for illnesses and injuries were calculated as the number of illnesses and injuries per 1000 athlete days.

3.2.6 Statistical Analysis

Data were analysed using SAS, Version 9.4. More than one injury or illness could be reported per athlete, and therefore Poisson regression was used to model the incidence of illness and injuries. Incidence rates (and 95% CIs) were reported for all illness and six systems of illness (respiratory, digestive, skin, neurological, genitourinary and all other systems). Impairment groups were included in the model as a covariate to obtain separate IRs for each group. There were few genitourinary system illnesses for the disability groups other than SCI, therefore all the other groups were combined for the analysis. For injuries, reporting the IR for a specific anatomical region (upper limb, lower limb) we considered an athlete without an injury in the specific region as a non-injury for the specific anatomical region (control). Other covariates included in the model were gender, age and an indicator variable for the two most common sport types (athletics, swimming). Gender and age (tertiles) were included in all models, i.e. models including the sport type were adjusted for age and gender.

3.2.7 Data collection

Four thousand one hundred and seventy six (4176) athletes from 164 countries participated in the London 2012 Summer Paralympic Games. Four countries elected not to participate in the data collection and 82 countries did not have their own medical staff to collect data on the WEB-IIS system. Thus, the medical staff of the LOCOG and medical personnel of other countries collected their data.

Athletes were grouped according to their impairment in the following groups; athletes with cerebral palsy (CP), athletes with a limb deficiency (LD), athletes with a spinal cord injury (SCI), athletes with visual impairment (VI) and all other disabilities. The category “All Other Disabilities” included smaller categories of athletes with impairments that could not be classified in one of these classifications (CP, SCI, LD or VI). These included athletes with polio, athletes with intellectual impairment, athletes classified as short of stature, athletes with impaired muscle power such as athletes with spina bifida or poliomyelitis, and others including such as impaired joint range of motion or ataxia due to brain injury or multiple sclerosis.

3.3 Results

3.3.1 Participants

Final information was obtained from a total of 3009 athletes (72% of the participating athletes). In this final study group, 709 athletes were grouped according to spinal-cord injury impairment, where one third of the athletes were female. An interesting observation was that largest group of athletes represented in the athletes with SCI (Table 1) was in the 35-67 age category (54 %) and the lowest in the 13-25 age group (11.6%). This is in contrast with the group of “other” impairment groups where 41.9% were in the younger age group and 23.2 % in the older age group.

Table 1: Age distribution of athletes at the 2012 London Summer Paralympic Games

Athletes	Age (yrs)		
	13-25	26-34	35-67
SCI	11.6 %	34.4 %	54.0 %
All other athletes	41.9 %	34.9 %	23.2 %

SCI: Athletes with Spinal cord injury

Data presented as % of total athletes

Athletes with SCI participated in 16 of the 20 sporting codes presented at the 2012 London Summer Paralympic Games (Table 2). The highest number of these athletes participated in athletics (24.3%) followed by swimming (11.4%).

Table 2: Sport participation of athletes with Spinal Cord Injury at the 2012 London Paralympic Games

Sport	Number of athletes (n)	Percentage of total athletes (%)
Archery	33	4.6
Athletics	173	24.3
Boccia	3	0.4
Cycling	46	6.5
Equestrian	20	2.8
Powerlifting	51	7.2
Rowing	15	2.1
Sailing	23	3.2
Shooting	18	2.5
Sitting Volleyball	8	1.1
Swimming	81	11.4
Table tennis	43	6.0
Wheelchair basketball	60	8.4
Wheelchair fencing	31	4.4
Wheelchair rugby	66	9.3
Wheelchair tennis	41	5.8

3.3.2 Injuries in athletes with spinal cord injury

There were no differences in the incidence rate (IR) for the total injuries sustained when comparing athletes with SCI to the Average IR (Figure 1) of the other disability groups in the London 2012 Summer Paralympic Games. The IR for injuries in SCI athletes was 12.5 injuries / 1000 athlete days (95% CI 9.7 - 16.2) and the Average IR for all other athletes was 12.9 injuries / 1000 athlete days (95% CI 10.5 - 15.8).

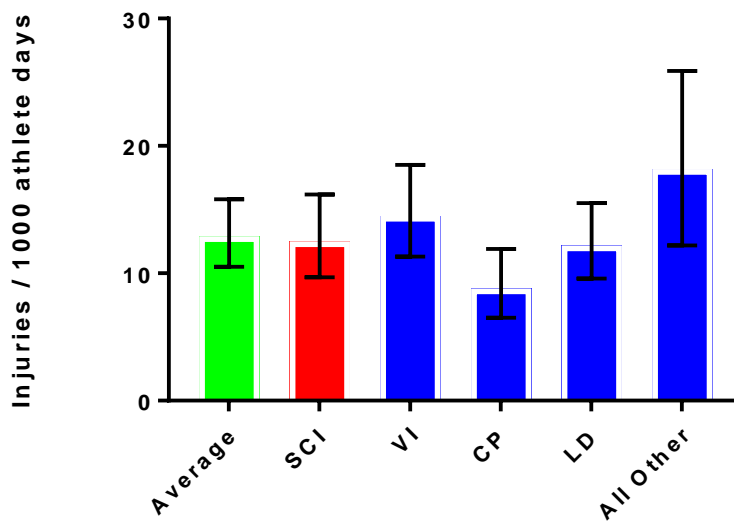


Figure 1: Incidence rate of injuries sustained at the 2012 London Summer Paralympic Games

