Sport, sex and age increase risk of illness at the Rio 2016 Summer Paralympic Games: a prospective cohort study of 51 198 athlete days

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ABSTRACT

Objective To describe the epidemiology of illness at the Rio 2016 Summer Paralympic Games.

Methods A total of 3657 athletes from 78 countries, representing 83.5% of all athletes at the Games, were monitored on the web-based injury and illness surveillance system (WEB-IISS) over 51 198 athlete days during the Rio 2016 Summer Paralympic Games. Illness data were obtained daily from teams with their own medical support through the WEB-IISS electronic data capturing systems.

Results The total number of illnesses was 511, with an illness incidence rate (IR) of 10.0 per 1000 athlete days (12.4%). The highest IRs were reported for wheelchair fencing (14.9), para swimming (12.6) and wheelchair basketball (12.5) ($p<0.05$). Female athletes and older athletes (35–75 years) were also at higher risk of illness (both $p<0.01$). Illnesses in the respiratory, skin and subcutaneous and digestive systems were the most common (IRs of 3.3, 1.8 and 1.3, respectively).

Conclusion (1) The rate of illness was lower than that reported for the London 2012 Summer Paralympic Games; (2) the sports with the highest risk were wheelchair fencing, para swimming and wheelchair basketball; (3) female and older athletes (35–75 years) were at increased risk of illness; and (4) the respiratory system, skin and subcutaneous system and digestive system were most affected by illness. These results allow for comparison at future Games.

INTRODUCTION

Although profiles of injuries in the Paralympic Games setting have been extensively studied, illness remains a relatively unstudied area. Comprehensive illness studies in the Paralympic athlete population have only been reported for the London 2012 Summer Paralympic Games and the Sochi 2014 Winter Paralympic Games.[1–3]

The existing literature indicates certain patterns of illness. Respiratory illnesses account for the most illnesses in this athlete population, with an incidence rate (IR) of 3.5 (95% CI 2.9 to 4.1) illnesses per 1000 athlete days at the London 2012 Summer Paralympic Games.[1 2] Furthermore, there is a higher prevalence of non-respiratory illnesses including skin, digestive and genitourinary illness in athletes with various impairments when compared with the able-bodied athlete population.[1] Indeed, prior data reveal that some illnesses are impairment or sport specific. Urinary tract infections are seen with higher prevalence in athletes with spinal cord injuries (29.9% of all illnesses at London were in athletes with spinal cord injury) and impairment categories that require the use of a wheelchair or limb prostheses for locomotion.[2 4] Furthermore, illnesses of the eye and adnexa were more prevalent in the Winter Paralympics (IR of 2.7 (95% CI 1.7 to 4.4)) and were reported with higher frequency in the indoor curling events.[3]

We aimed to establish further baseline data for the incidence of illness in a Summer Paralympic Games setting. We describe the profile of illnesses in a cohort of 3657 athletes whose attending physicians used the web-based injury and illness surveillance system (WEB-IISS) at the Rio 2016 Summer Paralympic Games. This initiative forms part of a larger prospective cohort study of Paralympic athletes at the various Games settings from the London Games onwards.

METHODS

Setting

This study was conducted by members of the International Paralympic Committee (IPC) Medical Committee as part of an ongoing prospective study examining injury and illness epidemiology in both the Summer and Winter Paralympic Games settings, and was conducted during the 3-day precompetition period and 11-day competition period of the Rio 2016 Summer Paralympic Games.

Participants

Informed consent was obtained for the use of deidentified data from all athletes during registration for the Games.

The present study used the WEB-IISS, which was successfully implemented at the London 2012 Summer Paralympic Games and Sochi 2014 Winter Paralympic Games. The system was designed for teams with their own medical support at the Games. A more detailed description of the WEB-IISS can be found in the previous literature.[1]

The organising committee medical facilities were used predominantly by countries who did not have their own medical support. However, given that the WEB-IISS was not used by the Rio local organising committee, we were unable to obtain reliable data regarding illnesses in this athlete group. Therefore, data regarding illness collected at the Rio organising

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committee polyclinic and other medical facilities have not been included in this study.

