

## **Illness among Paralympic Athletes – Epidemiology, Risk Markers and Preventative Strategies**

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## **Abstract**

**Background:** Paralympic athletes have unique pre-existing medical conditions that predispose them to increased risk of illness, but data are limited to studies conducted during the last three Paralympic Games.

**Objectives:** To review the epidemiology of illness (risk, patterns, and predictors) in Paralympic athletes, and provide practical guidelines for illness prevention.

**Methods:** A search on PubMed, CINAHL, Google Scholar and SPORTDiscus, was conducted using keywords in different combinations: Paralympic, impairment, disability, illness, prevention of illness, medical conditions, international sporting events and athletes. Of the 87 identified publications, 3 were related to the epidemiology of illness, 12 were related to unique medical problems, and 8 referred to preventative measures.

**Results:** The incidence rate of illness (per 1000 athlete days) in Paralympic athletes is high in Summer (10.0-13.2) and Winter (18.7) Paralympic Games. The incidence proportion of illness (% athletes with illness) is almost double in Paralympic compared to Olympic athletes for Summer (Paralympic = 12.4-14.2%; Olympic = 5-7%) and Winter Games (Paralympic = 17.4%; Olympic = 8%). The incidence of illness is highest in the respiratory system, skin / subcutaneous tissue, gastro intestinal tract (GIT) and genitourinary tract (GUT). Data on extrinsic (pre-competition vs. competition period, travel, training load, etc.) and intrinsic (sex, age, impairment type and unique underlying medical conditions) risk markers for illness are limited. In one study, using multi-variate analysis, athletics was associated with a higher risk of illness compared to other sporting codes. There are no published guidelines for prevention of illness in Paralympic athletes and we suggest general and specific preventative strategies to reduce the risk of illness in these athletes.

**Conclusion:** Paralympic athletes have a high risk of illness during times of competition, but risk markers for illness require further investigation. We propose general and specific guidelines on preventative strategies regarding illness in these athletes.

Abstract: word count 299

## **Introduction**

The Paralympic movement, through its International Paralympic Committee (IPC) Medical Code, is committed to ensure athlete health, and the IPC encourages all initiatives and measures to minimize the risk of injury and illness in Paralympic athletes (<https://www.paralympic.org/ice-hockey/athletes/health>; accessed 25 August 2017). One of these initiatives is to conduct injury and illness epidemiological studies during the Paralympic Games in order to identify the patterns of injury and illness, as well as identify risk factors associated with injury and illness. Such epidemiological studies have been conducted for injuries since 2002 at the Winter Paralympic Games<sup>1-3</sup>, and from 2012 for injury<sup>4,5</sup> and illness at the Summer<sup>4,6</sup>, and Winter Paralympic Games.<sup>3</sup> Although the injury profile of Paralympic athletes has been better-studied<sup>1-5</sup>, the literature on the illness profiles is limited to studies conducted at the London 2012 Summer Paralympic Games, the Sochi 2014 Winter Paralympic Games and the Rio 2016 Summer Paralympic Games.<sup>3,4,6</sup> Data from these studies can be used to design preventative strategies to reduce the risk of injury and illness in order to protect the health of Paralympic athletes.

Until recently, studies focused mostly on injury and injury prevention. However, illness is at least as important as injury, since it not only affects the athlete during the competition period, but also has a potential long-term effect on the health of the athlete after the competition period.<sup>4,7-9</sup> Paralympic athletes, in contrast to Olympic athletes potentially have a range of pre-existing medical conditions, and these athletes therefore face unique medical problems such as autonomic dysfunction, neurogenic

bladder, neurological disorders, premature osteoporosis and stump socket interface complications that can predispose them to an increased risk of further illness.<sup>1,10,11</sup>

The aim of this manuscript is to review illness in Paralympic athletes in the following 3 aspects: 1) the risk of illness, 2) patterns of illness, and 3) possible predictors of illness in Paralympic athletes that may predispose them to illness before, during and after competitions. Finally, we also want to suggest practical guidelines for the prevention of illness in Paralympic athletes.

## **Methodology**

A literature search was conducted to source published information on 1) the risk of illness, 2) patterns of illness and 3) possible predictors of illness in Paralympic athletes. Our search strategy to obtain relevant peer reviewed publications was based on the methodology employed in systematic reviews. A search was conducted on the PubMed, CINAHL, Google Scholar and SPORTDiscus databases, using the following keywords in different combinations: Paralympic, impairment, disability, illness, prevention of illness, medical conditions, international sporting events and athletes. We included only publications in English, and studies that involved human participants. After removing duplicates, the initial search revealed 66 publications. A further 21 publications were sourced from the reference lists of the reviewed publications. Two researchers (CJvR and MS), then independently reviewed the abstracts from these 87 publications, using the following inclusion criteria for studies in this review:

- Studies involving Paralympic athletes of all levels (recreational to elite) and sports;
- Studies involving a Paralympic Games setting
- Studies where a specific definition of illness was included and explained

For uniformity in reporting, we only used publications that defined illness as ‘any athlete requiring medical attention, regardless of the consequences with respect to absence from competition *or training*’. 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 or during or

immediately before the Winter/Summer Paralympic Games.<sup>3,6,12,13</sup> The final number of studies included in this narrative review of the risk of illness, patterns of illness and possible predictors of illness in Paralympic athletes was three. From the initial search (87 publications), all publications that related to the unique medical problems suffered by Paralympic athletes (12 publications), as well as those publications referring to general preventative measures (8 publications), were included for the final part of this manuscript.