Data shown as means with 95 % Confidence interval
Average, Average of all impairments excluding SCI; SCI, Spinal cord injury; VI, Visual impairment; CP, Cerebral Palsy; LD, Limb deficiency

However, a significant difference in IR for injuries was found in the upper and lower limbs. Athletes with SCI showed an IR of 6.4 injuries / 1000 athlete days (95% CI 4.6 - 8.9) and the Average of all other athletes was 4.4 injuries / 1000 athlete days (95% CI 3.4 - 5.8) for upper limb injuries ($p=0.007$) (Figure 2). Conversely, the IR for lower limb injuries in athletes with SCI was significantly lower at 1.4 injuries / 1000 athlete days (95% CI 0.8-2.5) than the IR in the Average of all other athletes of 4.2 injuries / 1000 athlete days (95% CI 3.3-5.4) ($p=0.0001$) (Figure 2).

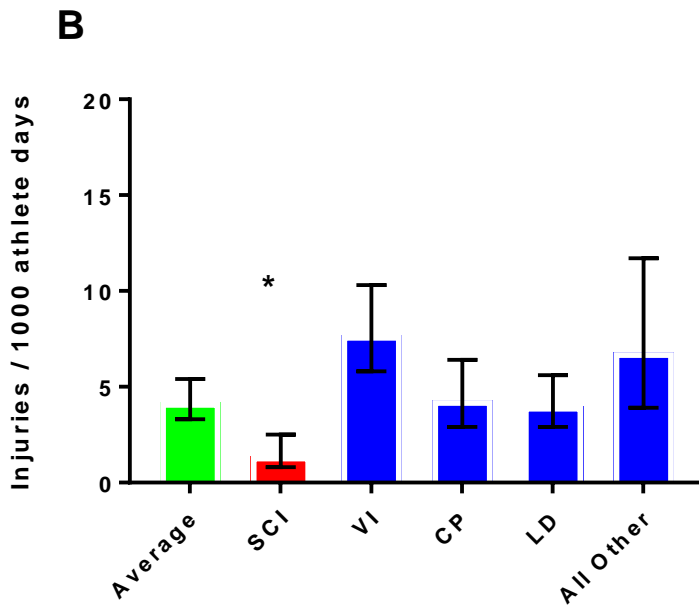
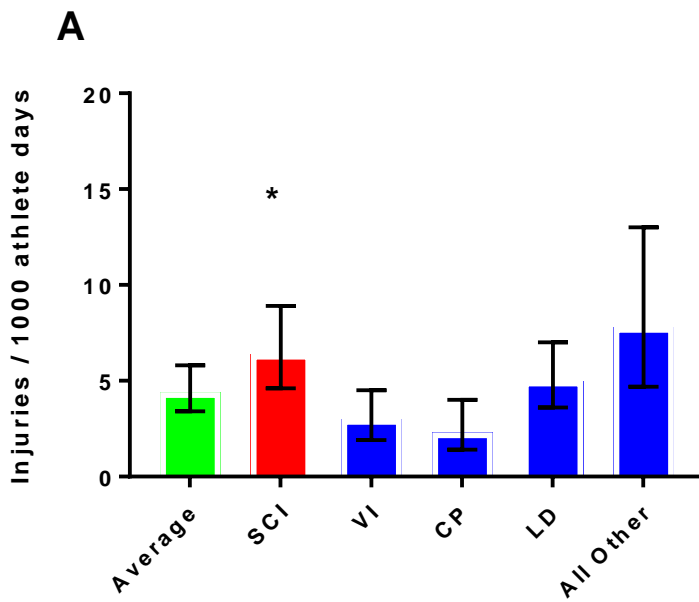


Figure 2: A) Incidence rate of upper limb injuries, B) Incidence rate of lower limb injuries in the 2012 London Summer Paralympic Games

Data shown as means with 95 % confidence interval

* Significant difference between the Average IR and the IR in athletes with SCI ($p=0.007$ for upper limb injuries and $p=0.0001$ for lower limb injuries)

Average, Average of all impairments excluding SCI; SCI, Spinal cord injury; VI, Visual impairment; CP, Cerebral Palsy; LD, Limb deficiency

The study population was divided into 3 age groups: 13-25 years, 26-34 years and 35-67 years. There was no statistical difference in the IR of all injuries between athletes with SCI and other athletes within each age group (Figure 3) and between gender (Figure 4). The IR for males was 12.8 injuries / 1000 athlete days (95% CI 9.8 - 16.7) for athletes with SCI and 13.2 injuries / 1000 athlete days (95% CI 10.7-16.4) for all the other male athletes. The IR for female athletes with SCI was 11.9 injuries / 1000 athlete days (95% CI 8.9 - 15.5) and that for all the other female athletes 12.3 injuries / 1000 athlete days (95% CI 9.6-15.6).