Engagement in the study by participating team physicians was promoted by providing introductory information about the study via email to all National Paralympic Committees (NPCs) chefs de mission (n=160), and further communication was sent to all attending chief medical officers and team physicians of the teams competing at the Games (n=81). Detailed information about the study was provided to the team physicians of all delegations at the medical briefing held during the precompetition period of the Games and through individualised training sessions at the polyclinic facility. Compliance from participating team medical staff was incentivised by the provision of a tablet computer (Samsung, Seoul, Korea) for data entry, to each participating country that had more than five athletes competing at the Games. The remainder of the countries with accompanying medical staff reported their data within the Paralympic Village, via laptop computers and wireless internet connection, through the same portal used on the tablets.

Data collection

Deidentified athlete information (age, sex and sport) was obtained from an IPC database of competitors. Information regarding the illness to be captured was gathered from the team physicians and included the presenting symptom(s) or sign(s), duration of symptoms (days), the specific final clinical diagnosis (a comprehensive list of common diagnoses was provided for each body system), the anticipated number of days lost from training or competition, the suspected aetiology of the illness (a comprehensive list of common causes was provided) and the impairment type and class of the athlete. All data were linked for statistical analyses and subsequently delinked to provide a deidentified database.

Definition of illness

The general definition for reporting an illness was described as 'any athlete requiring medical attention for an illness regardless of the consequences with regard to absences from training or competition'. A medical illness was specifically defined as 'any newly acquired illness as well as exacerbations of pre-existing illness that occurred during training and/or competition during the pre-competition or competition periods of the Rio 2016 Summer Paralympic Games'.[1]

Calculation of athlete days

Team size was captured per day by each team's physician at the same time as registration of any illnesses. However, an analysis of these data showed very little variation from each country's team size as published in the IPC master list of athletes attending the Games. These data were used as denominator data for the calculation of IR per 1000 athlete days. Accurate denominator data are essential to correct reporting and analysis of the epidemiology of illnesses in this setting, with multiple teams with constantly changing team sizes.

Calculation of the illness IR and illness proportion

The illness IR was calculated as illnesses per 1000 athlete days. The number of athlete days was reported separately by sport, age group and sex. The IR per 1000 athlete days was reported for all illnesses as well as illnesses in different sports and physiological systems. The proportion of athletes with an illness refers to the percentage of athletes reporting an illness and was calculated as follows: number of athletes with an illness/the total number of athletes competing in the relevant subgroup multiplied by 100.

Statistical analysis of the data

Data were in the form of counts (ie, the number of illnesses each athlete reported). Results for impairment data were reported via total number of illnesses (%) only since the impairment data of all the athletes participating at the Games were not available. Some athletes participated in more than one sport and/or more than one event; the primary sport of the athlete was used in the analysis. Some athletes incurred multiple illnesses during the 14 days; each of these were reported as distinct illness encounters. Standard descriptive statistical analyses were reported, including number of athletes participating in the various sports (combining track cycling and road cycling due to small numbers of participating athletes) by age (12–25 years, 26–34 years and 35–75 years) and sex (male or female), number of reported illnesses, number and proportion of athletes with an illness. Generalised linear Poisson regression modelling (SAS V.9.4) was used to model the number of reported illnesses overall, as well as the number of illnesses for physiological systems affected by an illness and were corrected for overdispersion and including the independent variables of interest. Results were reported as illness IRs per 1000 athlete days (including 95% CIs). Results for overall illness IRs were reported by sex, age group, type of sport and physiological system affected by illness. For the comparison between the London and Rio illness IRs, the correlation for athletes competing in both games could not be built into the model since we did not have the information linking the athletes. The significance of predictors in the model were tested using [[[NO ENTITY]]]^2 tests (type III analysis), paired comparisons between categories of predictors were tested using z-tests and all significance testing were done on a 5% level.