### **Risk of illness in Paralympic athletes**

#### *Incidence rate (IR) and incidence proportion (IP) of illness in Paralympic athletes vs. Olympic athletes*

The incidence of illness (Incidence Rate - IR) (per 1000 athlete days) and the incidence proportion of illness (IP) (% of all athletes with illness during the Games) in Paralympic athletes compared to Olympic athletes competing in both the Summer- and Winter Games are presented in Table 1. The first main observation from this table is that the IR in Paralympic athletes during the Summer Games varies from 10.0 to 13.2 (Rio 2016 Paralympic Games and London 2012 Paralympic Games). This implies that in a team of 100 athletes, the team physician will consult with about one ill athlete each day. A second observation is that in Paralympic athletes the IR is significantly higher in the Winter Games (Sochi 2014) (18.7; 95% CI, 15.1-23.2) compared both with the London (13.2; 95% CI, 12.2-14.2) and Rio (10.0; 95% CI, 9.2-10.9) Summer Games.

A further observation is that the IP of illness is almost twice as high in Paralympic compared to Olympic athletes, and this is evident in both the Summer (Paralympic = 12.4-14.2%; Olympic = 5-7%) and Winter Games (Paralympic = 17.4%; Olympic = 9%). Therefore, these data indicate that Paralympic athletes are at higher risk of contracting an illness during the Winter-, compared to the Summer Games, and that Paralympic athletes are at higher risk of illness compared with Olympic athletes.

**Table 1: The number of athletes, athlete days, number of illnesses, incidence proportion (IP), and incidence (per 1000 athlete days) of illness in the Summer- and Winter Paralympic and Olympic Games**

			<b>Athletes</b>	<b>Athlete days</b>	<b>No of illnesses</b>	<b>No of athletes with illness</b>	<b>IP (% athletes with illness)</b>	<b>IR / 1000 athlete days</b>	<b>IR 95% CI</b>
<b>Summer Games</b>	<b>Paralympic Games</b>	<b>London</b>	3565	49910	657	505	14.2	13.2	12.2 - 14.2
		<b>Rio</b>	3657	51198	511	454	12.4	10.0	9.2 - 10.9
	<b>Olympic Games</b>	<b>London</b>	10568	179656*	758	-	7.2	4.2**	-
		<b>Rio</b>	11274	191658*	613	587	5.4	3.2**	-
<b>Winter Games</b>	<b>Paralympic Games</b>	<b>Sochi (Winter)</b>	547	6564	123	95	17.4	18.7	15.1 - 23.2
	<b>Olympic Games</b>	<b>Sochi (Winter)</b>	2780	50040*	249	-	8.9	5.0**	-

IP: Incidence proportion (% illness in athletes)

IR: Incidence rate of illness (per 1000 athlete days)

\*: Estimated Athlete days (calculated as the total quantity of participating athletes multiplied by the number of days at the games. *Limitation:* assumption that all athletes were present for all days)

\*\*: Estimated IR

**Table 2: The number, percentage of all illnesses, incidence proportion of illness and incidence rate (per 1000 athletes) of illness in different organ systems in Paralympic athletes during the Summer- and Winter Paralympic Games**

	Summer Paralympic Games								Winter Paralympic Games			
	London 2012				Rio 2016				Sochi 2014			
	N*	%	IP	IR	N*	%	IP	IR	N*	%	IP	IR
Respiratory	180	29%	27.4	3.6	167	33%	4.4	3.3	37	30%	5.5	5.6
Skin and subcutaneous	120	20%	18.3	2.4	91	18%	2.4	1.8	16	13%	2.4	2.4
Digestive	95	15%	14.5	1.9	66	13%	1.8	1.3	16	13%	2.6	2.4
Genitourinary	56	9%	8.5	1.1	55	11%	1.5	1.1	8	7%	1.5	1.2
Nervous	63	10%	9.6	1.3	21	4%	0.5	0.4		0%		
Mental and behavior	7	1%	1.1	0.1	19	4%	0.5	0.4	8	7%	1.5	1.2
Ears and mastoid	44	7%	6.7	0.9	15	3%	0.4	0.3		0%		
Eye and adnexa	25	4%	3.8	0.5	13	3%	0.4	0.3	18	15%	3.1	2.7
Circulatory	3	0%	0.5	0.1	12	2%	0.3	0.2		0%		

N: number of illnesses

%: % of illness in organ systems

IP: Incidence proportion (% illness in athletes)

IR: Incidence rate of illness (per 1000 athlete days)

\*Illness in other systems were not included (London n=64, Rio n= 52, Sochi n=20)

### *Incidence of illness in Paralympic athletes in different organ systems*

The IR and IP of illness in Paralympic athletes in different organ systems during the Summer- and Winter Paralympic Games are represented in Table 2. The main observation is that the IR of illness in Paralympic athletes is consistently highest in the respiratory system, followed by skin and subcutaneous tissue, gastro intestinal tract (GIT) and genitourinary tract (GUT). In both the Summer and Winter Paralympic Games, illness was most common in the respiratory system. However, we note that during the Summer Paralympic Games there was a higher incidence of skin, nervous system and ear, nose, and throat (ENT) involvement compared to the Winter Paralympic Games, while mental illness and eye involvement were more common in the Winter Paralympic Games. (Table 2). Therefore, the overall pattern of illness affecting the different organ systems in Paralympic athletes during competition, show a very consistent pattern (respiratory, dermatological and digestive being the most common) but there are small differences in illness affecting organ systems during the Summer Games vs. the Winter Games.