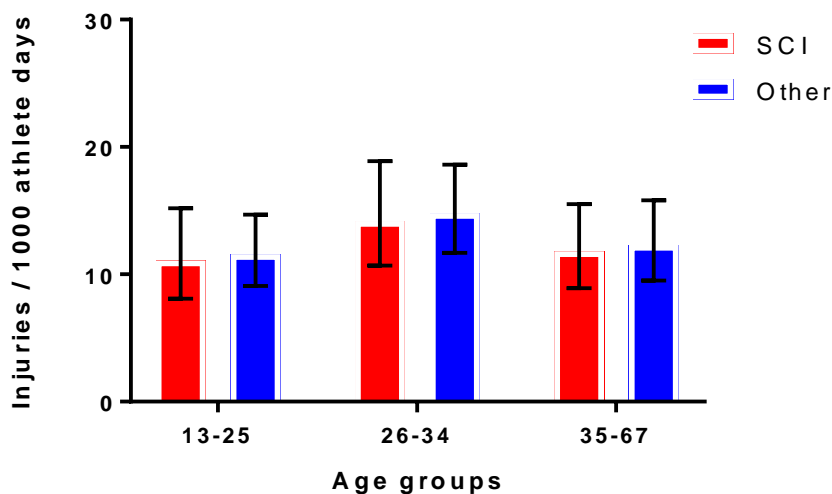


Figure 3: Incidence rate in age group categories for athletes with spinal cord injury and all the other athletes at the 2012 London Summer Paralympic Games

Data shown as means with 95 % Confidence interval
 SCI, Spinal cord injury; Other, All other impairment groups

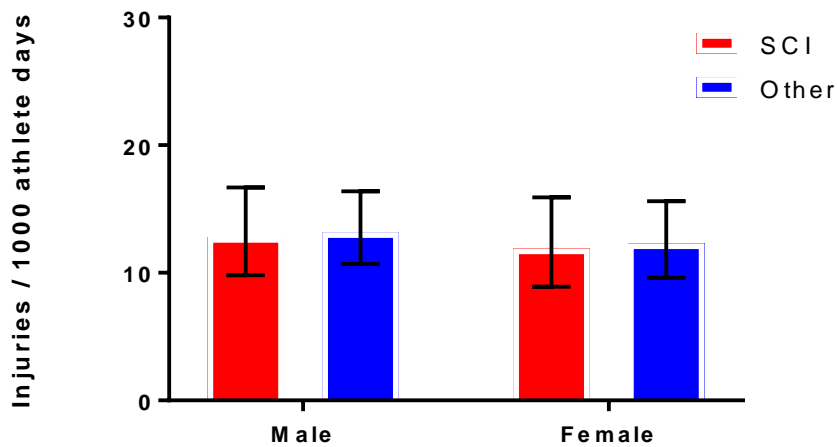


Figure 4: Incidence rate in male and female athletes at the 2012 London Summer Paralympic Games

Data shown as means with 95 % Confidence interval
 SCI, Spinal cord injury; Other, All other impairment groups

Athletics and swimming presented the only two sports with sufficient participants to make statistical comparison within the athletes with SCI (Figure 5). In both these sporting codes, there was no statistical difference in comparing the IR of injuries in athletes with SCI between swimmers and non-swimmers and between athletics and non-athletics participation.

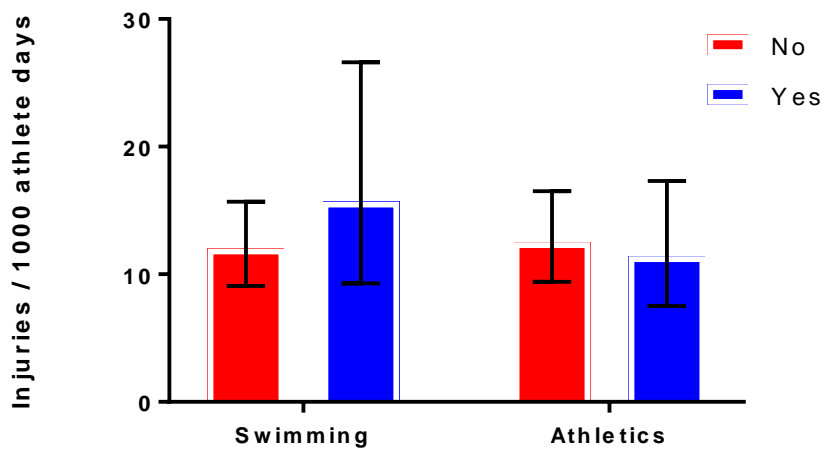


Figure 5: Incidence rate in athletes with SCI, participating or not participating in swimming and athletics, at the 2012 London Summer Paralympic Games