RESULTS

Participants

This study details the illnesses reported by the team physicians of countries who had their own medical support. Of these countries, 78 countries chose to participate in the study, and three chose not to participate. During the total Games period, 3657 athletes were monitored for a period of 51 198 athlete days. This athlete sample represented 48.8% of all countries participating at the Games (160 countries) yet represented 83.5% of the total number of all athletes at the Games (4378 athletes). A description of the number of athletes per sport, sex of the athletes and age group of the athletes is presented in table 1.

Incidence of illness by sport

The total number of illnesses as well as illnesses reported in 22 sports are presented in table 2. In total, there were 511 illnesses recorded in 454 athletes, representing 12.4% of all athletes on the WEB-IISS, with an IR of 10.0 illnesses per 1000 athlete days (95% CI 9.2 to 10.9). Wheelchair fencing (IR of 14.9 (95% CI 9.0 to 24.7), $p<0.05$), para swimming (IR of 12.6 (95% CI 10.2 to 15.6), $p<0.01$) and wheelchair basketball (IR of 12.5 (95% CI 9.2 to 17.1), $p<0.05$) had significantly higher rates of illness compared with all other sports. Although athletes competing in canoe and wheelchair rugby were noted to have a high IR, this did not reach significance, likely due to the lower number of athletes and thus low power. The sports with the lowest illness rates were football 7-a-side (IR of 3.2 (95% CI 1.3 to 7.7)) and judo (IR of 3.7 (95% CI 1.7 to 8.3)).

Table 1 Number of athletes participating in each sport at the Rio 2016 Summer Paralympic Games

Sport	All athletes	Females	Males	Age 12–25 years	Age 26–34 years	Age 35–75 years
All	3657	1389	2268	996	1320	1341
Archery	113	48	65	10	25	78
Boccia	99	30	69	23	34	42
Canoe	52	26	26	12	17	23
Cycling (track and road)	204	66	138	25	55	124
Equestrian	71	55	16	11	22	38
Football 5-a-side	70	0	70	23	36	11
Football 7-a-side	112	0	112	52	51	9
Goalball	102	54	48	34	46	22
Judo	115	41	74	26	60	29
Para athletics	894	354	540	294	354	246
Para powerlifting	141	62	79	13	50	78
Para swimming	492	217	275	287	141	64
Rowing	88	44	44	13	28	47
Sailing	76	15	61	3	16	57
Shooting para sport	130	43	87	8	19	103
Sitting volleyball	127	70	57	22	46	59
Table tennis	223	78	145	43	68	112
Triathlon	58	29	29	10	20	28
Wheelchair basketball	228	96	132	49	107	72
Wheelchair fencing	72	30	42	12	34	26
Wheelchair rugby	96	2	94	8	52	36
Wheelchair tennis	94	29	65	18	39	37

Incidence of illness by sex and age group

Table 3 shows the incidence of illness by sex (female and male) and age group (12–25 years; 26–34 years and 35–75 years). There was a significantly higher IR in female athletes (IR of 11.1 (95% CI 9.7 to 12.7)) compared with male athletes (IR of 9.3 (95% CI 8.3 to 10.4), p<0.05). Athletes in the age group of 35–75 years had a significantly higher rate of illness (IR of 11.8 (95% CI 10.3 to 13.4)) compared with the age groups of 12–25 and 26–34 years (p<0.01).

Incidence of illness in the precompetition (3 days) and competition period (11 days)

There were 105 illnesses recorded in 100 athletes in the pre-competition period (IR of 9.6 (95% CI 7.9 to 11.6)), and 406 illnesses recorded in 369 athletes during the competition period (IR of 10.1 (95% CI 9.2 to 11.1)) of the Rio 2016 Summer Paralympic Games (table 4). There was no significant difference of incidence of illness between these two periods.

