

ACCEPTED: May 2021

PUBLISHED ONLINE: June 2021

Busch A, Kubosch EJ, Meidl V, Bretthauer B, Leonhart R, Dallmann P, Wrobel N, Hirschmüller A. Health problems in German paralympic athletes preparing for the 2020 Tokyo Paralympic Games. *Dtsch Z Sportmed.* 2021; 72: 212-218. doi:10.5960/dzsm.2021.487

# Health Problems in German Paralympic Athletes Preparing for the 2020 Tokyo Paralympic Games

*Gesundheitliche Probleme bei deutschen paralympischen Athleten in der Vorbereitung auf die Paralympischen Spiele 2020 in Tokio*

1. UNIVERSITY OF POTSDAM, *Outpatient Clinic, Sports Medicine and Sports Orthopaedics, Potsdam, Germany*
2. BERN UNIVERSITY OF APPLIED SCIENCES, *Physiotherapy, Department of Health Professions, Bern, Switzerland*
3. ALBERT-LUDWIGS-UNIVERSITY OF FREIBURG, *Department of Orthopedics and Trauma Surgery, Faculty of Medicine, Medical Center, Freiburg, Germany*
4. ALBERT-LUDWIGS-UNIVERSITY OF FREIBURG, *Department of Psychology, Freiburg, Germany*
5. UNIVERSITY OF HEIDELBERG, *Center for Psychosocial Medicine, Department of General Psychiatry*
6. ALBERT-LUDWIGS-UNIVERSITY OF FREIBURG, *Department internal medicine, Faculty of Medicine, Medical Center, Freiburg, Germany*

ALTIUS SWISS SPORTMED CENTER, *Rheinfelden, Switzerland*

## Summary

- **Problem:** In-competition injury and illness incidences in Paralympic athletes have been studied extensively during the last decade. However, longitudinal monitoring data is still lacking. Therefore, the purpose of this study was to prospectively record incidence rates and type of health problems of Paralympic athletes during the preparation period for the 2020 Tokyo Paralympic Games.
- **Method:** German Paralympic athletes preparing for the 2020 Tokyo Paralympic Games were invited to complete the Oslo Sports Trauma Research Center questionnaire on health problems weekly using a web application. Additionally, training volume and competition exposure were asked.
- **Results:** 79 athletes were included in the study and were observed for 10 months. The health problem incidence rate was 7.5/1000 exposure hours (95% CI: 6.5-8.6). Illnesses were half of the reported health problems and acute injuries had the highest time loss with 13±24 days. Females, younger age groups, visual impaired athletes and participants in ambulatory sports had higher incidence rates compared to their pairs.
- **Discussion:** Reported incidence rates of health problems are high among Paralympic athletes. Obtained data is comparable to Paralympic Games and a Swedish Paralympic cohort. Injury and illness factors are manifold and demand further research to develop and implement preventive strategies.

## Zusammenfassung

- **Problem:** Die Häufigkeit von Verletzungen und Krankheiten bei paralympischen Athleten während eines Wettkampfes wurde in den letzten zehn Jahren mehrfach systematisch untersucht. Hingegen sind longitudinale Erhebungen rar. Das Ziel dieser Studie war die prospektive Erfassung der Häufigkeit und Art von Gesundheitsproblemen bei paralympischen Athleten in der Vorbereitungszeit auf die Paralympischen Spiele 2020 in Tokio.
- **Methode:** Deutsche paralympische Athleten, die sich auf die Paralympischen Spiele 2020 in Tokio vorbereiten, wurden eingeladen, den Fragebogen des Oslo Sports Trauma Research Center zu gesundheitlichen Problemen wöchentlich über eine Web-Applikation auszufüllen. Zusätzlich wurden Trainingsvolumen und Wettkampfbelastung erfragt.
- **Ergebnisse:** 79 Athleten wurden in die Studie eingeschlossen. Der hier rapportierte Erhebungszeitraum betrug 10 Monate. Die Inzidenzrate für gesundheitliche Probleme lag bei 7,5/1000 Belastungsstunden (95% KI: 6,5-8,6). Krankheiten machten die Hälfte der gemeldeten Gesundheitsprobleme aus und akute Verletzungen hatten mit 13±24 Tagen den höchsten Zeitverlust. Frauen, jüngere Altersgruppen, sehbehinderte SportlerInnen und TeilnehmerInnen an Fußgängersportarten hatten höhere Inzidenzraten gegenüber ihren Vergleichsgruppen.
- **Diskussion:** Die berichteten Inzidenzraten von Gesundheitsproblemen bei paralympischen Athleten sind hoch. Die erhobenen Daten sind vergleichbar mit denen bei Paralympischen Spielen und einer schwedischen paralympischen Kohorte. Verletzungs- und Krankheitsfaktoren sind vielfältig und erfordern weitere Forschung, um präventive Strategien zu entwickeln und umzusetzen.