### **Risk markers for illness in Paralympic athletes**

The identification of risk markers for illness is a key element in the development of any intervention strategy for illness. However, from our literature search, to date there are very limited data on extrinsic (pre-competition vs. competition period, sport code, medication and other), and intrinsic (age, sex and other,) risk markers for illness in Paralympic athletes. Indeed, we are only aware of four epidemiological studies where risk markers for illness in Paralympic athletes were explored.<sup>3,6,12,13</sup> In three of these studies<sup>3,12,13</sup>, only uni-variate analysis was performed, and in only one study<sup>6</sup> a regression model was applied to identify independent risk markers for illness in Paralympic athletes. Therefore, although data to identify risk markers for illness are very limited, we will review the evidence for these risk markers accordingly.



#### Pre-competition vs. Competition period

Evaluation of Pre-competition vs. Competition illness allows an indirect evaluation of the health status of athletes arriving in the Games setting. In one study during the 2010 Winter Paralympic Games, 2717 medical encounters were recorded (657 athletes, 682 International Federation/National Paralympic Committee officials, 57 International Paralympic Committee officials, 1075 workforce, 8 media, 127 spectators and 111 others). The investigators reported a higher incidence of medical encounters during the competition period.<sup>16</sup> However, since there was no distinction made between non-athletes and athletes, or between injury and illness, the pre-competition or competition periods could not be identified as extrinsic risk markers for illness from this study. In contrast, data from two recent prospective studies during the Summer Paralympic Games showed no difference in the IR of illness (per 1000 athlete days) between the pre-competition (London 2012 – IR 14.6; 95 % CI 12.4-17.1; Rio 2016 – IR 9.6; 95 % CI 7.9-11.6) vs. the competition period (London 2012 – IR 12.8; 95 % CI 11.7-17.1; Rio 2016 – IR 10.1; 95 % CI 9.2-11.1).<sup>6,13</sup> Therefore, the pre-competition vs. the competition period do not appear to be extrinsic risk markers for illness in Paralympic athletes.

#### Sport code

The IR of illness per 1000 athlete days as well as the IP of illness in Paralympic athletes per Summer sport codes is summarized in Table 3a. Reviewing the uni-variate data available from 2 datasets, the risk of illness differed between sporting codes. In London 2012 equestrian sports (20.7), powerlifting (15.8), athletics (15.4) and table tennis (15.2) had higher crude un-adjusted IR of illness compared to all other sports. In Rio 2016 wheelchair fencing (14.9), swimming (12.6) and wheelchair basketball (12.5) were the sporting codes with the highest IR. However, multi-variate regression analysis was only performed on the London 2012 data, and this showed that only athletics (adjusted for gender and age) was associated with a higher risk of illness compared to other sporting codes ( $p=0.01$ ). Therefore, Paralympic athletes participating in athletics during the Summer Paralympic Games appear to be more susceptible to illness compared with other sporting codes. However, this conclusion is based on only a

**Table 3a: The number of illnesses, percentage of total number of illnesses, incidence proportion and incidence rate of illness in different Summer Paralympic sporting codes**

	London 2012				Rio 2016			
Summer Paralympic Sporting Code	Total number of athletes competing in the sport code	Total number of illnesses in the sport code	IP in the sport code	IR in the sport code	Total number of athletes competing in the sport code	Total number of illnesses in the sport code	IP in the sport code	IR in the sport code
Archery	128	20	15.6	11.2	113	14	10.6	8.9
Athletics	977	210	21.5	15.4	894	129	12.9	10.3
Boccia	98	16	16.3	11.7	99	17	16.2	12.3
Canoe	\$	\$	\$	\$	52	10	17.3	13.7
Cycling (track and road)					204	30	13.2	10.5
Cycling—road	182	36	19.8	14.1				
Cycling—track	92	16	17.4	12.4				
Equestrian	69	20	29	20.7	71	9	11.3	9.1
Football 5-a-side	70	8	11.4	8.2	70	4	5.7	4.1
Football 7-a-side	96	3	3.1	2.2	112	5	4.5	3.2
Goalball	110	13	11.8	8.4	102	8	7.8	5.6
Judo	115	15	13	9.3	115	6	5.2	3.7
Powerlifting	163	36	22.1	15.8	141	16	9.9	8.1
Rowing	91	18	19.8	14.1	88	12	13.6	9.7
Sailing	70	13	18.6	13.3	76	12	13.2	11.3
Shooting	33	2	6.1	4.3	130	22	16.9	12.1
Sitting volleyball	154	22	14.3	10.2	127	14	10.2	7.9
Swimming	499	91	18.2	13	492	87	15.4	12.6
Table tennis	226	48	21.2	15.2	223	29	12.1	9.3
Triathlon	\$	\$	\$	\$	58	4	6.9	4.9
Wheelchair basketball	202	40	19.8	14.1	228	40	14.5	12.5
Wheelchair fencing	95	16	16.8	12	72	15	15.3	14.9

Wheelchair rugby	79	12	15.2	10.8	96	18	15.6	13.4
Wheelchair tennis	106	20	18.9	13.5	94	10	7.4	7.6

IP: Incidence proportion (% illness)

IR: Incidence rate of illness (per 1000 athlete days)

\$ - sport code only included from 2016

**Table 3b: The number of illnesses, percentage of total number of illnesses, incidence proportion and incidence rate of illness in different Winter Paralympic sporting codes**

Winter Paralympic Sporting Code	Total number of athletes competing in the sport code	Total number of illnesses in the sport code	IP in the sport code	IR in the sport code
Alpine skiing/snowboarding	219	51	18.7	19.4
Cross-country skiing/biathlon	149	30	16.1	16.8
Ice sledge hockey	129	30	14	19.4
Wheelchair curling	50	12	24	20

IP: Incidence proportion (% illness)

IR: Incidence rate of illness (per 1000 athlete days)

single study where sporting code, as a risk marker for illness, was assessed using multi-variate analysis.