Incidence of illness by onset

Table 5 depicts the incidence of illness by onset of illness, namely new or recurrent illness. There was a significantly higher IR recorded for new illnesses, with an IR of 8.7 (95% CI 7.9 to 9.6), while recurrent illnesses had an IR of 1.3 (95% CI 1.0 to 1.6, p<0.001).

Incidence of illness by primary physiological system

The primary physiological systems affected by illness are presented in table 6. The respiratory system had the highest IR (3.3 (95% CI 2.8 to 3.8)), followed by skin and subcutaneous tissue (IR of 1.8 (95% CI 1.4 to 2.2)) and the digestive system (IR of 1.3 (95% CI 1.0 to 1.6)).

Illness by impairment type

A description of the impairment types of the athletes who had illnesses are included in table 7. The impairment types with the highest proportion of reported illnesses were spinal cord injury (162 illnesses in 140 athletes, 30.8% of all ill athletes), limb deficiency (118 illnesses in 110 athletes, 24.2% of all ill athletes) and central neurologic injury (79 illnesses in 67 athletes, 14.8% of all ill athletes).

Time lost as a result of illness

Of the illnesses reported at the Games (511 illnesses), 427 illnesses (83.6%) did not result in the athlete requiring time away from competition or training. There were 84 illnesses (16.4%) that required the athlete to be absent from training or competition for an estimated period of 1 day or more. Of these, more than half (46 illnesses, 9% of total) required two or more days' exclusion from training or competition. The IR for days lost was 3.9 (95% CI 3.4 to 4.5), with almost 4 days lost per 1000 athlete days. Athletes in the age group of 35–75 years (IR of 5.5) had a significantly higher rate of time loss due to illness, compared with both the age groups of 12–25 years and 26–34 years (IR of 2.9 and 3.1 respectively, p<0.0007).

DISCUSSION

The aim of this study was to document the incidence of illness at the Rio 2016 Summer Paralympic Games in 22 sports. This study represents the largest significant contribution to the literature with regard to profiles of illness in a cohort of athletes with impairment in a Summer Paralympic Games setting.[1 2 4]

Lower overall incidence of reported illnesses at the Rio Games compared with the London Games

The first important finding of this study was that despite fears over the health of athletes prior to the Rio 2016 Summer Paralympic Games,[5 6] the overall IR of illness recorded at these Games (IR of 10.0 (95% CI 9.2 to 10.9)) was lower than that reported for the London 2012 Summer Paralympic Games (13.2 (95% CI 12.2 to 14.2), p<0.05). Similarly, the proportion of athletes with an illness was 12.4% at the Rio Games, which was lower than that reported for the London Games (14.2%). The reasons for this finding are not directly apparent but may reflect higher levels of awareness of the team physicians with regard to the patterns of illness in the teams they are managing, following their involvement in the London and Sochi Games studies. This may also represent a situation where illnesses may have been reported to the doctor in time to prevent time loss for the athlete involved and may also have prevented the spreading of contagious (respiratory) illnesses through the rest of the team, possibly reducing even more time loss for other athletes. However, this finding may reflect that illnesses at the London Games were recorded using both the WEB-IISS system and data from the ATOS system used by local medical services, whereas at the Rio Games, only WEB-IISS data were used, possibly resulting in a lower illness IR at these Games.[7] The lack of Rio polyclinic data constitutes a limitation of the current study.

