

Incidence of injury and illness among paediatric Team USA athletes competing in the 2020 Tokyo and 2022 Beijing Olympic and Paralympic Games

Eric G Post ^{1,2}, Travis Anderson ^{1,2}, Jeffrey S Shilt,^{3,4} Eric L Dugan,^{3,4} Stephanie C Clark,⁵ Emily G Larson,⁶ Kayle E Noble-Taylor,⁷ David M Robinson,⁷ Amber T Donaldson ^{1,2}, Jonathan T Finnoff ^{1,2,8}, William M Adams ^{1,2,9,10}

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ABSTRACT

Objective To describe the incidence of injuries and illnesses among paediatric Team USA athletes competing in the Tokyo 2020 Olympic and Paralympic Games, and the 2022 Beijing Olympic and Paralympic Games.

Methods An electronic medical record system documented all injuries and illnesses that occurred while competing in the four Games periods. Incidence (IR) with 95% CI per 1000 athlete days were calculated for both injuries and illnesses. Incidence rate ratios (IRR) were calculated to compare injury and illness rates based on age (paediatric vs non-paediatric) sex, Games period and sport type.

Results Two hundred paediatric athletes (age range, 15–21 years) competed across the four Games periods, representing 16.1% of all Team USA athletes. The overall injury IR (95% CI) was 13.4 (9.8 to 18.1), and the overall illness IR was 5.5 (3.3 to 8.7). There were no differences in incidence between paediatric and non-paediatric athletes for either injury (IRR (95% CI): 0.9 (0.6 to 1.2)) or illness (IRR (95% CI): 0.9 (0.5 to 1.5)). Female paediatric athletes were more likely to sustain an injury compared with male paediatric athletes (IRR (95% CI): 2.4 (1.1 to 5.3)). The most common mechanism of injury was gradual onset (IR, 4.3 (2.3 to 7.2)), and injuries most commonly occurred during practices (IR, 7.0 (4.5 to 10.5)).

Conclusion Paediatric athletes account for a substantial proportion of Team USA athletes. It is essential that paediatric sports medicine experts are included in the medical team given that paediatric Team USA athletes are just as likely as their adult teammates to sustain an injury or illness.

INTRODUCTION

Approximately 12 million paediatric athletes sustain a sport-related injury annually, thus understanding the distribution of injuries and illnesses in paediatric athletes is critical in order to design and implement effective injury prevention programmes.^{1 2} In order to achieve this goal, various extensive surveillance systems for sports injuries and illnesses have been established within

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Large-scale injury and illness surveillance systems have provided epidemiological data at the high school, collegiate and professional levels. However, there are limited data on the distribution of injuries and illnesses among Olympic and Paralympic paediatric athletes, which is critical to provide care for this unique population.

WHAT THIS STUDY ADDS

⇒ This is the first study to describe the incidence of injury and illness among paediatric athletes competing across both the Summer and Winter Olympic and Paralympic Games. We found that paediatric athletes and non-paediatric athletes sustained injuries and illnesses at similar rates and most paediatric athletes competed in individual sports. We also observed that female paediatric athletes were more than twice as likely to sustain an injury compared with male paediatric athletes, most injuries were gradual onset in nature, and injuries occurred most often during practice.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Our data suggest potential opportunities to develop and implement targeted injury and illness reduction programmes among paediatric Olympic and Paralympic athletes. More specifically, our data suggest that programming should focus on reducing injury rates among female athletes due to their higher risk of injury compared with male athletes, and in particular should use strategies to reduce the risk of lower extremity and gradual onset injuries in these athletes.

the USA, focusing on secondary school and collegiate levels. These include the National Athletic Treatment, Injury, and Outcomes Network Surveillance Program,³ the High School Reporting Information Online⁴ database, and the National Collegiate Athletics Association Injury Surveillance Program.⁴ In addition, injury and illness surveillance data



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For numbered affiliations see end of article.

Correspondence to

Dr Eric G Post;
eric.post@usopc.org

have also been collected and reported for elite adult athletes participating in professional sports^{5 6} or at the Olympic and Paralympic Games.⁷⁻¹³

While many epidemiological studies of elite adult athletes⁵⁻¹¹ or non-elite paediatric athletes¹⁴⁻¹⁶ exist, thus far, epidemiological data within elite paediatric athlete populations have been limited, or in the case of paediatric para-athletes, do not exist. In order to compete at the highest levels of sport, such as the Olympic or Paralympic Games, elite paediatric athletes must participate in intensive training and competition similar to their adult teammates.¹ However, paediatric athletes must withstand these stresses while they are in various stages of physical, psychosocial and hormonal development.^{1 17 18} In addition, the youth sports landscape is increasingly professionalised and specialised from an early age, which may also increase the susceptibility of elite paediatric athletes to concerns such as overuse injury or psychological burnout.^{19 20} Therefore, understanding the distribution of injury and illness within elite paediatric athletes is an important step in order to provide high-quality care to this unique population. Currently, the existing epidemiological data in elite paediatric athlete populations consist of either sport-specific studies^{18 21-23} or studies of athletes competing in Youth Olympic Games or Festivals.²⁴⁻²⁹ To our knowledge, no studies have reported the incidence of injury and illness among paediatric athletes participating at even higher levels of play, such as at the Olympic or Paralympic Games.