The IR of illness per 1000 athlete days as well as the IP of illness in Paralympic athletes per Winter sport codes is summarized in Table 3b. During the Sochi 2014 Winter Paralympic Games, the IR of illness was similar in four sporting categories. Again, based on very limited data, sporting code is not an independent risk marker for illness in Winter Paralympic athletes.

#### Other possible extrinsic risk markers for illness

It is well recognized that there are many more risk markers (travel, training load, competition load, nutrition, personal habits, etc.) that may contribute to increased risk of illness in elite athletes and these risk markers were recently reviewed.<sup>17</sup> However, these markers have not been researched in Paralympic athletes. It would be reasonable to assume that extrinsic risk markers for illness in elite Olympic athletes such as training load, travel and change of environment, would be equally applicable to Paralympic athletes.

Presently, data indicate that high absolute training and competition loads are associated with an increased risk of illness in sub-elite and recreational athletes (J-shaped curve), but are not related to increased risk of illness in elite athletes (S-shaped curve).<sup>17</sup> It has been suggested that training monotony is a possible risk marker for increased risk of illness. In elite cross-country skiers there was a lower risk of illness in the period when little changes were added to training load<sup>18</sup> but this finding could not be reproduced in a group of 32 rugby league players where training monotony was associated with a higher risk of illness.<sup>19</sup> The relationship between training load and illness in Paralympic athletes requires further study. Competition load has also been associated with increased risk of illness<sup>20</sup>, but this has not yet been studied systematically in Paralympic athletes.

The modern-day Paralympic athlete needs to travel globally, often across multiple time zones to compete. A study by Schwellnus et al.<sup>20</sup> showed that elite able-bodied athletes travelling to

international destinations crossing more than 5 time zones distant from their home country has a potential 2–3 times increased risk of all illness, in comparison to return to home travel. The same pattern was seen for respiratory tract illness, GIT illness and all infective illness. Thus an increase in the incidence of illness may also be associated with the distant destinations, rather than with travel per se. In another prospective study, international travel was also reported as an independent risk factor for illness among elite cross-country skiers.<sup>18</sup> Changes in environmental conditions (e.g. temperature, humidity, climate, altitude, pollution and pollens), nutrition and exposure to diverse cultures, populations and pathogens could all be involved.<sup>20</sup> Winter Paralympic Games compared to Summer Paralympic Games may also be associated with an increased risk of illness due to weather conditions and seasonal change. The relationship between international travel and changes in environmental conditions as risk markers for illness in Paralympic athletes requires further investigation.

Finally, other extrinsic risk markers for illness in Paralympic athletes, such as nutrition and personal habits have not been studied. These are important and should also be further investigated.

#### *Intrinsic risk markers for illness in Paralympic athletes*

##### Age

Crude un-adjusted IR's of illness in the Sochi 2014 Winter Paralympic Games and the Rio 2016 Summer Paralympic Games indicate that older athletes (above 35 years) had a higher IR of illness compared to younger athletes (Sochi 2014 - IR 22.6; 95 % CI, 16.0-31.9; Rio 2016 - IR 11.8; 95 % CI, 10.3-13.4).<sup>3,13</sup> However, adjusted IR's from the London 2012 Summer Paralympic Games, did not confirm that the older Paralympic athlete is at higher risk of illness.<sup>6</sup>

##### Sex

Sex does not appear to be an intrinsic risk marker for illness in Paralympic athletes. In the London 2012 Summer Paralympic Games, adjusted IR's of illness in female and male Paralympic athletes were not different.<sup>6</sup> Similarly, crude un-adjusted IR's of illness were similar in female and male

Paralympic athletes during the Sochi 2014 Winter Paralympic Games (Females - IR 18.1; 95 % CI, 11.6-28.3; Males - IR 18.9; 9% CI, 14.9-24.2).<sup>3</sup> However, in the Rio 2016 Summer Paralympic Games, Derman et al. reported that females had a higher risk of illness compared to males (Females - IR 11.1; 95 % CI, 9.7-12.7: Males - IR 9.3, 95 % CI, 8.3-10.4)<sup>13</sup>, but these were crude un-adjusted IR's. Therefore, we conclude that sex is not an intrinsic risk factor for illness in Paralympic athletes, but this also requires further research.

#### Other possible intrinsic risk markers for illness in Paralympic athletes

There are other potential intrinsic risk markers for illness in Paralympic athletes including impairment type, underlying unique medical problems in Paralympic athletes, and others. In general, research to identify these as independent intrinsic risk markers for illness is very limited.

#### Impairment Type

Although the classification system has recently been changed, literature identified for this review reported data based on the previous system, i.e. Spinal-cord related injury (SCI), amputation or limb deficiency, cerebral palsy (CP), *Les Autres* (all others), Visual impairment and Intellectual impairment.<sup>10</sup> There are data suggesting that the type of impairment is an intrinsic risk marker for illness in Paralympic athletes. For the London 2012 Summer Paralympic Games the highest proportion of illness was reported in athletes with SCI (115 illnesses; 29.9% of all illnesses) followed by athletes with amputation or limb deficiency (102 illnesses; 26.5% of all illnesses) and athletes with visual impairment (81 illnesses, 21% of all illnesses). Similarly, in the Rio 2016 Summer Paralympics Games, athletes with SCI had the highest proportion of illnesses (162 illnesses, 31.7% of all illnesses), followed by athletes with limb deficiency (118 illnesses, 23.1% of all illnesses), and central neurologic injury (79 illnesses, 15.5% of all illnesses) (Table 4). The major limitations of these data are that there was no control group of uninjured athletes for the various impairment types. Therefore, true IR, and adjusted IR, could not be reported. These are important areas for further research so that targeted prevention program for illness prevention in higher risk groups can be developed and implemented.