It is of interest that in the lead up to the Rio Games, health concerns over the Zika virus, other mosquito-borne infections and water sanitation issues led the public and health professionals to believe that these Games could have a higher rate

Table 2 Incidence of illness by sport for athletes competing at the Rio 2016 Summer Paralympic Games, in descending order of illness incidence rate

Sport	Total number of illnesses (percentage of total number of illnesses)	Number of athletes with an illness	Total number of athletes competing	Total number of athlete days	Proportion of athletes with an illness (%)	Illness incidence rate: number of illnesses/1000 athlete days (95% CI)
All	511 (100)	454	3657	51 198	12.4	10.0 (9.2 to 10.9)
Wheelchair fencing	15 (2.9)	11	72	1008	15.3	14.9 (9.0 to 24.7)*
Canoe	10 (1.9)	9	52	728	17.3	13.7 (7.4 to 25.5)
Wheelchair rugby	18 (3.5)	15	96	1344	15.6	13.4 (8.4 to 21.3)
Para swimming	87 (17.0)	76	492	6888	15.4	12.6 (10.2 to 15.6)*
Wheelchair basketball	40 (7.8)	33	228	3192	14.5	12.5 (9.2 to 17.1)*
Boccia	17 (3.3)	16	99	1386	16.2	12.3 (7.6 to 19.7)
Shooting para sport	22 (4.3)	22	130	1820	16.9	12.1 (8.0 to 18.4)
Sailing	12 (2.3)	10	76	1064	13.2	11.3 (6.4 to 19.9)
Cycling (track and road)	30 (5.9)	27	204	2856	13.2	10.5 (7.3 to 15.0)
Para athletics	129 (25.5)	115	894	12 516	12.9	10.3 (8.7 to 12.3)
Rowing	12 (2.3)	12	88	1232	13.6	9.7 (5.5 to 17.2)
Table tennis	29 (5.7)	27	223	3122	12.1	9.3 (6.5 to 13.4)
Equestrian	9 (1.8)	8	71	994	11.3	9.1 (4.7 to 17.4)
Archery	14 (2.7)	12	113	1582	10.6	8.9 (5.2 to 14.9)
Para powerlifting	16 (3.1)	14	141	1974	9.9	8.1 (5.0 to 13.2)
Sitting volleyball	14 (2.7)	13	127	1778	10.2	7.9 (4.7 to 13.3)
Wheelchair tennis	10 (1.9)	7	94	1316	7.4	7.6 (4.1 to 14.1)
Goalball	8 (1.6)	8	102	1428	7.8	5.6 (2.8 to 11.2)
Triathlon	4 (0.8)	4	58	812	6.9	4.9 (1.8 to 13.1)
Football 5-a-side	4 (0.8)	4	70	980	5.7	4.1 (1.5 to 10.9)
Judo	6 (1.2)	6	115	1610	5.2	3.7 (1.7 to 8.3)
Football 7-a-side	5 (1.0)	5	112	1568	4.5	3.2 (1.3 to 7.7)

*Significantly higher than all other sports (p<0.01).

of illness and perhaps this led to increased vigilance regarding illness prevention strategies.[5 6] However, the realisation of these health concerns were not reflected in the current data.

Univariate analysis of risk factors associated with incidence of illness

The second important finding was that there were certain non-independent risk factors for illness associated with participation at the Games in certain groups of athletes. The sports of wheelchair fencing (IR of 14.9 (95% CI 9.0 to 24.7)), para swimming (IR of 12.6 (95% CI 10.2 to 15.6)) and wheelchair basketball (IR of 12.5 (95% CI 9.2 to 17.1)) had a significantly higher incidence of illness, compared with all other sports. This finding is in accordance with previous research conducted in para swimming,[8] but not with the findings of the London Games, where the sports of equestrian, para powerlifting and para athletics were found to have the highest incidence of illness.[4] It is of interest that both the London and Rio Games reported the lowest rate of illness in football 7-a-side,[1 4] suggesting that the sport, or specific characteristics of athletes who compete in the sport, results in less athletes falling ill compared with other sports at the Games. In addition to the higher risk for illness in certain sports, a significantly higher overall illness rate was reported for female athletes (IR of 11.1 (95% CI 9.7 to 12.7), $p<0.05$) compared with male athletes (IR of 9.3 (95% CI 8.3 to 10.4)) and for athletes in the 35–75 years age group (IR of 11.8 (95% CI 10.3 to 13.4), $p<0.01$) compared with athletes in the 12–25 years age group (IR of 8.8 (95% CI 7.4 to 10.5)) and 26–34 years age group (IR of 9.0 (95% CI 7.8 to 10.5)).[9] A limitation of this univariate analysis is that these risk factors are not necessarily independent risk factors. A multiple model could not be applied due to lack of statistical power. This study was also not designed to explain these findings, but these data indicate that further research should be conducted on these subpopulations to investigate

