Incidence and burden of illness at the Tokyo 2020 Paralympic Games held during the COVID-19 pandemic: a prospective cohort study of 66 045 athlete days

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This study was conducted exclusively in athletes with disability, who are classified as a marginalised group, and was inclusive of all athletes participating at the Toko 2020 Paralympic Games. The author team is balanced. The researchers represent different genders, from both Northern and Southern hemispheres and different socioeconomic status countries. Furthermore, the research group includes individuals from marginalised groups, as well as perspectives from multiple disciplines.

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ABSTRACT

Objective To describe the incidence and burden of illness at the Tokyo 2020 Paralympic Games, which was organised with strict COVID-19 countermeasures.

Methods Daily illnesses were recorded via the web-based injury and illness surveillance system (teams with their own medical staff; n=81), and local polyclinic services (teams without their own medical staff; n=81). Illness proportion, incidence and burden were reported for all illnesses and in subgroups by sex, age, competition period, sports and physiological system.

Results 4403 athletes (1853 female and 2550 male) from 162 countries were monitored for the 15-day period of the Tokyo Paralympic Games (66 045 athlete days). The overall incidence of illnesses per 1000 athlete days was 4.2 (95% CI 3.8 to 4.8; 280 illnesses). The highest incidences were in wheelchair tennis (7.1), shooting (6.1) and the new sport of badminton (5.9). A higher incidence was observed in female compared with male athletes (5.1 vs 3.6; p=0.005), as well as during the precompetition versus competition period (7.0 vs 3.5; p<0.0001). Dermatological and respiratory illnesses had the highest incidence (1.1 and 0.8, respectively). Illness burden was 4.9 days per 1000 athlete days and 23% of illnesses resulted in time loss from training/competition>1 day.

Conclusion The incidence of illness at the Tokyo 2020 Paralympic Games was the lowest yet to be recorded in either the summer or winter Paralympic Games. Dermatological and respiratory illnesses were the most common, with the burden of respiratory illness being the highest, largely due to time loss associated with COVID-19 cases. Infection countermeasures appeared successful in reducing respiratory and overall illness, suggesting implementation in future Paralympic Games may mitigate illness risk.

WHAT IS ALREADY KNOWN ON THIS TOPIC?

⇒ The incidence of illness is higher during the Paralympic Games compared with the Olympic Games, in both the winter and summer settings.
⇒ Illnesses affecting the respiratory system are highest relative to other systems, such as dermatological, digestive and genitourinary systems, during previous Games.
⇒ The influence of the COVID-19 countermeasures on illness incidence during the Paralympic Games has not been studied previously.

WHAT THIS STUDY ADDS?

⇒ Overall, an incidence of 4.2 illnesses per 1000 athlete days were observed in athletes competing at the Tokyo 2020 Paralympic Games; this was the lowest yet to be recorded in either the summer or winter Paralympic Games setting.
⇒ Dermatological and respiratory illness showed the highest incidence (1.1 and 0.8, respectively).
⇒ Wheelchair tennis, shooting and the new sport of badminton showed the highest illness incidence, while the new sport of taekwondo had only one reported illness.
⇒ The overall illness burden was 4.9 days per 1000 athlete days, with a high illness burden for respiratory illnesses, specifically in athletes with COVID-19.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY?

⇒ The findings of this study provide evidence that the countermeasures implemented at the Tokyo 2020 Paralympic Games can serve as a blueprint for illness prevention strategies in future iterations of the Paralympic Games.
⇒ These data can inform team physicians and other medical staff to implement illness prevention measures, particularly for dermatological and respiratory illnesses.

INTRODUCTION

The surveillance of injuries and illnesses at major sport events, such as the Olympic and Paralympic Games, has become standard practice in order to protect the health and safety of athletes attending these events.[1 2] Results from previous studies have indicated that illness incidence is higher during the Paralympic Games[3–7] compared with the Olympic Games,[8–11] regardless of the setting (summer or winter). Furthermore, a high incidence of illnesses

affecting the respiratory system has been reported in both able-bodied and Para athletes. More specifically, the proportion of illnesses affecting the respiratory system has been observed as approximately two times than that of illnesses reported for other systems, such as dermatological, digestive and genitourinary systems.[4–11] These studies highlighted the need for rapid introduction of protective measures at international sporting events, particularly Para sport events for athletes with underlying medical impairments.