Data shown as means with 95 % Confidence interval
 Yes; participating
 No; not participating

3.3.3 Illnesses in athletes with spinal cord injury

We found a significantly greater IR for the total illnesses in athletes with SCI than the Average IR (Figure 6) of the other athletes in the 2012 London Summer Paralympic Games ($p=0.0004$). The IR for illnesses in athletes with SCI was 15.4 illnesses / 1000 athlete days (95% CI 11.8 - 20.1) compared to the Average IR of 11.0 illnesses / 1000 athlete days (95% CI 8.7 - 14.1) in the other disability groups.

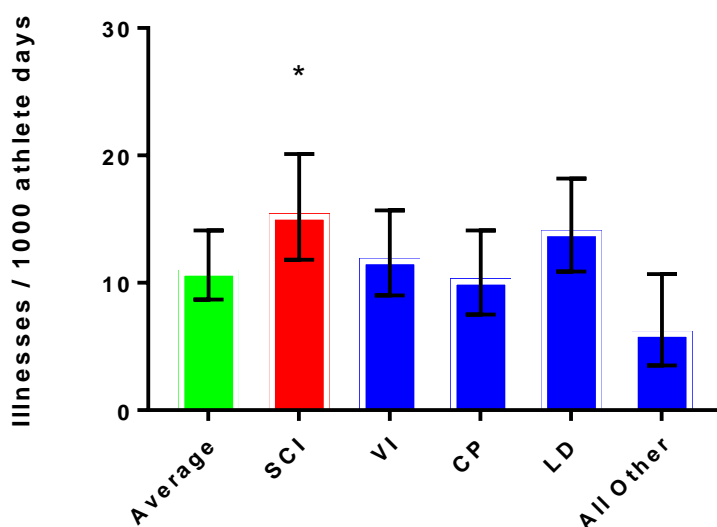


Figure 6: Incidence rate of illnesses suffered from at the 2012 London Summer Paralympic Games

Data shown as means with 95 % CI

*Significant difference between the Average IR and the IR in athletes with SCI ($p=0.0004$)

Average, Average of all impairments excluding SCI; SCI, Spinal cord injury; VI, Visual impairment; CP, Cerebral Palsy; LD, Limb deficiency

No significant difference was found in the IR of respiratory, digestive or neurological illnesses between athletes with SCI and the other impairment groups in the 2012 London Summer Paralympic Games (Figure 7). However, significant differences were found when comparing the IR for illnesses affecting the skin in athletes with SCI and the other impairment groups (Figure 7). The IR of skin conditions in SCI athletes was significantly greater with IR of 3.9 illnesses / 1000 athlete days (95% CI 2.5 - 6.2) compared to an Average IR of 1.8

illnesses / 1000 athlete days (95% CI 1.1 - 2.7) in the all the other athletes (p=0.0001).