Therefore, the purpose of this study was to describe the incidence of injuries and illnesses among paediatric Team USA athletes competing in the Tokyo 2020 Summer Olympic and Paralympic Games, and the 2022 Beijing Winter Olympic and Paralympic Games.

METHODS

The epidemiological data presented in this study were collected as part of the United States Olympic and Paralympic Committee (USOPC) injury and illness surveillance programme during the Tokyo 2020 Summer Olympic Games (SOG), the Tokyo 2020 Summer Paralympic Games (SPG), the Beijing 2022 Winter Olympic Games (WOG), and the Beijing 2022 Winter Paralympic Games (WPG). Data were collected during the precompetition period (11 days for all Games), the competition period (16 days for Tokyo 2020 SOG and Beijing 2022 WOG, 12 days for Tokyo 2020 SPG, and 9 days for Beijing 2022 WPG) and the postcompetition period (3 days for all Games).

Patient and public involvement

Athletes competing in the four Games, periods examined in this study were not directly involved in setting the research questions or outcomes of this study. The USOPC Research Review committee, which consists of Olympic and Paralympic athlete representatives, sports medicine clinicians, mental health providers, sport physiologists, sport nutritionists, strength and conditioning

coaches, sport national governing body representatives, and legal representatives, provided input on this study prior to collection and analysis of the data.

Equity, diversity and inclusion statement

The data for this study were reported from the diverse population of elite athletes competing for Team USA across the four Games periods (sex: female=51.4%, male=48.6%; self-identified ethnicity: Asian=2.4%, black=17.4%, white=62.8%, other=1.1%, two or more races=6.1%, declined to respond=9.9%; self-identified ethnic origin: of Hispanic/Latino/Spanish origin=5.4%, not of Hispanic/Latino/Spanish origin=84.6%, declined to respond=9.9%; Games: Olympic=75.2% and Paralympic=24.8%; season: Summer=76.3%, Winter=23.7%). The research team consists of a diverse, balanced group of expert clinicians and researchers (36% female).

Data collection

All injuries and illnesses that occurred among the total sample of Team USA athletes (n=1239) while competing across the four Games periods were documented using an electronic medical record system (EMR) (GE Centricity, General Electric, Fairfield, Connecticut, USA). Following the completion of each Games period, the research team conducted a quality control process and individually reviewed all medical encounters to ensure accuracy. Only consultations or evaluations for new injuries/illnesses, or of exacerbations of existing injuries/illnesses during each Games Period were included in the analysis for this study.

Definitions

In accordance with American Academy of Pediatrics guidelines,³⁰ paediatric athletes were defined as any athlete aged 21 or younger on the date of the opening ceremony for the respective Games period. To comply with the regulations set by the Institutional Review Board of the approving institution, athlete confidentiality was prioritised for sports events where fewer than 10 paediatric athletes competed for Team USA. Therefore, instead of conducting specific sport comparisons, this study focused on collective analysis of individual and team sports.

Injury and illness were defined following the 2020 IOC Consensus Statement for recording and reporting sport epidemiological data and the Orchard Sports Injury and Illness Classification System (OSIICS) was used to classify all injuries and illnesses.^{31 32} Injuries were defined as 'tissue damage or other derangement of normal physical function due to participation in sports, resulting from rapid or repetitive transfer of kinetic energy'. Injuries were classified by general anatomic region (head/face/neck, upper limb, torso, or lower limb) and by specific anatomic location (eg, head/face, neck, shoulder, upper arm, etc). The onset of injuries was classified as 'acute' or 'gradual onset'. Acute onset was defined as an injury with

a sudden onset during sport participation. Gradual onset was defined as an injury that did not have an identifiable precipitating event or was an exacerbation of a previous injury. The mechanism of acute onset was further classified as either 'contact acute' or 'non-contact acute'. Contact injuries were defined as either direct ('mechanisms directly leading to the health problem in an immediate and proximal manner') or indirect ('mechanisms stemming from contact with other athletes or an object, but with the force not applied directly to the injured area'). Non-contact injuries were defined as 'mechanisms that lead to health problems without any direct or indirect contact from another external source'. Finally, injuries were also classified by the event type where they occurred (practice, competition, or non-sport).