Table 3 Incidence of illness by sex and age group for athletes competing at the Rio 2016 Summer Paralympic Games

Sex/age group (years)	Total number of illnesses (percentage of total number of illnesses)	Number of athletes with an illness	Total number of athletes competing	Total number of athlete days	Proportion of athletes with an illness (%)	Illness incidence rate: number of illnesses/1000 athlete days (95% CI)
All	511 (100)	454	3657	51 198	12.4	10.0 (9.2 to 10.9)
Female	216 (42.2)	193	1389	19 446	13.9	11.1 (9.7 to 12.7)*
Male	295 (57.7)	261	2268	31 752	11.5	9.3 (8.3 to 10.4)
Age 12–25 years	123 (24.0)	110	996	13 944	11.0	8.8 (7.4 to 10.5)
Age 26–34 years	167 (32.7)	144	1320	18 480	10.9	9.0 (7.8 to 10.5)
Age 35–75 years	221 (43.2)	200	1341	18 774	14.9	11.8 (10.3 to 13.4)†

*Significantly higher than male sex (p<0.05).
†Significantly higher than age groups 12–25 years and 26–34 years (p<0.01).

Table 4 Incidence of illness in the precompetition and competition periods for athletes competing at the Rio 2016 Summer Paralympic Games

Period	Total number of illnesses (percentage of total number of illnesses)	Number of athletes with an illness	Total number of athletes competing	Total number of athlete days	Proportion of athletes with an illness (%)	Illness incidence rate: number of illnesses/1000 athlete days (95% CI)
All	511 (100)	454	3657	51 198	12.4	10.0 (9.2 to 10.9)
Precompetition	105 (20.5)	100	3657	10 971	2.7	9.6 (7.9 to 11.6)
Competition	406 (79.5)	369	3657	40 227	10.1	10.1 (9.2 to 11.1)

Table 5 Incidence of illness by onset for athletes competing at the Rio 2016 Summer Paralympic Games

Type of illness	Total number of illnesses (percentage of total number of illnesses)	Number of athletes with an illness	Proportion of athletes with an illness (%)	Illness incidence rate: number of illnesses/1000 athlete days (95% CI)
All	511 (100)	454	12.4	10.0 (9.2 to 10.9)
New illness	446 (87.3)	405	11.1	8.7 (7.9 to 9.6)*
Recurrent illness	65 (12.7)	60	1.6	1.3 (1.0 to 1.6)

*Significantly higher than recurrent illness (p<0.05).

these risk profiles and institute appropriate prevention interventions in these groups.

Respiratory illness requires attention

The third important finding was that in accordance with other studies conducted at the London 2012 Summer Paralympic Games and Sochi 2014 Winter Paralympic Games, illness in the respiratory system had the highest recorded IR 3.3 (95% CI 2.8 to 3.8)), compared with the other primary physiological systems affected by illness. This has been reported previously in the literature and indicates that this is an important system on which to focus with respect to prevention programmes.[10–13] Indeed, the IR of respiratory illness is similar to that reported for the London Games (IR of 3.5 (95% CI 2.9 to 4.1)).