**Table 4: The total number of reported illnesses (on the WEB-ISS system), and the percentage of illnesses by impairment type\* during the Summer Paralympic Games**

	London 2012 (WEB-ISS data)		Rio 2016 (WEB-ISS data)	
	Total number of illnesses	% of total number of illnesses	Total number of illnesses	% of total number of illnesses
Spinal cord injury	115	29.9%	162	31.7%
Limb deficiency (amputation, dysmelia, congenital deformity)	102	26.5%	118	23.1%
Central neurologic injury (cerebral palsy, traumatic brain injury, stroke, other neurologic impairment)	38	9.9%	79	15.5%
Visual impairment	81	21%	62	12.1%
Intellectual impairment	10	2.6%	27	5.3%
Les Autres (non-spinal polio myelitis, ankylosis, leg shortening, joint movement restriction, nerve injury resulting in local paralysis)	39	10.1%	13	2.5%
Other			31	6.1%
Unknown			6	1.2%
Short stature			13	2.5%

\*Previous classification system used to conform as per reported in the identified publications

**Table 5: Unique medical conditions (including mechanisms and pathophysiology) in Paralympic athletes that may predispose to illness risk**

Impairment type	Illness risk	Mechanism / Pathophysiology	Preventative measures
<b>Spinal-cord related injury (SCI)</b>	Heat illness / Hypothermia	Altered regulation of body temperature: Loss of ANS if level above T8 Loss of mechanisms such as sweating and shivering Medication use Loss of sensation	Prevent dehydration and heat illness Use of cooling vests, water sprays, cooling fans (combined with wetted hair and head) Emersion of hands and wrists in cold water Nutritional interventions Appropriate clothing
	Urinary tract infection	Neurogenic bladder: Dehydration Incomplete voiding Increased pressure Catheter use Poor hand hygiene	Proper hydration Good hand hygiene & sanitation Regular bladder emptying Antiseptic catheterization Routine (daily) urine Dipstix monitoring If asymptomatic: routine treatment with antibiotics not recommended (many SCI patients have culture bacteriuria) If symptomatic: antibiotic course for 10-14 days
	Renal calculi	Neurogenic bladder: Dehydration Incomplete voiding Increased pressure	Proper hydration Regular bladder emptying
	Constipation	Bowel mobility is compromised	Nutritional intervention (e.g. dried fruit and increased fiber) Proper hydration
	CV stressors	Restricted potential for improvement in cardiac output & VO <sub>2</sub> max (Excess CV strain) Lesion around T1-4 will limit HR to 110-130 Resting heart rate is decreased Stroke volumes is lowered at rest and during exercise	Wear of heart rate monitors Manage training and competition load
	Life threatening conditions in the CNS (cerebral hemorrhage, seizures), CV (arrhythmias, myocardial ischemia) and pulmonary (edema) systems	Autonomic dysreflexia Injury usually at or above T6 level Injury blocks the descending regulatory impulses Sympathetic pathway blocked Hypertension. Vagal nerve activity (HR substantially lower)	Avoid triggers (bladder distension, urinary tract infections, catheter blocks, noxious stimuli) Education (bowel and bladder maintenance, skin care) Do not allow training or competition in a boosted state (IPC)
	Pressure ulcers (sores)	Extrinsic risk factors (pressure, shear, friction, immobility, and moisture) Intrinsic risk factors (condition of the patient, such as sepsis, local infection, decreased autonomic control, altered level of consciousness, increased age, vascular occlusive disease, anemia, malnutrition, sensory loss, spasticity, and contractures)	Skin care



	Premature osteopenia / osteoporosis	Disuse Neural factors	Mechanical stimulus to bones of lower limb Nutritional interventions e.g. Calcium supplements, Vit D Consider medication (Calcitonin, Bisphosphonates) Care with transfer from chair
<b>Cerebral Palsy (CP)</b>	Convulsive disorders	Underlying pathology Triggers (dehydration, emotional stress, hypoglycemia, hyperventilation, electrolyte imbalances)	Increased lactic acid (lowered pH) stabilizes membranes and lower risk of seizures (aerobic exercise) Prevent triggers (dehydration, emotional stress, hypoglycemia, hyperventilation, electrolyte imbalances) Compliance with anti-seizure medication
	Predisposition for musculoskeletal injury	Increased muscle tone Altered biomechanical stresses	Focus strength training on extension exercise (flexion often dominates) Physical therapy with special attention to stretching
<b>Amputees</b>	Heat illness / Hypothermia	Altered regulation of body temperature Loss of body surface	Prevent dehydration and heat illness Use of cooling vests, water sprays, ice slush ingestion, cooling fans (combined with wetted air and head) Emersion of hands and wrists in cold water Nutritional requirements Appropriate clothing
	Infections (stump)	Chafing of stump	Well fitted prosthesis and socket Silicone lining Appropriate skin care (talcum powder / cool clothing) Appropriate rest and recovery of stump Daily stump skin inspection
	Choke syndrome	Venous return from the stump is impaired, allowing for lymphatic and venous pooling in surrounding soft tissue	Daily assessment of stump Correct use of liners for compression
	Phantom limb pain		Good pain management, advanced management with respect to psychological and physiotherapeutic interventions e.g. cognitive behavioural therapy, mindfulness interventions and mirror therapy
	Recurrence of malignancy		Screening
<b>Les Autres</b>	Diverse diagnosis	e.g. Multiple sclerosis: increased risk of exacerbation by - Over fatigue - Increased core temperature	Participate in water sports
<b>Visually impaired</b>	Sleep patterns		Education Choice of accommodation area
<b>Intellectually impaired</b>	e.g. Down's syndrome:	Concern is cervical instability /Heart defects	Comprehensive pre-participation evaluation

ANS: Autonomic Nervous System  
HR: Heart Rate

CV: Cardiovascular  
IPC: International Paralympic Committee

BP: Blood Pressure

### Underlying unique medical conditions in Paralympic athletes

Various impairment types are associated with unique and pre-existing medical conditions. Most of these medical conditions are associated with co-morbidities, and therefore are potentially associated with a higher risk of illness.<sup>4</sup> Some of the unique medical conditions in Paralympic athletes from various impairment categories are summarized in Table 5.