Illnesses were defined as 'a complaint or disorder experienced by an athlete, not related to injury. Illnesses include health-related problems in physical (eg, influenza), mental (eg, depression) or social well-being, or removal or loss of vital elements (air, water, warmth)'. Illnesses were further classified by the involved body system (eg, cardiovascular, gastrointestinal, etc). For the purposes of this study, mental health problems and medical diagnoses associated with the SARS-COV-2 virus were not included in the analyses, due to the extremely low proportion (<1%) of Team USA athletes who were diagnosed with COVID-19 during these games.³³ Based on the methods by which Team USA psychological service providers provided mental health support for athletes, the lack of specific diagnostic classifications within the OSIICS coding system on mental health conditions,³² and the lack of standardised methods to conduct surveillance of mental health conditions within athletes at the time of data collection (the mental health supplement to the IOC surveillance consensus statement was published in July 2023),³⁴ mental health encounters were not included within this analysis.

Calculation of exposure

Athlete exposure, quantified as athlete days (AD), was calculated for each individual using the number of days that an athlete was in the host country during the respective Games period. The flight manifests for each Games period were used to determine the date of arrival and departure from the host country for each athlete. The AD of each individual athlete were summed to determine the total number of AD, both within the total athlete sample and within each subgroup of interest, which served as the denominator for calculating incidence.

Statistical analysis

The number of athletes participating, total number AD, frequency of injuries and illnesses, sports represented and athlete ages were all summarised using descriptive statistics. Injury and illness incidence proportions (IP) were calculated as the number of cases per 100 athletes using the formula: ((number of injuries or illnesses/number of athletes)×100). Incidence (IR) was calculated

per 1000 AD using the formula: ((total number of injuries or illnesses/total number of AD)×1000). IPs and IRs were calculated both overall and by sex, sport type (team vs individual), anatomic location/body system, mechanism of injury and event type. Incidence rate ratios (IRR) were calculated to compare injury and illness rates between paediatric and non-paediatric athletes, Summer and Winter athletes, Olympic and Paralympic athletes, male and female athletes, and individual and team sport athletes. 95% CIs were calculated for incidence and IRR. All analyses were performed using R statistical software (R Foundation for Statistical Computing, Vienna, Austria) and all IR, IRR and 95% CIs were calculated as described above using the 'epiR' package.³⁵ Statistical significance for all IRR was set at a two sided a priori of $p < 0.05$.

RESULTS

Two hundred paediatric athletes (age, mean±SD: 19±2 years old, range: 15–21 years old) competed across the four Games periods (Tokyo 2020 SOG, n=97; Tokyo 2020 SPG, n=43; Beijing 2022 WOG, n=52; Beijing 2022 WPG n=8). Overall, paediatric athletes represented 16.1% of all Team USA athletes, and the Games period with the largest proportion of paediatric athletes was the Beijing 2022 WOG (29.1% of all Team USA athletes). The five sports with the largest number of paediatric athletes across the four Games periods were swimming/para-swimming (n=37), athletics/para-athletics (n=23), gymnastics (n=19), snowboard/para-snowboard (n=13), and ice hockey/sled hockey (n=12). The distribution and proportion of paediatric athletes by sport and Games period are presented in figure 1.

Overall incidence of injury and illness

Table 1 presents the overall incidence of injury and illness across the four Games periods, as well as between paediatric and non-paediatric athletes. Paediatric athletes sustained a total of 44 injuries (14.6% of all injuries) and 18 illnesses (14.8% of all illnesses). The overall injury IR (95% CI) was 13.4 (9.8 to 18.1) and was highest during the Tokyo 2020 SOG (IR, 15.7 (9.9 to 23.5)). The overall illness IR was 5.5 (3.3 to 8.7) and was highest during the Beijing 2022 WOG (IR, 9.1 (3.9 to 18.0)).

Overall, there were no differences in incidence between paediatric and non-paediatric athletes for either injury (IRR (95% CI), 0.9 (0.6 to 1.2), $p=0.47$) or illness (IRR (95% CI), 0.9 (0.5 to 1.5), $p=0.69$). When specifically comparing paediatric Olympic athletes to non-paediatric Olympic athletes, there were also no differences in injury (IRR (95% CI), 1.1 (0.7 to 1.5), $p=0.77$) or illness (IRR (95% CI), 1.1 (0.6 to 2.0), $p=0.80$) incidence. Likewise, there were no differences in injury (IRR (95% CI), 0.5 (0.2 to 1.1), $p=0.07$) or illness (IRR (95% CI), 0.6 (0.2 to 1.5), $p=0.25$) incidence when comparing paediatric Paralympic athletes to non-paediatric Paralympic athletes.