## KEY WORDS:

OSTRC, Injury, Illness, Epidemiology, Prevention, Strategy, Olympic Games

## SCHLÜSSELWÖRTER:

OSTRC, Verletzung, Erkrankung, Prävention, Strategie, Olympic Games

## Introduction

Over the last years, participation in Paralympic sports increased (28). However, an increase in training load, intensities and competition participation increases the risk of injuries or illnesses, as well (13). The term health problem was implemented, extending the sole state of injured or ill with mental or social non well-being (1). The epidemiology of injuries and illnesses during the

Paralympic Games have been extensively studied (7, 10, 15, 29). Incidence and prevalence of injuries and illnesses among elite Para athletes are higher than among their able-bodied pairs (8) and their injuries and illnesses often have more serious consequences (15, 16). However, prospective monitoring data of Para athletes are still sparse (11, 14).

downloaded: 26.4.2024

source: <https://doi.org/10.24451/dzsm.2021.487>



Article incorporates the Creative Commons Attribution – Non Commercial License. <https://creativecommons.org/licenses/by-nc-sa/4.0/>



Scan QR Code and read article online.

## CORRESPONDING ADDRESS:

Aglaja Busch, M.Sc  
University of Potsdam  
Outpatient Clinic, Sports Medicine  
and Sports Orthopaedics  
Am Neuen Palais 10  
14469 Potsdam, Germany  
E-mail: agbusch@uni-potsdam.de

Table 1

Characterization of reported health problems. SD=standard deviation, min=minimum, max=maximum.

	TOTAL HEALTH PROBLEMS	INJURY	OVERUSE	ILLNESS	MULTIPLE HEALTH PROBLEMS
Per participant (mean±SD; min; max)	2.6±2.4 (0;13)	0.6±0.8 (0;3)	0.6±0.9 (0;5)	1.3±1.6 (0;8)	0.1±0.8 (0;7)
Duration in weeks (mean±SD; min; max)	2.4±3.6 (1;29)	4.2±5.5 (1;27)	2.9±4.5 (1;29)	1.7±1.3 (1;8)	1.5 (1;3)
Time loss in days (mean±SD; min; max)	6.6±13.7 (0;130)	13±23.8 (0;123)	4.2±7 (0;27)	4.6±6.4 (0;24)	3.6±3.3 (0;13)
Non-substantial (N; %)	80 (38.8%)	17 (34.7%)	25 (55.6%)	38 (36.9%)	-
Substantial (N; %)	126 (61.2%)	32 (65.3%)	20 (44.4%)	65 (63.1%)	9 (100%)

It has been shown that significantly higher injury rates occur in the three-day pre-competition phase compared to injury rates during the Paralympic games (7,8). Further, sex might be affecting the risk of getting injured or ill. The most common injury location was the upper extremity and respiratory infections were identified as the most frequent illness (6,9). Nonetheless, these data were collected during intense competition. It may be hypothesized that injury and illness profiles vary considerably in out-of-competition periods. Thus, longitudinal surveillance of health problems throughout preparation and training periods are relevant. These additions contribute to understanding possible health problem risks and patterns and are important for a comprehensive establishment of health problem prevention programs (7).