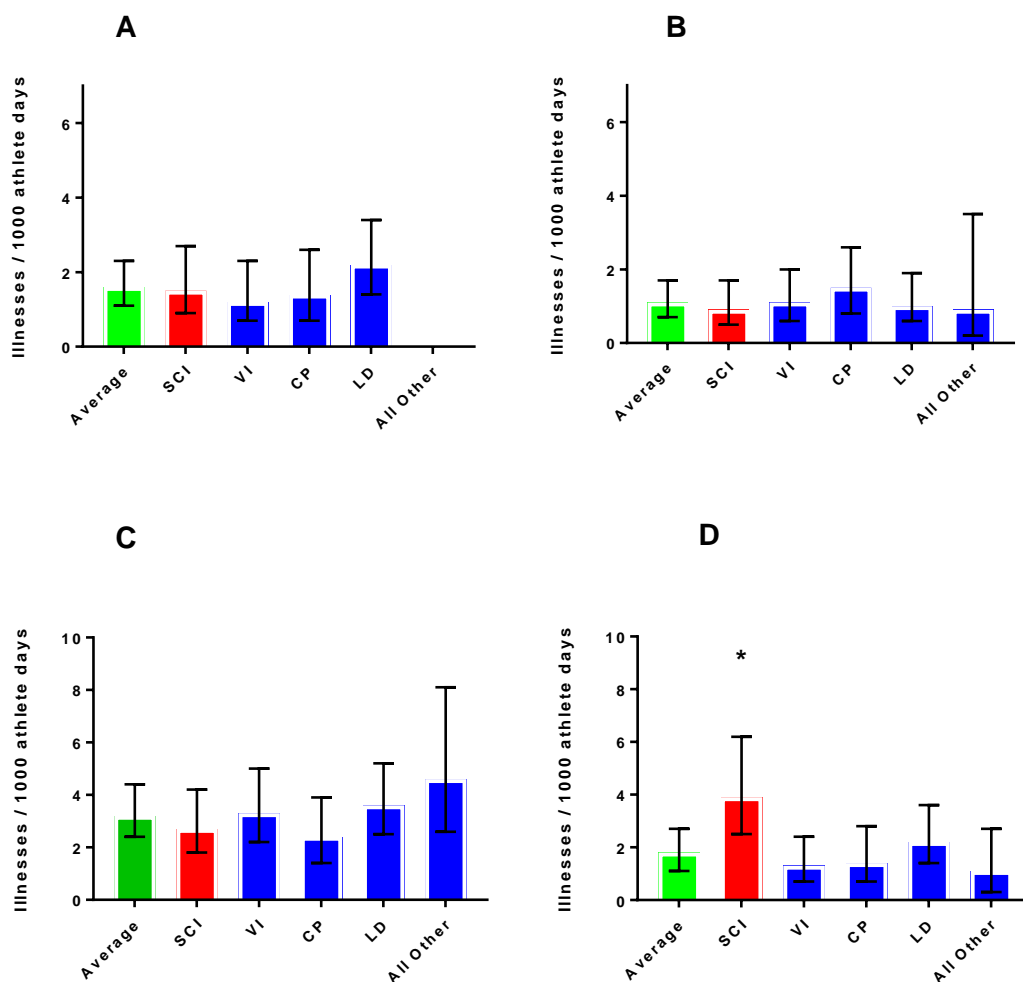


Figure 7: Incidence Rate of illness according to the system affected for the different impairment groups; A) Respiratory Illness; B) Digestive Illness; C) Neurological Illness; D) Skin & Subcutaneous Tissue Illness at the 2012 London Summer Paralympic Games

Data shown as means with 95 % Confidence interval

* Significant difference between the Average IR and the IR in athletes with SCI (p=0.0001)

Average, Average of all impairments excluding SCI; SCI, Spinal cord injury; VI, Visual impairment; CP, Cerebral Palsy; LD, Limb deficiency

Although the total number of genito-urinary illnesses were low in relation to other illnesses, there was a significant difference in the IR between athletes with SCI and the Average IR of all other athletes (p=0.0001, Figure 8). The IR for genito-urinary illness in athletes with SCI injured athletes was significantly greater at 2.3

illnesses / 1000 athlete days (95% CI 1.8 - 4.6) than the Average IR of 0.5 illnesses / 1000 athlete days (95% CI 0.3 - 0.8) for all the other athletes. More than two thirds of all genito-urinary illnesses occurred in athletes with SCI.

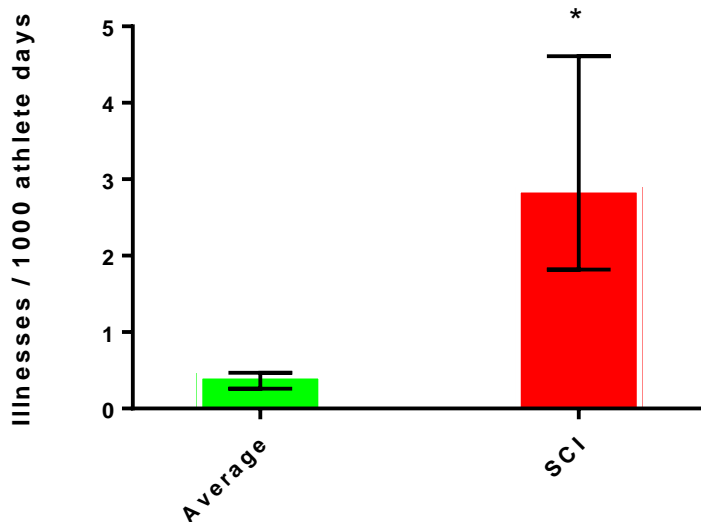


Figure 8: Incidence rate of genito-urinary illnesses suffered from at the 2012 London Summer Paralympic Games

Data shown as means with 95 % Confidence interval

* Significant difference between the Average IR and the IR in athletes with SCI (p=0.0001)

Average, Average of all impairments excluding SCI; SCI, Spinal cord injury

There were no significant differences in the incidence rate of total illnesses in athletes with SCI between the age groups and gender (Figure 9 & Figure 10). However, the IR of total illnesses for all Other female athletes was significantly greater than male athletes (p=0.01, Figure 10), where for females the IR was 12.7 illnesses / 1000 athlete days (95% CI 9.7 - 16.7) and for males the IR was 10.2 illnesses / 1000 athlete days (95% CI 7.9 - 13.1).