The COVID-19 pandemic in 2020 resulted in the implementation of global illness countermeasures as well as the postponement of the Tokyo 2020 Olympic and Paralympic Games by 1 year.[12] The Playbook for the Tokyo Olympic and Paralympic Games described a 'safety-first' environment in which strict countermeasures were put in place to protect the health of all Games participants.[13] These measures included practicing thorough hygiene, social distancing, isolation of teams to residences, limited movement within the village and no spectators being present at the Games.[14] All attendees had to wear a face mask and participate in daily COVID-19 testing, in accordance with the 'test, trace and isolate' policy outlined in The Playbook.[13] Monitoring the influence of these COVID-19 countermeasures on illness during the Games could provide evidence for the implementation of such countermeasures at future Games.

Thus, the aim of this study was to describe the incidence and burden of illness at the Tokyo 2020 Paralympic Games, which were the first Paralympic Games to be hosted within the environment described above. This study is also the third iteration of the Paralympic Injury and Illness Surveillance Study in the summer setting as well as the first description of illnesses sustained by athletes participating in the new sports at the Paralympic Games of badminton and taekwondo.

METHODS

Study design

This study is a component of the larger ongoing epidemiological study of illnesses sustained during the Paralympic Games, implemented since the London 2012 Paralympic Games. Athletes were prospectively monitored over a 15-day period, including the precompetition period and competition period of the Tokyo 2020 Paralympic Games.

Participants

This study was co-ordinated by Medical Committee members of the International Paralympic Committee (IPC). During the registration process for the Paralympic Games, all athletes consented for the use of medical data gathered during the Games to be used for the current study in a deidentified manner.

Data collection

All National Paralympic Committee (NPC) chefs de missions, chief team physicians and medical staff of teams were notified about the study prior to the Games. During the medical briefing held during the precompetition period, detailed information about the study was provided.

The athlete information used in this study (age, sex, sport, etc) was gathered from the IPC master list of athletes participating at the Games. NPCs with medical staff used the web-based injury and illness surveillance system (WEB-IISS) to record illnesses during the Paralympic Games, including precompetition and competition periods. Data regarding illnesses from NPCs without accompanying medical staff were collected through the local organising committee medical (polyclinic) facilities' surveillance system. This system was additionally used for hospital, medical, radiology and pharmacy services as well as services at sport venues. Where athletes sustained more than one illness during the Games, each illness was reported as a separate encounter. After the conclusion of the Games, polyclinic data were delinked and cleaned for duplicates and non-athlete entries. They were then combined with the WEB-IISS entries, and duplicates between the systems were resolved. Bracing and physiotherapy requests, non-ophthalmological eye examinations (optometry), all routine dentistry, as well as radiology visits were excluded, after which the polyclinic and WEB-IISS datasets were merged with the IPC master list for statistical analyses. In instances where the same illness was reported through both the polyclinic and the WEB-IISS dataset, each illness was counted only once and was based on the best clinical description in each illness report. Thus, this study describes all illnesses reported by team medical staff and local polyclinic services during the Tokyo Paralympic Games.

Definition of illness

An illness was defined in accordance with the International Olympic Committee (IOC) consensus statement regarding injury and illness reporting in sport and presented in online supplemental file 1.[1 2] Athletes were tested for COVID-19 by a rapid saliva antigen test on a daily basis.[14] When the saliva antigen test was returned positive, a saliva PCR test was done.[14] All COVID-19 cases were identified and managed according to guidelines in The Playbook, which included immediate isolation of the affected athlete(s).[13]

Calculation of athlete days

Team size for each country was obtained from the master list of all participating athletes published by the IPC. An estimate of athlete days was calculated by multiplying the team size of each team by the total participation days (total 15 days: 3-day precompetition and 12-day competition periods). This comprised denominator data for the calculation of the incidence of illness per 1000 athlete days. This is consistent with previous iterations of this study.[4–7]

Calculation of the illness proportion (IP) and incidence

The IP was calculated as the percentage of athletes with one or more illnesses during the Games period. The percentage of athletes with an illness was calculated by dividing the total number of athletes with an illness by the total number of athletes in each subgroup. This result was then multiplied by 100. Illness incidence was calculated as the number of athletes reporting illness relative to the total number of athletes in the relevant subcategory and reported as illnesses per 1000 athlete days (95% CI) in 23 sports, by age and sex, by competition period, as well as in 14 physiological systems.