A first prospective study reported the incidence and risk factors of injuries and illnesses in a Swedish Paralympic cohort. An eHealth-based self-reporting application to collect sports-related injuries and illnesses in Paralympic sport (SRIIPS) was used. 107 athletes completed weekly the questionnaire over one year. They revealed incidence proportions of 68% for injuries and 77% for illnesses (11). These findings support the need for more prospective and longitudinal studies to determine and compare health problems among Paralympic athletes (7).

Therefore, an injury and illness surveillance for German Paralympic athletes was implemented (2, 14). This prospective study aimed to describe incidence rates and type of health problems in German Paralympic athletes preparing for the Tokyo 2020 Paralympic Games.

## Material and methods

The study procedures followed the declaration of Helsinki and were approved by the institutional ethic committee.

All German candidate Athletes preparing for the Tokyo 2020 Paralympic Games, were invited to participate in this prospective injury and illness surveillance study. The participants completed weekly the validated German version of the Oslo Sports Trauma Research Center questionnaire on health problems (OSTRC-HP) (17, 20). This article reports data collected before the beginning of the corona pandemic (May 2019 - February 2020; 10 months). The OSTRC-HP questionnaire consists of four short questions about sports participation, training volume, performance, and health problems experienced during the previous 7 days (4). Health problems were defined following the International Olympic Committee consensus statement as any condition that reduces an athlete's normal state of full health (1). In case of health problems, athletes were asked to provide further information on the number of training/competition days lost due to the problem and whether they have received medical attention. Disorders of the musculoskeletal system and concussions were classified as injuries and further sub-categorized into acute (onset linked to a specific injury event)

or overuse injuries (no specific injury event), whereas disorders of other body systems were classified as illnesses. Moreover, the location, symptoms and diagnosis of the health problem were completed. After the reporting of a health problem the diagnosis was either added by the team physician or by the study nurse in consultation with the athlete based on the described symptoms. The SMDCS coding system was used to classify health problems (1). Health problems are divided into substantial and non-substantial health problems, depending on how much the athlete is affected by the health problem. The more the athlete reports to be affected the higher the resulting severity score is (4, 5). Multiple substantial health problems were present when two or more health problems were reported within one week, and both were classified as substantial. In the event of an ongoing or recurrent health problem, the participant could refer to the already reported problem. With an additional question, the participants were asked to provide their training volume and/or competition exposure during the last week. The questionnaire was sent to the athletes once a week via a web application (AthleteMonitoring, FitStats Technologies Inc, Moncton Canada). In absence of a response a reminder was sent two days after the end of the week. The web application was tested for its feasibility in a prior conducted pilot study (2). The questionnaire is well established, valid and reliable and was recently updated (4,22). Participants were declared "dropout", when they withdraw their informed consent and declared that their obtained data should not be used for analysis.

## Statistics

Health problem characteristics were presented using descriptive statistics in the software R (version 4.0 (24), package incidence (19)). Incidence rates were calculated from the number of reported incidents over 1000 exposure hours for injuries and overuse problems or 100 athlete days for illnesses. Additionally the 95 % confidence interval was reported (epi.conf function, package epiR (26)). Further, incidence rates of following subgroup were reported: male/female athletes, different age groups (14-25, 26-34 and 35-63 years of age) and different impairment groups (paraplegia vs. visual vs. extremity vs. central neurological vs. other impairment), type of sport (team vs individual) and mobility (wheelchair vs. ambulatory).

## Results

Out of approx. 250 athletes within the German Paralympic program, invited by the National Paralympic Committee, a total of 85 athletes were recruited. Six dropped out during the monitoring phase, leaving 79 participants included in the analysis. The overall mean weekly response rate over 10 months of surveillance was 73%. The mean age was 29.5 ± 10.9 years; 49 (62%) athletes were males and 30 (38%) females. 18 >

Table 2

Incidence rates of health problems. CI=Confidence Interval, Para=Paraplegia; Visual=visual impairment, Extr=extremity impairment, CNS=central neurological impairment.