When comparing paediatric Olympic athletes to paediatric Paralympic athletes, there were also no differences

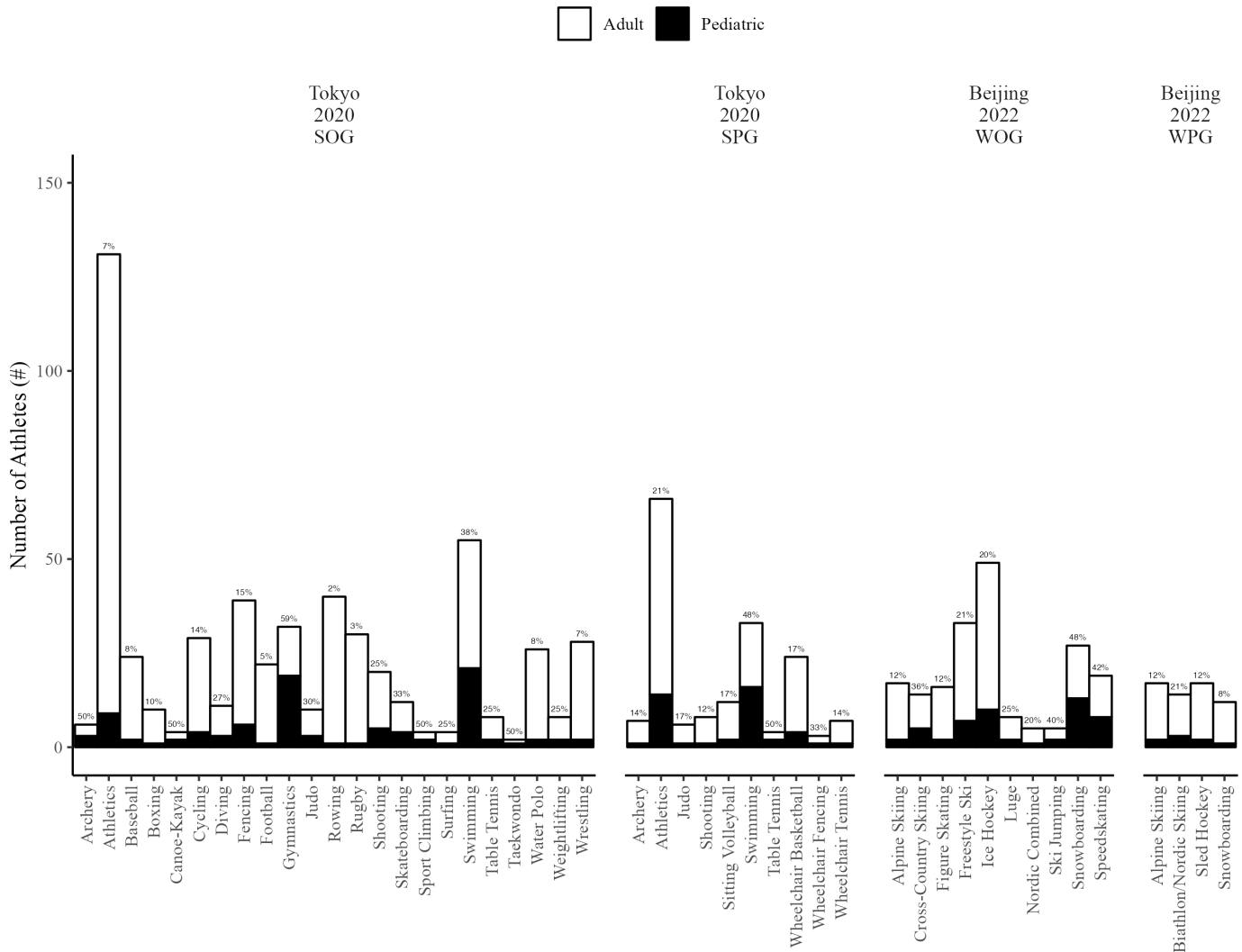


Figure 1 Distribution and proportion of paediatric and non-paediatric Team USA athletes across the four Games periods. SOG, Summer Olympic Games; SPG, Summer Paralympic Games; WOG, Winter Olympic Games.

in incidence of either injury (IRR (95% CI), 1.8 (0.8 to 4.4), $p=0.14$) or illness (IRR (95% CI), 1.0 (0.3 to 3.7), $p=0.96$). Finally, there were no differences in injury (IRR (95% CI), 0.9 (0.5 to 1.7), $p=0.64$) or illness (IRR (95% CI), 0.5 (0.2 to 1.3), $p=0.08$) incidence between paediatric athletes based on whether they competed in the Summer or Winter Games.