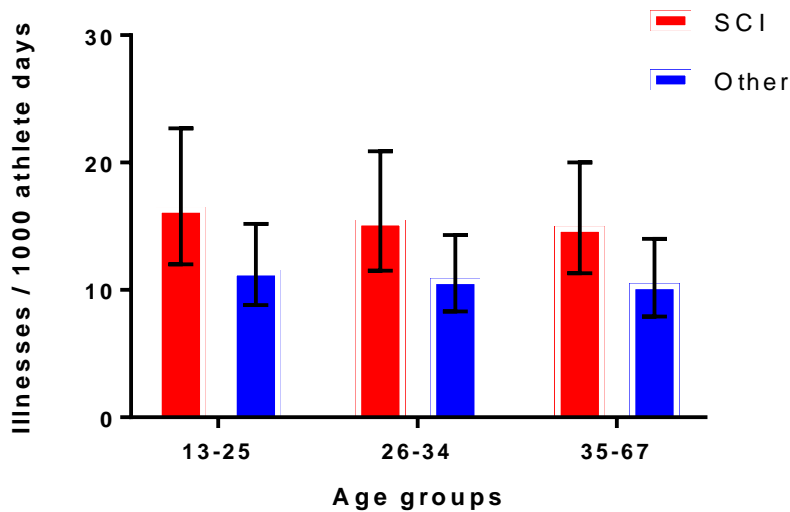


Figure 9: Incidence rate in age group categories for athletes with spinal cord injury and all the other athletes at the 2012 London Summer Paralympic Games

Data shown as means with 95 % Confidence interval
 SCI, Spinal cord injury; Other, All other impairment groups
 Age group in years

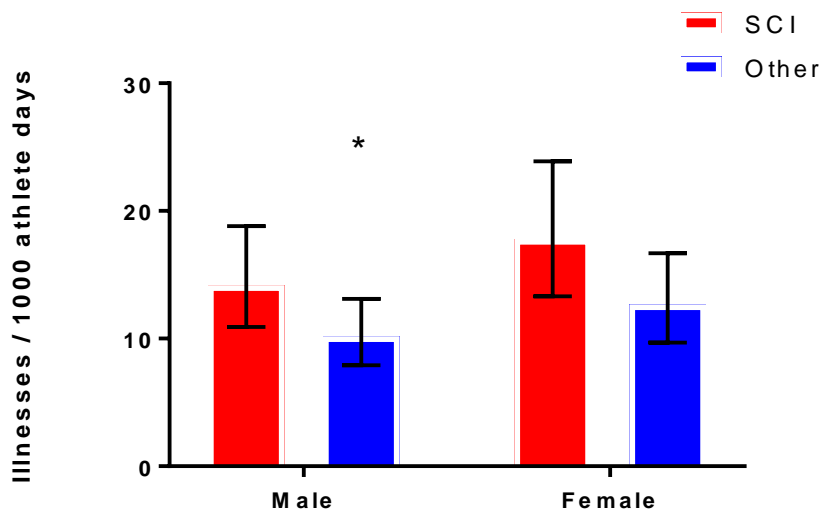


Figure 10: Incidence rate of illnesses in male and female athletes at the 2012 London Paralympic Games

Data shown as means with 95 % Confidence Interval
 * Significant difference between the IR for male and female athletes (p=0.01)
 SCI, Spinal cord injury; Other, All other impairment groups

Athletics and swimming presented the only two sports with enough participants to make comparison within the athletes with SCI (Figure 11). In both these sporting

codes, there was no statistical difference in the comparison of the IR of illnesses in athletes with SCI between swimmers and non-swimmers and between athletics and no athletics participation.

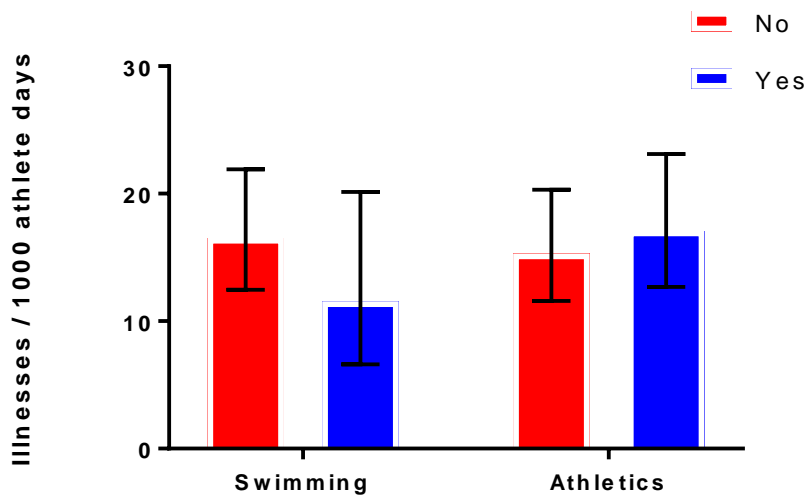


Figure 11: Incidence rate in athletes with SCI, participating or not participating in swimming and athletics, at the 2012 London Summer Paralympic Games

Data shown as means with 95 % Confidence interval

Yes; participating

No; not participating

3.4 Discussion:

As no data is available on the incidence of injuries and illnesses in athletes with SCI, the aim of this study was to determine the incidence and nature of injuries and illnesses in athletes with SCI at the 2012 London Summer Paralympic Games.