Of particular interest is a recent study in which a high prevalence of cardiovascular abnormalities was reported in Paralympic athletes. In a group of Italian athletes (n=267) that were studied between 2000 and 2012, structural cardiac abnormalities (cardiomyopathy (CMP), aorta root dilatation and valvular disease) were reported in 33 athletes (12 %), and arrhythmogenic cardiac disease was identified in 9 athletes (3.4%).<sup>30</sup> Underlying cardiovascular disease may therefore also predispose these athletes to a risk of an acute event.<sup>30</sup> Additionally, a reasonably high prevalence of coronary risk factors (systemic hypertension, family history of premature coronary heart disease, smoking, elevated triglycerides, high cholesterol, diabetes and obesity) were reported in a small cohort of Brazilian Paralympic athletes (79 athletes).<sup>31</sup>

In one study, chronic medication use, as part of the management of these underlying medical conditions, was documented in Paralympic athletes. The major groups of medicines used by Paralympic athletes include central nervous system drugs, anti-hypertensives, anti-thrombotics, cholesterol lowering drugs and bronchodilators.<sup>22</sup> Chronic medication use carries a risk of side effects that may compromise the athlete's health. The additional intake of pain medication may further burden the Paralympic athlete's health.

### **Preventative strategies to decrease risk of illness in Paralympic athletes**

#### *General preventative strategies*

The general preventative strategies to reduce the risk of illness in elite athletes have recently been reviewed.<sup>17</sup> It is reasonable to assume that these measures are equally applicable to Paralympic

**Table 6: General guidelines for illness prevention in Paralympic athletes**

*A. Infective illness (Referring mostly to respiratory and GIT)*

**Athletes are advised to:**

1. Minimize contact with infected people, young children, animals and contagious objects;
2. Avoid crowded areas and shaking hands and minimize contact with people outside the team and support staff;
3. Keep at distance to people who are coughing, sneezing or have a 'runny nose', and when appropriate wear (or ask them to wear) a disposable mask;
4. Cough or sneeze on to the elbow and not on the hands—always clean the hands and nose after sneezing or coughing;
5. Wash hands regularly and effectively with soap and water, especially before meals, and after direct contact with potentially contagious people, animals, blood, secretions, public places and bathrooms;
6. Use disposable paper towels and limit hand to mouth/nose contact when suffering from upper respiratory symptoms or gastrointestinal illness (putting hands to eyes and nose is a major route of viral self-inoculation);
7. Carry insect repellent, antimicrobial foam/cream or alcohol-based hand washing gel with them;
8. Not share drinking bottles, cups, cutlery, towels, etc., with other people;
9. Choose beverages from sealed bottles, avoid raw vegetables and undercooked meat, wash and peel fruit before eating, while competing or training abroad.

**Medical staff are advised to:**

1. Screen for airway inflammation disturbances (asthma, allergy and other inflammatory airway conditions);
2. Arrange for single room accommodation during tournaments for athletes with heavy competition load or known susceptibility to respiratory tract infections, or high performance priority athletes;
3. Consider protecting the airways of athletes from being directly exposed to very cold ( $<0^{\circ}\text{C}$ ) and dry air during strenuous exercise by using a facial mask;
4. Update athletes and support staff on vaccines needed at home and for foreign travel and take into consideration that influenza vaccines take 5–7 weeks to take effect, intramuscular vaccines may have a few small side effects, vaccinations are performed preferably out of season and avoid vaccinating just before competitions or if symptoms of illness are present;
5. Consider zinc lozenges ( $>75$  mg zinc/day; high ionic zinc content) at the onset of upper respiratory symptoms, as there is some evidence that the number of days with illness symptoms can be reduced.

6. Measure and monitor for early signs and symptoms of illness:

- a. On-going illness (and injury) surveillance systems should be implemented in all sports;
- b. Athletes be monitored, using sensitive tools, for subclinical signs of illness such as non-specific symptoms and signs, or selected special investigations;
- c. Athletes be monitored for overt symptoms and signs of illness.

**The athlete support team can:**

1. Consider to advise athletes to ingest probiotics such as Lactobacillus probiotics on a daily basis;
2. Consider advising athletes on the regular consumption of fruits and plants, polyphenol supplements (e.g. quercetin), or foodstuffs (e.g. non-alcoholic beer and green tea) that may reduce risk of illness.

*B. Travel issues*

**Environmental conditions:**

Take into consideration:

1. Temperature changes;
2. Destination altitude;
3. Humidity;
4. Atmospheric pollution;
5. Aero allergen exposure;
6. Different strains of pathogenic organisms.

**Jetlag and travel fatigue:**

Depending on east-bound or west-bound flight the guidelines will differ:

1. Non pharmacological management:
  - a. Pre-adaptation;
  - b. Bright light therapy making use of blue light exposure, amber lenses and natural light. Exposure in late evening delays and exposure in the morning advances our body clock;
  - c. Sleep patterns based on flight schedule, power naps, sleep and wake times and sleep hygiene;

- d. Dietary regimes should be adapted to avoid alcohol at all times and caffeine at night times. Timing of the meal seems to be more important than the type of the meal;
  - e. Exercise cannot reliably shift circadian rhythms but may maintain arousal levels. Change the training routine not to coincide with the circadian nadir (2-4am) at the departure zone.
2. Pharmacological management:
- a. Melatonin can be used as a chrono-biotic (phase shifter) and chrono-hypnotic (sleep initiator). Product quality may be a concern;
  - b. Sleeping tablets (short acting) recommended in athletes with persistent insomnia that have tolerated it before;
  - c. Stimulants are banned substances but can be considered in team management for daytime sleepiness.