Incidence of injury and illness by sex

Incidence of injury and illness by sex among paediatric Team USA athletes is presented in [table 2](#). One-hundred and seventeen (58.5%) of the paediatric athletes were female, while 83 (41.5%) were male. Nearly one-quarter (23.1%) of all paediatric female athletes sustained an injury (IP, 29.1; IR, 17.6 (12.2 to 24.5)) across the four Game periods. The incidence of injury among female paediatric athletes was over two times greater than the rate of injury among male paediatric athletes (IRR (95% CI), 2.4 (1.1 to 5.3), $p=0.02$). There were no differences in illness incidence between female and male athletes (IRR (95% CI), 1.4 (0.5 to 4.5), $p=0.52$).

Incidence of injury and illness by sport type

Incidence of injury and illness by sport type (individual sport vs team sport) among paediatric Team USA athletes is presented in [table 3](#). Overall, the vast majority ($n=175$, 87.5%) of paediatric Team USA athletes participated in individual sports. The injury IR among individual sport athletes was 14.1 (10.1 to 19.2) compared with an injury IR of 9.1 (2.5 to 23.2) among team sport athletes. There were no differences in injury incidence between individual and team sport athletes (IRR (95% CI), 1.6 (0.6 to 6.0), $p=0.39$). The illness IR among individual sport athletes was 6.0 (3.5 to 9.6) compared with 2.3 (0.1 to 12.6) among team sport athletes. There was no difference in illness incidence between individual and team sport athletes (IRR (95% CI), 2.7 (0.4 to 110.9), $p=0.32$).

Incidence of injury and illness by anatomic location and body system

[Table 4](#) presents the incidence of injury or illness by anatomic region and body system among paediatric Team USA athletes. The lower limb was the anatomic

Table 1 Incidence of injury and illness by Games period and between paediatric and non-paediatric Team USA athletes

	Number of athletes competing	Number of athlete days	Number of injuries	Number of illnesses	Injury IR	95% CI		Illness IR	95% CI	
						Lower limit	Upper limit		Lower limit	Upper limit
Overall										
Paediatric	200	3273	44	18	13.4	9.8	18.1	5.5	3.3	8.7
Non-paediatric	1039	17062	258	104	15.1	13.3	17.1	6.1	5.0	7.4
All	1239	20335	302	122	14.9	13.2	16.6	6.0	5.0	7.2
Tokyo 2020 Olympics										
Paediatric	97	1470	23	5	15.7	9.9	23.5	3.4	1.1	7.9
Non-paediatric	604	9710	133	46	13.7	11.5	16.2	4.7	3.5	6.3
All	701	11180	156	51	14.0	11.9	16.3	4.6	3.4	6.0
Tokyo 2020 Paralympics										
Paediatric	43	795	6	4	7.6	2.8	16.4	5.0	1.4	12.9
Non-paediatric	201	3094	40	21	12.9	9.2	17.6	6.8	4.2	10.4
All	244	3889	46	25	11.8	8.7	15.8	6.4	4.2	9.5
Beijing 2022 Olympics										
Paediatric	52	878	13	8	14.8	7.9	25.3	9.1	3.9	18.0
Non-paediatric	179	3356	57	21	17.0	12.9	22.0	6.3	3.9	9.6
All	231	4234	70	29	16.5	12.9	20.9	6.9	4.6	9.8
Beijing 2022 Paralympics										
Paediatric	8	130	2	1	15.4	1.9	55.6	7.7	0.2	42.9
Non-paediatric	55	902	28	16	31.0	20.6	44.9	17.7	10.1	28.8
All	63	1032	30	17	29.1	19.6	41.5	16.5	9.6	26.4

region with the greatest injury proportions and rates (IP, 10.5; IR, 6.4 (4.0 to 9.8)). More specifically, the ankle (IP, 5.5; IR, 3.4 (1.7 to 6.0)) and the knee (IP, 2.5; IR, 1.5 (0.5 to 3.6)) were the most commonly injured anatomic locations. The illness categories with the highest proportions and rates were infections (IP, 2.5; IR, 1.5 (0.5 to 3.6)) and gastrointestinal conditions (IP, 1.5; IR, 0.9 (0.2 to 2.7)).

Incidence of injury by mechanism and event type

The incidence of injury by mechanism and event type among paediatric Team USA athletes is presented in [table 5](#). The most common mechanism of injury was

gradual onset (IP, 7.0, IR: 4.3 (2.3 to 7.2)), followed by acute contact and acute non-contact (both IP, 6.5, IR: 4.0 (2.1 to 6.8)). Injuries most often occurred during practice (IP, 11.5, IR: 7.0 (4.5 to 10.5)), followed by competition (IP, 6.0, IR: 3.7 (1.9 to 6.4)).