3.4.1 Injuries in athletes with spinal cord injury

Although we found no difference in the IR for total injuries between athletes with SCI and the average for all the other athletes, the IR for upper limb injuries in athletes with SCI was significantly greater than other athletes participating at the 2012 London Summer Paralympic Games. Athletes with SCI had an IR of 6.4 injuries / 1000 athlete days (95% CI 4.6 - 8.9) for upper limb injuries versus an average IR of 4.4 injuries / 1000 athlete days (95% CI 3.4 - 5.8) for all the other athletes (Figure 2).

The higher incidence of upper limb injuries in athletes with disability has also been seen in other studies ^(4,7,8). The largest single study published on Paralympic athletes was done by Willick et al (2013) on the 2012 London Paralympics ⁽⁴⁾. The study found shoulder injuries to be the most common injury (17.7%). In addition, combined, upper limb injuries accounted for 41% of all injuries incurred by the athletes. The predominance of upper limb injuries was also the only major difference in comparing injuries in Paralympic athletes with similar epidemiological studies in able-bodied athletes ⁽⁴⁾. A reason postulated for this was that a significant proportion of athletes at the Paralympic games utilize wheelchairs.

In a review on injuries in Paralympic athletes, Fagher and Lexell (2014) found that the different rate denominators and definitions of injury cause inconsistencies in the reported data, making any comparisons between studies difficult. However, it was also shown that upper limb injuries (especially shoulder injuries) were the most common injuries in wheelchair athletes ⁽¹⁷⁾.

This study is the first to show that athletes with SCI, as a sub-group of athletes participating at the 2012 London Summer Paralympic Games, sustained the more upper limb injuries compared to all the other athletes. The most probable explanation for this is the fact that SCI athletes are almost exclusively wheelchair users and all sporting activities involve mainly upper limb activity. As their upper limb use is an essential part, not only of daily living, but also of mobility and wheelchair use, upper limb injuries can have a serious impact on daily living and independence in athletes with SCI.

The second relevant finding was that for lower limb injuries, the IR for athletes with SCI was lower at 1.4 injuries / 1000 athlete days (95% CI 0.8 - 2.5) versus an average IR of 4.2 injuries /1000 athlete days (95% CI 3.3 - 5.4) for all the other athletes (Figure 2). The most probable reason for the lower incidence of lower limb injuries is that due the nature of their spinal cord injuries athletes with SCI do not have the use of their limbs for mobilization. In addition, their lower limbs are protected within the wheel chairs they are using to mobilize.

These findings are also consistent with that of Fagher and Lexell (2014) which showed that lower extremity injuries were more common in walking athletes, whereas upper extremity injuries were more prevalent in wheelchair athletes ⁽¹⁷⁾.

3.4.2 Illnesses in athletes with spinal cord injury

In this study, the third relevant finding was that athletes with SCI had a significantly greater IR for illnesses compared to the average IR for the other athletes participating at the 2012 London Summer Paralympic Games. The IR for illnesses in athletes with SCI was 15.4 illnesses / 1000 athlete days (95% CI 11.8 - 20.1) compared to an average of 11.0 illnesses / 1000 athlete days (95% CI 8.7 - 14.1) in all the other athletes (Figure 6). Impaired immune function in athletes with SCI may contribute to the higher IR rate reported in this study ⁽²⁰⁾. In this study athletes with SCI were also older than the other athletes competing at the 2012 London Summer Paralympic Games (Table 1). Increased age is another factor that may cause impaired immune function ⁽²¹⁾ and the higher IR for illness in athletes with SCI as found in our study.

Gawroński et al (2013), studied the Polish Paralympic team at the 2008 Beijing and 2012 London Summer Paralympic Games. They also observed a higher incidence of illnesses in athletes with SCI ⁽¹⁶⁾. In Beijing, the IR was 16.2 illnesses / 1000 athlete days (95% CI 5.1 - 13.8) and in London 11.9 illnesses / 1000 athlete days (95% CI 6.4 - 17.2). They showed a significantly lower IR in athletes with SCI in London, which was also 23 % lower than the IR of 15.4 in our study. The main finding of their study was that the more stringent medical care guidelines implemented by the team management before the London 2012 Paralympic Games, may have had a direct impact on the improved results achieved by the Polish athletes at the 2012 London Summer Paralympic Games ⁽¹⁵⁾.

The fourth relevant finding of our study was that illness of the skin and genito-urinary physiological systems were greater in athletes with SCI than all the other athletes at the 2012 London Summer Paralympic Games.