Calculation of time loss and burden

Time loss from training and competition associated with illnesses was anticipated by the attending physician at the time of the entry. To account for illness incidence as well as the severity of illness (time lost), the illness burden (IB) was calculated by reporting the number of days lost per 1000 athlete days (95% CI).

Table 1 Number of athletes participating in each sport at the Tokyo 2020 Paralympic Games

Sport	All athletes	Females	Males	Age 12–25	Age 26–34	Age 35–75
All	4403	1853	2550	1244	1651	1508
Archery	139	60	79	16	41	82
Athletics	1 144	491	653	392	451	301
Badminton*	90	44	46	25	32	33
Boccia	114	41	73	23	45	46
Canoe	88	40	48	12	33	43
Cycling (track and road)	228	79	149	27	68	133
Equestrian	78	55	23	16	20	42
Football 5-a-side	62	0	62	14	32	16
Goalball	118	58	60	43	55	20
Judo	138	58	80	34	66	38
Powerlifting	178	88	90	17	64	97
Rowing	96	48	48	20	34	42
Shooting	154	54	100	16	33	105
Sitting volleyball	188	92	96	26	70	92
Swimming	606	264	342	366	185	55
Table tennis	278	105	173	58	96	124
Taekwondo*	71	34	37	24	35	12
Triathlon	78	39	39	10	30	38
Wheelchair basketball	263	119	144	66	127	70
Wheelchair fencing	96	48	48	11	45	40
Wheelchair rugby	92	4	88	6	45	41
Wheelchair tennis	104	32	72	22	44	38

*New sports.

Statistical analysis of the data

All data were analysed by SAS statistical software (V.9.4) via counts. Impairment data were only reported as the total number of illnesses and percentage of all illnesses, because impairment information was not available for all athletes (polyclinic records did not include impairment information). Athletes who participated in multiple sports were included under their primary sport. Descriptive statistical analyses are reported by 23 sports, by age, sex, precompetition and competition periods, chronicity, anatomical area, impairment (for WEB-IISS entries), as well as number and percentage of athletes reporting an illness. The Poisson distribution with the PROC GENMOD statement and an associated log link option were used for analysis. All results reported were from univariate Poisson models, and included a scale parameter, due to some modest overdispersion in the Poisson models. Univariate unadjusted incidence (with 95% CIs) were reported for illness overall, illness by sex and age, by period and in physiological systems. In cases where incidence differed significantly between subgroups, the incidence ratio (IR) was reported. To determine IR, the subgroup with the highest incidences were compared with a combination of all other categories.

RESULTS

Participants

There were a total of 4403 (1853 female and 2550 male) athletes from 162 countries who competed for 15 days (66 045 athlete days) in 23 sports at the Tokyo Paralympic Games. There were 3836 (87%) athletes from 81 countries (50%) who used the WEB-IISS and 567 (13%) athletes from 81 countries who used the polyclinic and venue facilities. Table 1 presents a description of the number of female and male athletes aged 12–24, 25–34 and 35–75 years, as well as in the 23 sports contested at the Tokyo Paralympic Games (cycling road and track combined).

Incidence of illness by sport

Table 2 shows the number and incidence of illnesses reported at the Tokyo Paralympic Games. After the removal of duplicates, there were 280 (207 WEB-IISS, 73 polyclinic) illnesses recorded in 261 athletes (5.9% of all athletes) in 23 sports. The overall incidence was 4.2 illnesses per 1000 athlete days (95% CI 3.8 to 4.8). There were more new illnesses (n=261; 4.0 (95% CI 3.5 to 4.5)) compared with subsequent illnesses (n=19; 0.3 (95% CI 0.2 to 0.5); IR=13.7 (95% CI 8.7 to 21.7); p<0.0001). The sports of wheelchair tennis (7.1 (95% CI 3.8 to 13.0)), shooting (6.1 (95% CI 3.4 to 10.7)) and badminton (5.9 (95% CI 2.6 to 13.5)) had the highest incidences, while goalball (1.7 (95% CI 0.6 to 5.2)) and sitting volleyball (1.4 (95% CI 0.5 to 3.7)) had the lowest incidences of illness. There was only one illness reported for athletes participating in taekwondo.