DISCUSSION

To our knowledge, this is the first study to describe the incidence of injury and illness among paediatric athletes competing across both the Summer and Winter Olympic and Paralympic Games. We found that paediatric

Table 2 Incidence of injury and illness by sex for paediatric Team USA athletes

	Total number of injuries or illnesses	Number of athletes with injury or illness	Total number of athletes competing	Total number of athlete days	Injury or Illness Incidence proportion (per 100 athletes)	Injury or illness incidence rate (per 1000 AD)	95% CI	
							Lower limit	Upper limit
Injury								
Male	10	10	83	1337	12.1	7.5	3.6	13.8
Female	34	27	117	1936	29.1	17.6	12.2	24.5
All	44	37	200	3273	22.0	13.4	9.8	18.1
Illness								
Male	6	5	83	1337	7.2	6.2	3.2	10.8
Female	12	10	117	1936	10.3	4.5	1.7	9.8
All	18	15	200	3273	9.0	5.5	3.3	8.7

Table 3 Incidence of injury and illness by sport type among paediatric Team USA athletes

	Total number of injuries or illnesses	Number of athletes with injury or illness	Total number of athletes competing	Total number of athlete days	Injury or Illness Incidence proportion (per 100 athletes)	Injury or illness incidence rate (per 1000 AD)	95% CI	
							Lower limit	Upper limit
Injury								
Individual	40	34	175	2831	22.9	14.1	10.1	19.2
Team	4	3	25	442	16.0	9.1	2.5	23.2
All	44	37	200	3273	22.0	13.4	9.8	18.1
Illness								
Individual	17	14	175	2831	9.7	6.0	3.5	9.6
Team	1	1	25	442	4.0	2.3	0.1	12.6
All	18	15	200	3273	9.0	5.5	3.3	8.7
Individual sports: alpine skiing/para alpine skiing, archery/para archery, athletics/para athletics, para biathlon, boxing, canoe-kayak, cross-country skiing, cycling, diving, fencing, figure skating, freestyle skiing, gymnastics, judo/para judo, luge, Nordic combined, shooting, skateboarding, ski jumping, snowboard/para snowboard, speedskating, sport climbing, surfing, swimming/para swimming, table tennis/para table tennis, taekwondo, weightlifting, wheelchair fencing, wheelchair tennis, wrestling. Team sports: baseball, football, rowing, rugby, water polo, sitting volleyball, wheelchair basketball, ice hockey, sled hockey.								

non-paediatric athletes sustained injuries and illnesses at similar rates. Further, female paediatric athletes were more likely to sustain an injury compared with male paediatric athletes, most paediatric athletes competed in individual sports, and the most common types of illness among paediatric athletes were infections and gastrointestinal conditions. We also observed that most injuries occurred to the ankle or knee, were gradual onset in nature and most often occurred during practice. Our data highlight the potential opportunities and need for healthcare providers working with elite paediatric athletes to develop interventions that focus on reducing injury rates among female paediatric athletes, with a specific focus on preventing lower extremity and gradual onset injuries.

Paediatric athletes represented approximately 1 in 6 of all Team USA athletes competing over the four Games periods examined in this study. It is well documented that the care of paediatric athletes at both the elite and non-elite levels requires unique considerations in terms of psychosocial health, hormonal maturation and injury characteristics.^{1 17 36 37} Overall, we observed a similar burden of injury and illness in paediatric Team USA athletes compared with non-paediatric athletes, with no differences in either injury or illness rates between those groups. Therefore, it is essential that paediatric sports medicine experts be included as part of the larger sports medicine team during the Olympic and Paralympic Games due to the large proportion of paediatric athletes and the similar rates of injury and illness seen in the population compared with their adult teammates.

While we found no differences in illness rates between male and female athletes, paediatric female athletes were more than twice as likely to sustain an injury compared with male athletes (IRR (95% CI), 2.4 (1.1 to 5.3)). Increased risk of injury among female paediatric athletes has been documented among both secondary

school^{14 16 18 38} and collegiate^{39 40} athletes for a variety of sports and injury types, including concussion,^{14 40} lower extremity injury^{40–42} and gradual onset injuries.^{16 38 39} While we lack the sample size to make statistical comparisons between injury location or mechanism based on sex, in our data female athletes sustained all (100%) reported head injuries, 76% of all reported lower extremity injuries, and 57% of all gradual onset injuries. In contrast, data from recent Youth Olympic Games^{24 28} and SOG/WOG^{7–9} have typically reported no differences in injury rates between male and female athletes. Therefore, further research should focus on potential disparities in injury rates among paediatric female and male elite athletes, and whether these disparities are similar to those previously observed in other populations of paediatric athletes, as any potential differences are likely influenced by various factors, including injury type, sport, athlete's biological, developmental and training age, as well as the training environment specific to youth athletes. In the meantime, providers working with elite female paediatric athletes should focus preventative efforts towards reducing the risk of head injuries, lower extremity injuries and gradual onset injuries, using techniques previously established as effective.^{43–45}