Non-respiratory illness in athletes with impairment

The fourth important finding was that the non-respiratory physiological systems were also reported to have high illness rates in the present study. This includes skin and subcutaneous tissue (IR of 1.8 (95% CI 1.4 to 2.2)),[14] digestive (IR of 1.3 (95% CI 1.0 to 1.6))[15] and genitourinary (IR of 1.1 (95% CI 0.8 to 1.4))[16] illnesses. This is in accordance with the findings reported for the London and Sochi Games, where these conditions were found to have higher IRs than other physiological systems affected by illness. The incidence of skin illnesses has often been attributed to prosthesis use in athletes with limb deficiency or athletes with reduced sensation who occupy a sitting position in wheelchairs for long periods of time. Furthermore, respiratory and genitourinary illnesses have been reported more frequently in athletes with spinal cord injury who use wheelchairs for ambulation as well as for participation in sport.[3 4]

Spinal cord injury may predispose athletes to illness

Although the provision of impairment denominator data was not possible in this study, we note that the proportion of athletes with an illness was highest in athletes with spinal cord injury (30.8%), followed by the impairment types of limb deficiency (24.2%) and central neurological injury (14.8%). This finding is important as the presence of spinal cord injury has a well-documented impact on the functioning of the immune system.[16 17] Illness in athletes with spinal cord injury may be the result of the predisposition of athletes with this impairment to illness

Table 6 Incidence of illness by primary physiological system affected for athletes competing at the Rio 2016 Summer Paralympic Games, in descending order of illness incidence rate

Physiological system	Total number of illnesses (percentage of total number of illnesses)	Number of athletes with an illness	Proportion of athletes with an illness (%)	Illness incidence rate: number of illnesses/1000 athlete days (95% CI)
All	511 (100)	454	12.4	10.0 (9.2 to 10.9)
Respiratory	167 (32.7)	162	4.4	3.3 (2.8 to 3.8)
Skin and subcutaneous	91 (17.8)	86	2.4	1.8 (1.4 to 2.2)
Digestive	66 (12.9)	65	1.8	1.3 (1.0 to 1.6)
Genitourinary	55 (10.8)	54	1.5	1.1 (0.8 to 1.4)
Other signs and symptoms	27 (5.3)	27	0.7	0.5 (0.4 to 0.8)
Nervous	21 (4.1)	20	0.5	0.4 (0.3 to 0.6)
Mental and brain	19 (3.7)	18	0.5	0.4 (0.2 to 0.6)
Ears and mastoid	15 (2.9)	15	0.4	0.3 (0.2 to 0.5)
Eye and adnexa	13 (2.5)	13	0.4	0.3 (0.1 to 0.4)
Circulatory	12 (2.3)	12	0.3	0.2 (0.1 to 0.4)
Specific sport-related conditions	11 (2.2)	11	0.3	0.2 (0.1 to 0.4)
Other infections and parasites	8 (1.6)	8	0.2	0.2 (0.1 to 0.3)
Endocrine, nutrition and metabolic	3 (0.6)	3	0.1	0.1 (0.0 to 0.2)
Haematological and immune	3 (0.6)	3	0.1	0.1 (0.0 to 0.2)

Table 7 Description of illnesses by impairment type for athletes competing at the Rio 2016 Summer Paralympic Games

Impairment type	Total number of illnesses (percentage of total number of illnesses)	Number of athletes with an illness	Proportion of ill athletes in each impairment type (%)
All	511 (100)	454	100
Spinal cord injury	162 (31.7)	140	30.8
Limb deficiency (amputation, dysmelia, congenital deformity)	118 (23.1)	110	24.2
Central neurological injury (cerebral palsy, traumatic brain injury, stroke other neurological impairment)	79 (15.5)	67	14.8
Visual impairment	62 (12.1)	58	12.8
Other	31 (6.1)	29	6.4
Unknown	6 (1.2)	6	1.3
Intellectual impairment	27 (5.3)	22	4.8
Les autres (non-spinal polio myelitis, ankylosis, leg shortening, joint movement restriction, nerve injury resulting in local paralysis)	13 (2.5)	11	2.4
Short stature	13 (2.5)	11	2.4