Incidence of illness by sex and age group

Table 3 presents the incidence of illness in female and male athletes in three age categories. Female athletes reported significantly more illnesses (5.1 (95% CI 4.3 to 6.1)) compared with male athletes (3.6 (95% CI 3.0 to 4.3); IR=1.4 (95% CI 1.1 to 1.8); p=0.005). No significant interaction effects were found between sex and age group. There were no significant differences between the age group categories.

Incidence of illness in the 3-day precompetition and 12-day competition period

There were 93 (7.0 (95% CI 5.7 to 8.6)) and 187 (3.5 (95% CI 3.1 to 4.1)) illnesses reported during the precompetition and competition periods, respectively, shown in table 4. The precompetition period saw a significantly higher incidence

Table 2 Incidence of illness by sport for athletes competing at the Tokyo 2020 Paralympic Games, in descending order of incidence

Sport	Total number of illnesses (% 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: number of illnesses/1000 athlete days (95% CI)
All	280 (100)	261	4403	66 045	5.9	4.2 (3.8 to 4.8)
Wheelchair tennis	11 (3.9)	10	104	1 560	9.6	7.1 (3.8 to 13.0)
Shooting	14 (5.0)	12	154	2 310	7.8	6.1 (3.4 to 10.7)
Badminton	8 (2.9)	6	90	1 350	6.7	5.9 (2.6 to 13.5)
Wheelchair basketball	22 (7.9)	17	263	3 945	6.5	5.6 (3.4 to 9.2)
Boccia	9 (3.2)	9	114	1 710	7.9	5.2 (2.8 to 9.9)
Judo	10 (3.6)	10	138	2 070	7.2	4.8 (2.7 to 8.8)
Archery	10 (3.6)	10	139	2 085	7.2	4.8 (2.6 to 8.7)
Cycling (track and road)	16 (5.7)	15	228	3 420	6.6	4.7 (2.8 to 7.7)
Swimming	40 (14.3)	37	606	9 090	6.1	4.4 (3.2 to 6.1)
Athletics	75 (26.8)	74	1144	17 160	6.5	4.4 (3.5 to 5.5)
Wheelchair rugby	6 (2.1)	5	92	1 380	5.4	4.3 (1.8 to 10.7)
Table tennis	18 (6.4)	17	278	4 170	6.1	4.3 (2.7 to 6.9)
Rowing	6 (2.1)	5	96	1 440	5.2	4.2 (1.7 to 10.3)
Wheelchair fencing	6 (2.1)	5	96	1 440	5.2	4.2 (1.7 to 10.3)
Equestrian	4 (1.4)	4	78	1 170	5.1	3.4 (1.3 to 8.9)
Triathlon	4 (1.4)	4	78	1 170	5.1	3.4 (1.3 to 8.9)
Football 5-a-side	3 (1.1)	3	62	930	4.8	3.2 (1.1 to 9.7)
Powerlifting	7 (2.5)	7	178	2 670	3.9	2.6 (1.3 to 5.4)
Canoe	3 (1.1)	3	88	1 320	3.4	2.3 (0.7 to 6.9)
Goalball	3 (1.1)	3	118	1 770	2.5	1.7 (0.6 to 5.2)
Sitting volleyball	4 (1.4)	4	188	2 820	2.1	1.4 (0.5 to 3.7)
Taekwondo	1 (0.4)	1	71	1 065	1.4	–

compared with the competition period (IR=2.0 (95% CI 1.6 to 2.5; p<0.0001).

Incidence of illness in each physiological system

Table 5 presents the number and incidence of illness by physiological system. The dermatological system (1.1 (95% CI 0.9 to 1.4)), respiratory system (0.8 (95% CI 0.6 to 1.0)) and gastrointestinal system (0.6 (95% CI 0.5 to 0.8)) had the highest incidence of illness. Combined, these 3 systems represent 59% of all illnesses.