During the previous four Games periods, paediatric Team USA athletes competed predominantly in individual sports compared with team sports. Previous research in a general sample of youth athletes reported that individual sport athletes were at greater risk of injury, and specifically overuse injury, compared with team sport athletes.⁴⁶ While we observed no differences in injury or illness rates between individual sport participants and team sport participants (IRR (95% CI), 1.6 (0.6 to 6.0)), we did find that gradual onset was the most common mechanism of injury among paediatric Team USA athletes. Additionally, the gradual onset injury rate that we observed among paediatric Team USA athletes

Table 4 Incidence of injury or illness by anatomic location and body system for paediatric Team USA athletes

Anatomic location	Total number of injuries	Number of athletes with an injury	Injury or illness incidence proportion (per 100 athletes)	Injury or illness incidence rate (per 1000 AD)	95% CI	
					Lower limit	Upper limit
Head/face/neck	5	5	2.5	1.5	0.5	3.6
Head/face	4	4	2.0	1.2	0.3	3.1
Neck	1	1	0.5	0.3	0.0	1.7
Upper limb	7	6	3.5	2.1	0.9	4.4
Shoulder	4	3	2.0	1.2	0.3	3.1
Upper arm	1	1	0.5	0.3	0.0	1.7
Elbow	1	1	0.5	0.3	0.0	1.7
Forearm	0	0	0.0	0.0	0.0	0.0
Wrist/hand	1	1	0.5	0.3	0.0	1.7
Torso	11	11	5.5	3.4	1.7	6.0
Chest	1	1	0.5	0.3	0.0	1.7
Trunk/abdomen	1	1	0.5	0.3	0.0	1.7
Thoracic spine	2	2	1.0	0.6	0.1	2.2
Lumbar spine	4	4	2.0	1.2	0.3	3.1
Pelvis/buttocks	1	1	0.5	0.3	0.0	1.7
Hip/groin	2	2	1.0	0.6	0.1	2.2
Lower limb	21	20	10.5	6.4	4.0	9.8
Thigh	1	1	0.5	0.3	0.0	1.7
Knee	5	5	2.5	1.5	0.5	3.6
Lower leg	2	2	1.0	0.6	0.1	2.2
Ankle	11	10	5.5	3.4	1.7	6.0
Foot	2	2	1.0	0.6	0.1	2.2
Body system	Total number of illnesses	Number of athletes with an illness	Injury or illness incidence proportion (per 100 athletes)	Injury or illness incidence rate (per 1000 AD)	95% CI	
					Lower limit	Upper limit
Cardiovascular	1	1	0.5	0.3	0.0	1.7
Dermatologic	2	2	1.0	0.6	0.1	2.2
ENT	1	1	0.5	0.3	0.0	1.7
Eye and ocular adnexa	0	0	0.0	0.0	0.0	0.0
Gastrointestinal	3	3	1.5	0.9	0.2	2.7
Genitourinary	0	0	0.0	0.0	0.0	0.0
Infection	5	5	2.5	1.5	0.5	3.6
Neurological	1	1	0.5	0.3	0.0	1.7
Respiratory	2	2	1.0	0.6	0.1	2.2
Rheumatological	0	0	0.0	0.0	0.0	0.0
Undiagnosed	3	3	1.5	0.9	0.2	2.7

(IR, 4.3 (2.3 to 7.2)) was similar to overuse injury rates in previous epidemiological studies of paediatric athletes at both the collegiate (IR, 5.4 (5.2 to 5.5))³⁹ and secondary school (IR, 5.3 (5.1 to 5.7))¹⁶ levels. Therefore, despite having access to what may be assumed to be improved coaching, training periodisation, and healthcare, paediatric Olympic and Paralympic athletes appear to sustain

overuse injuries at similar rates to paediatric athletes with fewer resources at the secondary school level. The intensive training demands required to participate at the Olympic or Paralympic level, as well as the demands of increasingly specialised participation at lower levels of sport, both appear to result in injuries due to overuse in a significant number of paediatric athletes.