### **Deep Vein Thrombosis:**

- a. Prevention:
  - a. Compression hose;
  - b. Hydration strategy;
  - c. Avoid periods of prolonged immobility.
  - d. Consider anticoagulant prophylaxis in athletes with high risk medical conditions;
- b. Monitoring after arrival:
  - a. Educate about symptoms and signs after arrival;
  - b. Recommend self-check for calf swelling/redness and report early

### *C. Training and competition load management*

#### **General recommendations may include:**

- 1. Very high loads can have either positive or negative influences on risk of illness in athletes, with the athlete's level of competition (elite), load history (chronic load) and intrinsic risk factor profile being important;
- 2. Athletes should have a detailed individualized training and competition plan, including post-event recovery measures (encompassing nutrition and hydration, sleep, and psychological recovery);
- 3. The training load is monitored using measurements of external and internal load;
- 4. Training load is managed by adopting the following principles:

- a. Changes in training load should be individualized as there are large intra-individual and inter-individual variances in the timeframe of response and adaptation to load;
- b. Changes in training load should be in small increments, with data (from the injury literature) indicating that weekly increments should be <10%;
- 5. The competition load is monitored and managed;
- 6. Variation in an athlete's psychological stressors should guide the prescription of training and/or competition loads;
- 7. It is recommended that coaches and support staff schedule adequate recovery, particularly after intensive training periods, competitions and travel, including nutrition and hydration, sleep and rest, active rest, relaxation strategies and emotional support;
- 8. Sports governing bodies have the responsibility to consider the competition load, and hence the health of the athletes when planning their event calendars. This requires increased coordination between single-sport and multisport event organizers, and the development of a comprehensive calendar of all international sports events;
- 9. Psychological load management:
  - a. Develop resilience strategies that help athletes understand the relationship between personal traits, negative life events, thoughts, emotions and physiological states, which, in turn, may help them minimize the impact of negative life events and the subsequent risk of illness;
  - b. Educate athletes in stress management techniques, confidence building and goal setting, optimally under supervision of a sport psychologist, to help minimize the effects of stress and reduce the likelihood of illness;
  - c. Reduce training and/or competition loads and intensities to mitigate risk of illness for athletes who appear unfocused as a consequence of negative life events or ongoing daily hassles;
  - d. Implement periodical stress assessments (e.g. hassle and uplift scale, LESCA) to inform adjustment of athletes' training and/or competition loads. An athlete who reports high levels of daily hassle or stress could likely benefit from reducing the training load during a specified time period to prevent potential fatigue, illness or burnout.

athletes and can therefore be applied in these athletes. In Table 6, we suggest general preventative strategies for preventing illness in Paralympic athletes, which we adapted from the recently reviewed strategies for able-bodied athletes.<sup>17</sup>

### *Specific preventative strategies*

However, in Paralympic athletes there is an additional layer of medical complexity that is related to the considerable structural and anatomical differences in athletes with disabilities.<sup>28,29</sup> Therefore, specific medical considerations and related preventative strategies to reduce the risk of illness in Paralympic athletes are important. We therefore suggest specific preventative strategies for these unique medical conditions in Paralympic athletes (Table 5).

Finally, regular periodic health assessments (PHA) are essential and should include a baseline and frequent functional reviews. Information on health conditions, medication use and immunization are important. In this process the team physician can identify conditions that may require close supervision during training or even needs further evaluation before the athlete is cleared for participation.<sup>3,28,29,32</sup>

## **Summary**

Paralympic athletes have a documented risk of contracting an illness at times of key sporting events such as the Paralympic Games. In this review we identify that Paralympic athletes have a significantly higher likelihood of becoming ill in the Winter Games, compared to the Summer Games. Furthermore, illness patterns are consistent for the Summer- and Winter Paralympic Games, mainly affecting the respiratory-, dermatological – and digestive systems. Data are limited on identifying potential risk markers for illness, but there are data that show that sporting code (specifically athletics), may be an important extrinsic risk marker for illness. Current available studies suggest that age and sex are not accountable as risk markers. However, the type of impairment (e.g. SCI and athletes with limb deficiencies) as well as the unique underlying medical problems (e.g. neurogenic bladder, etc.) may be

contributing factors. We recommend preventative strategies (general and specific) that take all these factors into account and also suggest that a periodic health assessment (PHA) should be mandatory in all Paralympic athletes.