There were 13 respiratory illnesses diagnosed as COVID-19 (0.2 (95% CI 0.11 to 0.34)). Five of the cases were in the sport of judo, and four of these cases were from one country. There were two cases reported in the sport of swimming and athletics. All COVID-19 cases were reported with 10 days lost from sport, in alignment with The Playbook guidelines.[13]

There were 16 thermoregulatory illnesses reported in 16 athletes (0.2 (95% CI 0.1 to 0.4)), 8 (50%) of which were in the sport of athletics, 2 each in triathlon and shooting and 1 each in road cycling, judo, swimming and wheelchair tennis. All illnesses were diagnosed as hyperthermia/heat illness. Most athletes were managed with bed rest and cooling strategies. In 69% of these cases, the athletes did not require any time lost from sport.

Illness by impairment

A description of the impairment of 189 athletes who reported illnesses via the WEB-IISS is included in table 6. Most illnesses were reported in athletes with spinal cord related disorders (n=64; IP=30.7%), followed by limb deficiency (n=50; IP=23.3%), brain disorders (n=25; 12.2%) and visual impairment (n=20; IP=10.1%).

Estimated time loss and burden of illness

Of the illnesses reported at the Tokyo Paralympic Games (280 illnesses), 216 illnesses (77.1%) did not result in days lost from competition or training. There were 64 time-loss illnesses (22.9%; ≥1 days lost from training or competition). Of these, 42 illnesses (15.0% of total) required 2 or more days exclusion from training or competition. The overall IB was 4.9 days lost per 1000 athlete days (95% CI 3.5 to 6.9). The sport with the highest IB was judo (IB 24.6 (95% CI 18.3 to 32.4)) followed by wheelchair rugby (IB 20.4 (95% CI 13.5 to 29.3)) and swimming (IB 9.6 (95% CI 7.7 to

Table 3 Incidence of illness by sex and age group for athletes competing at the Tokyo 2020 Paralympic Games

Sex/age group (years)	Total number of illnesses (% 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: number of illnesses/1000 athlete days (95% CI)
All	280 (100)	261	4403	66 045	5.9	4.2 (3.8 to 4.8)
Female	142 (50.7)	129	2550	38 250	5.1	5.1 (4.3 to 6.1)*
Male	138 (49.3)	132	1853	27 795	7.1	3.6 (3.0 to 4.3)
Age 12–25	70 (25.0)	66	1244	18 660	5.3	3.8 (2.9 to 4.8)
Age 26–34	115 (41.1)	104	1651	24 765	6.3	4.6 (3.8 to 5.6)
Age 35–75	95 (33.9)	91	1508	22 620	6.0	4.2 (3.4 to 5.1)

*Significantly higher than male athletes (p=0.005).

Table 4 Incidence of illness in the precompetition and competition periods for athletes competing at the Tokyo 2020 Paralympic Games

Period	Total number of illnesses (% 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: number of illnesses/1000 athlete days (95% CI)
All	280 (100)	261	4403	66 045	5.9	4.2 (3.8 to 4.8)
Precompetition	93 (33.2)	85	4403	13 209	2.1	7.0 (5.7 to 8.6)*
Competition	187 (67.8)	176	4403	52 836	4.0	3.5 (3.1 to 4.1)

*Significantly higher than competition period (p<0.0001).

11.8)). Significant differences were observed in IB between athletes in the age group of 35–75 years (IB 2.3 (95% CI 1.1 to 4.7)), compared with 12–25 years (IB 6.5 (95% CI 3.8 to 11.2); p=0.023) and 26–34 years (IB 6.1 (95% CI 3.7 to 10.2); p=0.029). There were no significant differences between males and females for IB (female IB 5.4 (95% CI 3.4 to 8.7); male IB 4.5 (95% CI 2.8 to 7.3)). The IB of the respiratory system was significantly higher than all other physiological systems (186 days lost; IB 2.8 (95% CI 2.4 to 3.3)). The IB related to COVID-19 was 2.0 (95% CI 1.6 to 2.3). When COVID-19 were excluded from the analysis, the IB of respiratory system was 0.8 (95% CI 0.6 to 1.1). The physiological systems with the second and third highest IB were the dermatological system (IB 0.6 (95% CI 0.4 to 0.8)) and the neurological system (IB 0.5 (95% CI 0.3 to 0.7)).