**Table 5** Incidence of injury by mechanism and event type for paediatric Team USA athletes

	Total number of injuries	Number of athletes with an injury	Injury or illness incidence proportion (per 100 athletes)	Injury or illness incidence rate (per 1000 AD)	95% CI	
					Lower limit	Upper limit
Mechanism						
Acute: contact	13	11	6.5	4.0	2.1	6.8
Acute: non-contact	13	10	6.5	4.0	2.1	6.8
Gradual onset	14	14	7.0	4.3	2.3	7.2
Undisclosed	4	4	2.0	1.2	0.3	3.1
Event type						
Practice	23	19	11.5	7.0	4.5	10.5
Competition	12	11	6.0	3.7	1.9	6.4
Non-sport	4	4	2.0	1.2	0.3	3.1
Undisclosed	5	5	2.5	1.5	0.5	3.6

Clinical implications

Sport epidemiological data provide information regarding the distribution and causes of injuries and illnesses within an athletic population, which in turn can help drive evidence-based clinical decision-making. The results of this study highlight the potential opportunities to develop and implement targeted injury and illness reduction programmes among paediatric Olympic and Paralympic athletes. Specifically, programming should focus on reducing injury rates among female athletes, and in particular should use strategies to reduce the risk of lower extremity and gradual onset injuries in these athletes.

Limitations

Our study has several limitations. First, this is a descriptive study that reports only the epidemiological data from a single country's delegation's injury/illness surveillance system during the most recent four Games periods. Therefore, we are unable to determine whether the incidence of injury and illness among paediatric athletes differs based on the characteristics of various National Olympic and Paralympic Committees, such as geographical region or delegation size. Future research using other designs and analyses is needed to explore the potential causal relationships between variables of interest and injury. Additionally, by limiting to the most recent four Games periods, we are not able to examine trends over time in the experiences of paediatric Olympic and Paralympic athletes. Future research should include athletes from a variety of delegations and over a longer duration to better understand the burden of injury and illness within paediatric Olympic and Paralympic athletes, and how paediatric injury and illness may manifest during the transition to adult athletic careers. For our comparison of injury and illness rates between paediatric and non-paediatric athletes, we did not match participants based on demographics such as sport or sex, which may

be confounders when examining potential differences in injury or illness rates between these populations. Since we did not track exposures at the event-type level and rather used athlete-days as our measure of exposure, we were not able to compare injury/illness incidence between practices and competitions. Therefore, the fact that injuries most commonly occurred during practices may reflect a greater number of practice sessions compared with competitions during a Games period, rather than truly increased risk during practices as compared with competitions. Additionally, due to limitations in the EMR system used for surveillance during the Games periods in this study, we were unable to determine time loss from sport, so we are not able to describe injury burden among paediatric Team USA athletes. Finally, while we included a quality control process within our data collection procedures, the data presented in this paper is ultimately dependent on accurate and complete documentation by the medical providers delivering care as well as accurate reporting by the Team USA athletes competing during the four Games periods.

CONCLUSIONS

Paediatric athletes accounted for approximately one in six Team USA athletes competing during the Tokyo 2020 and Beijing 2022 Olympic and Paralympic Games. Paediatric athletes were just as likely to sustain injuries and illnesses as their adult teammates, highlighting the importance of paediatric sports medicine expertise among healthcare providers during the Olympic and Paralympic Games. Female paediatric athletes were more than twice as likely to sustain an injury compared with male paediatric athletes, most injuries were gradual onset in nature, and injuries occurred most often during practice, highlighting potential areas for injury reduction interventions.

Author affiliations

¹Department of Sports Medicine, United States Olympic and Paralympic Committee, Colorado Springs, CO, USA

²United States Coalition for the Prevention of Illness and Injury in Sport, Colorado Springs, CO, USA

³Texas Children's Hospital, Houston, Texas, USA

⁴Baylor College of Medicine, Houston, Texas, USA

⁵Family Medicine, Rehabilitation and Performance Medicine Swedish Medical Group, Seattle, Washington, USA

⁶Department of Physical Medicine and Rehabilitation, Mayo Clinic, Rochester, New York, USA

⁷Department of Physical Medicine and Rehabilitation, Harvard Medical School, Boston, Massachusetts, USA

⁸Department of Physical Medicine and Rehabilitation, University of Colorado, Denver, CO, USA

⁹Department of Kinesiology, University of North Carolina at Greensboro, Greensboro, NC, USA

¹⁰School of Sport, Exercise, and Health Sciences, Loughborough University, Leicestershire, UK

Twitter William M Adams @william_m_adams

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ORCID iDs

Eric G Post <http://orcid.org/0000-0003-0268-0460>

Travis Anderson <http://orcid.org/0000-0001-5292-7877>

Amber T Donaldson <http://orcid.org/0009-0002-8057-4911>

Jonathan T Finnoff <http://orcid.org/0000-0003-3635-3919>

William M Adams <http://orcid.org/0000-0001-7372-8455>

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