## References:

1. Webborn N. *The disabled athlete*. In: Brukner P, Khan K, eds. *Clinical sports medicine*. New York: McGraw-Hill; 2006.: McGraw-Hill; 2006.
2. Webborn N, Willick S, Emery CA. The injury experience at the 2010 winter paralympic games. *Clin J Sport Med*. 2012;22(1):3-9.
3. Derman W, Schwellnus MP, Jordaan E, et al. The incidence and patterns of illness at the Sochi 2014 Winter Paralympic Games: a prospective cohort study of 6564 athlete days. *Br J Sports Med*. 2016;50(17):1064-1068.
4. Derman W, Schwellnus M, Jordaan E, et al. Illness and injury in athletes during the competition period at the London 2012 Paralympic Games: development and implementation of a web-based surveillance system (WEB-IISS) for team medical staff. *British journal of sports medicine*. 2013;47(7):420-425.
5. Willick SE, Webborn N, Emery C, et al. The epidemiology of injuries at the London 2012 Paralympic Games. *British journal of sports medicine*. 2013;47(7):426-432.
6. Schwellnus M, Derman W, Jordaan E, et al. Factors associated with illness in athletes participating in the London 2012 Paralympic Games: a prospective cohort study involving 49 910 athlete-days. *British journal of sports medicine*. 2013;47(7):433-440.
7. Derman W. Profile of medical and injury consultations of Team South Africa during the XXVIIIth Olympiad, Athens 2004. *SAJSM*. 2008;20(3):72-76.
8. Engebretsen L, Soligard T, Steffen K, et al. Sports injuries and illnesses during the London Summer Olympic Games 2012. *Br J Sports Med*. 2013;47(7):407-414.
9. Mountjoy M, Junge A, Alonso JM, et al. Sports injuries and illnesses in the 2009 FINA World Championships (Aquatics). *Br J Sports Med*. 2010;44(7):522-527.
10. Webborn N, Van de Vliet P. Paralympic medicine. *Lancet*. 2012;380(9836):65-71.



11. Miller SL. MEDICAL ASPECTS OF PARALYMPIC SPORT. *SportEX Medicine*. 2009(42).
12. Derman W, Schwellnus M, Jordaan E. Clinical characteristics of 385 illnesses of athletes with impairment reported on the WEB-IISS system during the London 2012 Paralympic Games. *Pm R*. 2014;6(8 Suppl):S23-30.
13. Derman W SM, Jordaan E, Runciman P, Bauwet C, Webborn N, Lexell J, Van de Vliet P, Taukli-Wosornu Y, Kissick J, Stomphorst J. Sport, gender and age increase risk of illness at the Rio 2016 summer paralympic games: A prospective cohort study of 51,198 athlete days. *British Journal of Sports Medicine*. 2017.
14. Soligard T, Steffen K, Palmer D, et al. Sports injury and illness incidence in the Rio de Janeiro 2016 Olympic Summer Games: A prospective study of 11 274 athletes from 207 countries. *Br J Sports Med*. 2017;bjsports-2017-097956.
15. Soligard T, Steffen K, Palmer-Green D, et al. Sports injuries and illnesses in the Sochi 2014 Olympic Winter Games. *Br J Sports Med*. 2015;49(7):441-447.
16. Taunton J, Wilkinson M, Celebrini R, et al. Paralympic medical services for the 2010 paralympic winter games. *Clinical Journal of Sport Medicine*. 2012;22(1):10-20.
17. Schwellnus M, Soligard T, Alonso J-M, et al. How much is too much? (Part 2) International Olympic Committee consensus statement on load in sport and risk of illness. *British Journal of Sports Medicine*. 2016;50(17):1043-1052.
18. Svendsen IS, Taylor IM, Tønnessen E, Bahr R, Gleeson M. Training-related and competition-related risk factors for respiratory tract and gastrointestinal infections in elite cross-country skiers. *British journal of sports medicine*. 2016;bjsports-2015-095398.
19. Thornton HR, Delaney JA, Duthie GM, et al. Predicting Self-Reported Illness for Professional Team-Sport Athletes. *Int J Sports Physiol Perform*. 2015.
20. Schwellnus MP, Derman WE, Jordaan E, et al. Elite athletes travelling to international destinations> 5 time zone differences from their home country have a 2–3-fold increased risk of illness. *British journal of sports medicine*. 2012;46(11):816-821.
21. Johnson B, Mushett C, Richter K, Peacock G. Sport for athletes with physical disabilities: injuries and medical issues. *BlazeSports America*. 2004.

22. Tsitsimpikou C, Tsiokanos A, Tsarouhas K, et al. Medication use by athletes at the Athens 2004 Summer Olympic Games. *ClinJ Sport Med*. 2009;19(1):33-38.
23. Halpern BC, Boehm R, Cardone DA. The disabled athlete. *Principles and practice of primary care sports medicine Philadelphia: Lippincott Williams & Wilkins*. 2001:115-132.
24. Garcia Leoni M, Esclarin De Ruz A. Management of urinary tract infection in patients with spinal cord injuries. *Clinical Microbiology and Infection*. 2003;9(8):780-785.
25. Jiang S-D, Dai L-Y, Jiang L-S. Osteoporosis after spinal cord injury. *Osteoporosis International*. 2006;17(2):180-192.
26. Maimoun L, Fattal C, Micallef J, Peruchon E, Rabischong P. Bone loss in spinal cord-injured patients: from physiopathology to therapy. *Spinal Cord*. 2006;44(4):203.
27. Moran de Brito C, Battistella L, Saito E, Sakamoto H. Effect of alendronate on bone mineral density in spinal cord injury patients: a pilot study. *Spinal Cord*. 2005;43(6):341.
28. Klenck C, Gebke K. Practical management: common medical problems in disabled athletes. *Clinical Journal of Sport Medicine*. 2007;17(1):55-60.
29. Hawkeswood JP, O'Connor R, Anton H, Finlayson H. The preparticipation evaluation for athletes with disability. *Int J Sports Phys Ther*. 2014;9(1):103.
30. Pelliccia A, Quattrini FM, Squeo MR, et al. Cardiovascular diseases in Paralympic athletes. *Br J Sports Med*. 2016;bjsports-2015-095867.
31. Salvetti X, de Mello M, da Silva A. Coronary risk in a cohort of Paralympic athletes. *British journal of sports medicine*. 2006;40(11):918-922.
32. Gawroński W, Sobiecka J. Medical care before and during the Winter Paralympic Games in Turin 2006, Vancouver 2010 and Sochi 2014. *Journal of human kinetics*. 2015;48(1):7-16.