DISCUSSION

The aim of this study was to describe the incidence and burden of illness among Paralympic athletes participating at the Tokyo 2020 Paralympic Games. These were the first Paralympic Games that were organised after the start of the COVID-19 pandemic in 2020, and strict countermeasures were implemented to prevent the spread of COVID-19 and protect the health of all Games participants. The main findings of this study are that: (1) the incidence of illness at the Tokyo Paralympic Games was the lowest yet to be recorded in either the summer or winter Paralympic Games settings, (2) the new Paralympic sport of badminton was found to have the third highest incidence of illness among the sports while there was only one illness reported in the other new sport of taekwondo, (3) respiratory illness showed the highest burden, mostly due to the time loss accompanying the few COVID-19 cases and (4) heat illnesses had a low incidence, despite hot and humid environmental conditions.

Respiratory illness countermeasures result in low illness incidence in all physiological systems

The current study found that there was a low incidence of all illnesses at the Tokyo Paralympic Games (4.2 (95% CI 3.8 to 4.8); IP 5.9), most likely due to the COVID-19 countermeasures implemented at the Tokyo Paralympic Games. This incidence was the lowest we have recorded in the Paralympic Games; lower than reported for the London 2012 Games (12.8 (95% CI 11.7 to 13.9); IP 14.2) and Rio 2016 Games (10.0 (95% CI 9.2 to 10.9); IP 12.4).[4 5] There was also a low incidence in the respiratory system, which historically has been reported as the most at-risk system in both Olympic and Paralympic cohorts.[4–11 15] In fact, respiratory illness incidence was ranked second to the dermatological system for the first time. This finding likely demonstrates the effect of the strict COVID-19 countermeasures that were implemented during the Tokyo Paralympic Games. Some of the strategies that were used included mandatory vaccination and use of face masks, practicing thorough hygiene, early recognition of COVID-19 symptomatology, using the 'test–trace–isolate' principle that entailed daily testing for COVID-19 and isolation of athletes who tested positive, as well as restriction of movement of all participants within the Games environment.[14] These strict countermeasures were specifically implemented to limit the spread of COVID-19.[14] However, the findings show that the low incidence was not limited to the respiratory system and that there was a concomitant low incidence in all other physiological systems. The strict countermeasures implemented during the Tokyo Paralympic Games comprised the most comprehensive

Table 5 Incidence of illness in each primary physiological system affected for athletes competing at the Tokyo 2020 Paralympic Games, in descending order of incidence

Physiological system	Total number of illnesses (% total number of illnesses)	Number of athletes with an illness	Proportion of athletes with an illness (%)	Illness incidence: number of illnesses/1000 athlete days (95% CI)
All	280 (100)	261	5.9	4.2 (3.8 to 4.8)
Dermatological	73 (26.1)	70	1.6	1.1 (0.9 to 1.4)
Respiratory	50 (17.9)	48	1.1	0.8 (0.6 to 1.0)
COVID-19	13 (4.6)	13	0.3	0.2 (0.1 to 0.3)
Gastrointestinal	41 (14.6)	40	0.9	0.6 (0.5 to 0.8)
Genitourinary	20 (7.1)	20	0.5	0.3 (0.2 to 0.5)
Neurologic	21 (7.5)	21	0.5	0.3 (0.2 to 0.5)
Psychiatric/psychological	23 (8.2)	23	0.5	0.3 (0.2 to 0.5)
Thermoregulatory	16 (5.7)	16	0.4	0.2 (0.1 to 0.4)
Otological	9 (3.2)	9	0.2	0.14 (0.07 to 0.26)
Musculoskeletal	7 (2.5)	7	0.2	0.11 (0.05 to 0.22)
Ophthalmologic	6 (2.1)	6	0.1	0.09 (0.04 to 0.02)
Cardiovascular and circulatory	5 (1.8)	5	0.1	0.08 (0.03 to 0.18)
Endocrinological, nutritional or metabolic	5 (1.8)	5	0.1	0.07 (0.03 to 0.18)
Multiple systems	4 (1.4)	4	0.1	0.06 (0.02 to 0.16)