(specifically genitourinary and respiratory illness), the use of wheelchairs in this cohort of athletes as well as high loads placed on these athletes as a requirement for elite competition. Specifically, it has been postulated previously that, given the impaired sensation below the level of lesion in athletes with spinal cord injury, illness symptomology may be imprecise in nature, often leading to under-reporting of illness in this athlete population.[2]

STRENGTHS AND LIMITATIONS OF THE STUDY

The main strength of this study was that this is the largest study of its kind to date to be conducted. In conjunction with the data reported for the London Games, it has resulted in a significantly large dataset (approximately 100 000 athlete days of data) that could be used as a baseline to test the efficacy of prevention programmes in the future. Furthermore, medical doctors collected these data, and the majority have worked on this study at previous Games (London and Sochi), thus significantly adding to the quality of the data gathered.

The study did have certain limitations, including the non-availability of polyclinic and venue medical station data as used at the London Games. This may have introduced selection bias in the study (and subsequently a lower rate of reported illness), as only countries who had larger team sizes with medical support were included, possibly representing a certain group of athletes from delegations that could afford team physician medical support at the Games and may have the possibility of being involved in NPC prevention programmes at the time of the Games. It is possible that certain NPCs or sporting federations may have instituted illness prevention programmes following the London Games; however we were not directly aware of this. Further research is planned by this group of researchers to investigate the efficacy of sporting policy changes and formal illness prevention programmes in the Paralympic population. Additionally, only univariate analysis of risk factors could be conducted, and therefore the data presented in this study did not allow for modelling of independent risk factors associated with illness, which would increase the significance of the findings presented. Further analysis comparing the London and Rio Games in only the group of athletes monitored on the WEB-IISS, with additional statistical modelling, is planned for the future by this group of researchers. A further limitation of the study was that this study relied on the accuracy and honesty of illness reporting by the team physicians into the WEB-IISS portal. Specifically, doctors were asked to anticipate the number of days lost due to illness and were unable to validate their estimate once the athlete had recovered. Updates to the WEB-IISS are planned in the future to allow the doctors to amend their records with regard to time loss data.

CONCLUSION

This study completed at the Rio 2016 Summer Paralympic Games constitutes the second significant dataset to describe the incidence of illness in a Summer Paralympic setting. It was found that there was a lower overall incidence of illness at the Rio 2016 Summer Paralympic Games compared with the London 2016 Summer Paralympic Games. Additionally, respiratory illness had the highest IR, in accordance with the findings of studies conducted at the London Games and the Sochi 2014 Winter

What are the findings?

- This is the largest dataset to date documenting the incidence of illness per 1000 athlete days in a Summer Paralympic Games setting
- There was a lower incidence of illness at the Rio 2016 Summer Paralympic Games, compared to the London 2012 Summer Paralympic Games.
- Wheelchair fencing, Para swimming and wheelchair basketball had a significantly higher incidence of illness, compared to all other sports
- Female athletes and older athletes (35-75 years) were at higher risk for illness.
- The respiratory, skin and subcutaneous and digestive systems were the systems most affected by illness.

How might it impact on clinical practice in the future?

- The data presented in this study allow for the establishment of a baseline illness dataset for the current cohort, to be used as comparison data for data gathered at future Paralympic Games.
- These data, in conjunction with the data from the London 2012 Summer Paralympic Games, will provide the basis for evidence-based illness prevention programs to be implemented in the future.
- These future prevention programs should be targeted at older athletes and female athletes, as well as the respiratory, skin and subcutaneous and digestive physiological systems.

Paralympic Games. Furthermore, univariate analysis showed that there was a higher incidence of illness in athletes competing in the sports of wheelchair fencing, para swimming and wheelchair basketball, female athletes and athletes in the age group of 35–75 years. The data gathered in this study stand to contribute to baseline data for illness in the Paralympic population in a Summer Games setting, which can be used for comparison in the implementation of illness prevention programmes in the future.

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