The IR of skin conditions in athletes with SCI was higher at 3.9 illnesses / 1000 athlete days (95% CI 2.5 - 6.2) compared to 1.8 illnesses / 1000 athlete days (95% CI 1.1 - 2.7) in all other athletes (Figure 7). Athletes with SCI are wheelchair users with impaired motor and sensory function. In addition, tetraplegics and some paraplegics does not have trunk control. They are often strapped in their wheelchairs for extended periods in competitive sports. The use of wheelchairs, friction related to repetitive sport and humid environments in combination with the sensory deficits in athletes with SCI, can all contribute to a higher incidence of skin related illnesses ⁽⁷⁾.

For genito-urinary illnesses the IR for athletes with SCI was 2.3 illnesses / 1000 athlete days (95% CI 1.8 - 4.6) compared to an Average IR of 0.5 (95% CI 0.3-0.8) for the other athletes (Figure 8). Genito-urinary illnesses in athletes with SCI accounted for two thirds of all genito-urinary at the 2012 London Summer Paralympic Games. The fact athletes with SCI have a neuropathic bladder and use either indwelling catheters or intermittent self-catheterization to drain urine most probably predispose them to a higher incidence of genito-urinary illness ⁽⁷⁾. Krassioukov et al ⁽²²⁾ reported that athletes who re-used catheters experienced

significantly more frequent urinary tract infections (UTI). Athletes from developing nations were significantly more likely to re-use catheters, and exhibited double the UTIs per year compared to athletes from developed nations ⁽²²⁾. Other factors that has also been shown to affect the incidence of UTI include hand hygiene, the frequency of catheterisation and adequate hydration ⁽²³⁾. In paralympic sport these risks can be present due to the nature of different competitions and venues.

We also found that female athletes had a higher IR of illness compared to males at the 2012 London Summer Paralympic Games. For females, the IR was 12.7 illnesses / 1000 athlete days (95% CI 9.7 - 16.7) and for males the IR was 10.2 illnesses / 1000 athlete days (95% CI 7.9 - 13.1) (fig 10). Similar results were also shown by Engebretsen et al (2013) of able-bodied athletes at the 2012 London Summer Olympic Games. They found females experienced 60 % greater incidence of illness than men. This finding has also been reported in other events including the 2009 World Athletics Championships, and the 2009 World Swimming Championships and the 2010 Vancouver Winter Olympics. However, at the 2011 World Athletics Championships and the US Open Tennis Tournament (1994-2009) there was no difference in the IR for illnesses between men and women ⁽¹⁸⁾. As there is no consistency in the studies, the higher prevalence of illness in female athletes at the 2012 London Summer Paralympic Games might be incidental and more studies need to be done to establish whether gender is an independent risk factor for illness in female para-athletes.

Chapter 4

4.1 Strength and Limitations

This is the first study to evaluate the incidence rate of injuries and illnesses in athletes with SCI at a major sporting event, presenting reliable information that can be used in future research.

Not all the athletes participating at the London 2012 Summer Paralympic Games were part of this study. Four countries opted not to provide any data. The data were also captured on three different systems. Incomplete capturing also reduced the number of athletes that were part of the final study.

Low numbers of athletes participating in specific sporting codes make sport specific findings more difficult. In this study, we only evaluated individual sporting codes in which more than 10% of SCI athletes participated.

4.2 Conclusion and Clinical Recommendations

Athletes with SCI constitute a unique group of athletes. Not only do they have physical restrictions due to loss of movement, but also have sensory and autonomic deficits that challenge their health and well-being ⁽⁷⁾. As a single group, they participated in the most sporting codes at the 2012 London Summer Paralympic Games (16 out of 20) and represented 21% of the total number of athletes participating at the London 2012 Summer Paralympic Games.

This study is the first to document injuries and illness at any international sporting event (single or multi-code) for athletes with SCI. It is therefore the first set of reliable data that can be used to reduce injury and illness in this group of athletes that are already at risk, not only due to their limited mobility, but also because of inherent sensory and autonomic deficits.

The IR of injuries in athletes with SCI is like that of other Paralympic athletes. However, their injuries are predominantly in the upper limb compared with other Paralympians. Teams should therefore take more preventative measures to

reduce the incidence of upper limb injuries. Optimising shoulder girdle muscle strength and function, the early identification and treatment of chronic injuries may all help to reduce injuries.

The higher IR for illnesses in athletes with SCI and specifically skin- and genitourinary illnesses, may also be reduced by implementing improved care measures. Athletes who needs intermittent catheterization should be supplied with sufficient catheters to avoid the re-using of catheters ^(22, 23). Teams should also ensure that adequate hygiene measures and hydration are available to athletes at all times ⁽²³⁾. Wheel chair cushioning and mechanics should also be optimised to reduce possible pressure points and skin friction ⁽⁷⁾. As athletes with SCI already have an impaired immune function ⁽²⁰⁾, care should be taken to improve immunity with inter alia optimal nutrition, rest and management of training loads.

In this study we only looked at the IR of illness and injury and the data did not include any specific sensory and autonomic deficits in the athletes with SCI studied. In this group is however an important factor to take into account ^(7,15) and should be investigated in future studies.

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