Table 6 A description of impairment types of the 189 athletes with an illness on the WEB-IISS at the Tokyo 2020 Paralympic Winter Games, in descending order of illness proportion

Impairment type	Total number of illnesses (% total number of illnesses on WEB-IISS)	Number of athletes with an illness	Proportion of athletes with an illness on WEB-IISS (%)
All	207 (100)	189	100
Spinal cord related disorders (paraplegia; tetraplegia)	64 (30.9)	58	30.7
Limb deficiency (amputation; dysmelia)	50 (24.2)	44	23.3
Brain disorders (eg, cerebral palsy; traumatic brain injury; stroke, multiple sclerosis, etc)	25 (12.1)	23	12.2
Visual impairment	20 (9.7)	19	10.1
Neuromuscular disorders—stable (eg, post polio syndrome; peripheral nerve injury, etc)	15 (7.2)	13	6.9
Neuromuscular disorders—progressive (eg, neuromuscular disease; myopathy; muscular dystrophy, etc)	10 (4.8)	9	4.8
Intellectual impairment	6 (2.9)	6	3.2
Short stature	5 (2.4)	5	2.6
Impaired passive range of motion (eg, arthrogryposis; clubfoot, etc)	3 (1.4)	3	1.6
Leg length difference	2 (1.0)	2	1.1
Other/unknown	7 (3.4)	7	3.7

WEB-IISS, web-based injury and illness surveillance system.

illness prevention strategy employed at an international sporting event, whose continued use may or may not be entirely feasible. For the organisation of future events such as the Paralympic Games, it is suggested that these countermeasures are tailored to continue mitigating illness in athletes during competition. In addition, team physicians can use these tailored countermeasures to prevent the spread of illness within their team, with consideration of some Paralympic athletes who might be more susceptible to illness.[16] In particular, these countermeasures can be implemented when physicians travel with the team, which is known to be a period of high illness susceptibility.[17] While implementing countermeasures, organising committees of future events should take into account the potential mental health implications of some of these measures (eg, isolation) and try to minimise negative effects.[18]

One element of the countermeasures implemented was the mandatory isolation of athletes with confirmed COVID-19 for a period of 10 days, even for asymptomatic athletes. This time period was set by The Playbook and may not have reflected the true severity of the illness, contributing to the high IB observed in the respiratory system (2.8 (95% CI 2.4 to 3.3)).[13] Indeed, the IB for COVID-19 alone was 2.0 (95% CI 1.6 to 2.3), and if COVID-19 cases were to be excluded from the burden analysis, IB for the respiratory system would be 0.8 (95% CI 0.6 to 1.1) indicating a high IB associated with COVID-19. It is interesting that five of the COVID-19 cases were in the sport of judo, a contact sport, with four of these cases from one country, confirming that proximity and close contact between athletes likely facilitated transmission of infection within the team.[19 20]

The incidence of illness in the new sports of badminton and taekwondo

This is the first study to report illnesses in athletes participating in the new Paralympic sports of badminton (5.9 (95% CI 2.6 to 13.5); IP 6.7) and taekwondo (IP 1.4). While badminton was ranked third highest in illness incidence, with eight illnesses reported in six athletes, there was only one illness reported by an athlete participating in taekwondo. It is of interest to note that epidemiological studies at the Olympic Games show a high proportion of illness in athletes participating in badminton as well as taekwondo.[8 10] However, this study had a relatively small sample (n=90 for badminton; n=71 for taekwondo) and further surveillance is warranted in these sports.

The incidence of heat illness at the Tokyo 2020 games

The hot and humid weather conditions of Japan in mid-summer were a medical concern for the Tokyo Paralympic Games, based on the potential high risk of exercise-related heat illness in athletes competing in these conditions.[21] There was particular concern regarding the Paralympic Games, as previous studies have shown that individuals with impairments such as spinal cord related disorders, brain disorders or multiple sclerosis may be more susceptible to hyperthermia.[22 23] The Tokyo Paralympic Games organising committee instituted 'Beat the Heat' guidelines to prevent and manage heat illness in athletes.[24] These measures included the establishment of heat decks in medical support areas at competition venues with whole-body cooling options, preparatory heat acclimation in teams, wet-bulb globe temperature (WBGT) measurements at each venue and the scheduling of events in the cooler morning and evening hours.[25 26] Procedures that were implemented specifically for the Paralympic population included upskilling local medical providers' awareness on the effect of heat in athletes with certain impairment types and accommodation of team medical staff within the heat decks.[27] The first week of the Tokyo Paralympic Games were held under extreme weather conditions with WBGTs between 30°C and 35°C and humidity ranging from 72% to 84%.[28] According to the position stand of the American College of Sports Medicine, exercise under these conditions should be limited or cancelled.[21] However, during the last days of the Tokyo Paralympic Games, WBGTs dropped to 20°C–24°C, which allowed for normal activity (with monitored fluid intake). It could be speculated that perhaps the few hyperthermic illnesses (n=16; 0.2 (95% CI 0.1 to 0.4)) reported (mostly in athletics) were due to the temperate

climate in the second half of the Games, as well as the measures put in place. This finding is consistent with observations during the 2015 IPC Athletics World Championships that were held in WBGTs of 24.6°C–36.0°C (Doha, Qatar), where only seven cases of heat related illness were recorded.[29]

Other important findings

The finding that the incidence of dermatological illnesses (1.1 (95% CI 0.9 to 1.4); IP 1.6) was highest indicates that team physicians travelling with Paralympic teams should, besides respiratory illnesses, also focus on dermatological illnesses. For example, physicians should be mindful of skin pressure throughout long haul travel and changes in temperature and humidity. The findings of this study support previous epidemiological studies of the London and Rio Games and show the importance of implementing countermeasures for illnesses in these systems, given the potential link between certain athlete impairment types and susceptibility to illness.[5–11 30–35] Particularly, countermeasures such as thorough hand hygiene and reduced person-to-person contact could have contributed to the low incidence of illness in the gastrointestinal and genitourinary systems. It is therefore advised to implement these countermeasures in future Games. It is also interesting to note that this is the first iteration that showed a significantly higher incidence of illness during the precompetition period compared with the competition period. In addition, female athletes had a significantly higher incidence of illness than male athletes, which is consistent with observations during the Rio 2016 Paralympic Games.[5] These findings are new contributions to the epidemiology of illness in Para athletes and require further investigation.

Limitations

This study was potentially limited by the use of full team sizes from the IPC master list for the duration of the competition. To adhere with COVID-19 countermeasures, teams had staggered arrival and departure dates to limit the number of people in the Games environment.[13] It was therefore not possible to obtain true team sizes per day, and thus the crude IPC numbers were used. This could have resulted in an overestimation of athlete days (up to 10 000 athlete days), and subsequent attenuation of illness incidence by up to 18%, which translates into an incidence of 1.0 fewer illnesses per 1000 athlete days. Another limitation includes the lack of impairment data for all athletes at the Games, which impacted the incidence of reporting per impairment type. In addition, the analysis of the illness incidence and burden was limited for certain subgroups, due to small illness numbers that were reported, such as the sport of taekwondo in which only one illness was reported. Furthermore, the forced 10-day isolation period for COVID-19 might have resulted in an overestimation of the true time loss, as asymptomatic athletes also had to isolate.

CONCLUSION

The current study is the third iteration of the Paralympic Injury and Illness Surveillance Study reporting the epidemiology of illness at the Paralympic Games. The results of this study showed an incidence of illness during the Tokyo Paralympic Games that was the lowest yet to be recorded in either the summer or winter Paralympic Games settings. In addition, this is the first iteration of the Paralympic Games that dermatological illness accounted for the highest incidence instead of respiratory illness, which ranked second highest. However, respiratory illness showed the highest burden, which was associated with COVID-19. While the implementation of strict countermeasures were intended to prevent the spread of COVID-19, the incidences of illness in all physiological systems were low. This indicates that the countermeasures implemented during these Games were successful in reducing the incidence of illness in general. Furthermore, the new sport of badminton was found to have the third highest incidence of illness among the sports, but only one illness was documented in the new sport of taekwondo. There were also few COVID-19 and hyperthermic illness cases reported. For the organisation of future iterations of the Paralympic Games, it is advised that the current countermeasures are tailored and certain elements implemented. This is important in order to protect the health of athletes participating at large international tournaments with multiple teams and sports.

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