	INCIDENCE RATE (IR)/1000 HOURS OF EXPOSURE (95% CI)			IR/100 ATHLETE DAYS
	TOTAL	INJURY	OVERUSE	ILLNESS
<b>Total (n=79)</b>	7.5 (6.5-8.6)	1.8 (1.3-2.3)	1.6 (1.2-2.2)	0.6 (0.5-0.7)
<b>Sex</b>				
<b>Male (n=49)</b>	5.8 (4.7-7.1)	1.5 (1-2.3)	1.2 (0.7-1.9)	0.5 (0.3-0.6)
<b>Female (n=30)</b>	10.2 (8.4-12.3)	2.1 (1.3-3.2)	2.2 (1.4-3.4)	0.8 (0.6-1.1)
<b>Age</b>				
<b>14-25 (n=30)</b>	8.5 (6.5-10.8)	1.7 (0.9-2.9)	2.3 (1.3-3.7)	0.6 (0.3-0.9)
<b>26-34 (n=32)</b>	8.1 (6.5-10.2)	2.4 (1.5-3.5)	1.9 (1.1-2.9)	0.6 (0.4-0.8)
<b>35-63 (n=17)</b>	6.1 (4.6-7.9)	1.2 (0.6-2.1)	0.7 (0.3-1.5)	0.6 (0.4-0.9)
<b>Impairment</b>				
<b>Para (n=18)</b>	6.3 (4.4-8.6)	1.6 (0.7-2.9)	1.2 (0.5-2.5)	0.5 (0.3-0.9)
<b>Visual (n=10)</b>	11.3 (7-17.1)	3.5 (1.4-7.4)	3 (1.1-6.7)	0.6 (0.2-1.2)
<b>Extr (n=26)</b>	7.8 (6.2-9.8)	1.6 (0.9-2.6)	1.8 (1-2.8)	0.6 (0.4-0.9)
<b>CNS (n=23)</b>	7.6 (5.9-9.8)	1.8 (1-2.9)	1.4 (0.7-2.5)	0.6 (0.4-0.9)
<b>Other (n=2)</b>	3.7 (0.7-10.9)	1.2 (0.03-6.9)	1.2 (0.03-6.9)	0.3 (0.008-1.8)
<b>Sport</b>				
<b>Team (n=40)</b>	7.3 (5.9-8.9)	1.4 (0.8-2.2)	1.5 (0.9-2.4)	0.5 (0.4-0.7)
<b>Individual (n=39)</b>	7.8 (6.4-9.4)	2.1 (1.4-3.1)	1.7 (1.1-2.5)	0.7 (0.5-0.9)
<b>Mobility</b>				
<b>Wheelchair (n=65)</b>	7.2 (6.2-8.4)	1.5 (1-2.1)	1.5 (1-2)	0.6 (0.5-0.8)
<b>Ambulatory (n=14)</b>	9.8 (6.6-13.9)	3.7 (1.9-6.6)	2.8 (1.3-5.4)	0.4 (0.1-0.8)

(22.8%) participants were paraplegic athletes, 10 (12.7%) had a visual impairment, 26 (32.9%) an extremity impairment, 23 (29.1%) a central neurological impairment and two (2.5%) other impairments. 40 (50.6%) athletes took part in a team sport, while 39 (49.4%) participated in individual sports. 65 (82.3%) performed their sport in a wheelchair and 14 (17.7%) ambulatory. A total of 27,147 exposure hours and 15,939 athlete days were recorded, leaving a mean exposure of 10.2 ( $\pm$  7.2) hours per athlete per week.

In total, 206 health problems were reported by 65 athletes (82% of all participants). Half of these were illnesses (n=103), 23.8% acute injuries (n=49), 21.8% overuse injuries (n=45) and 4.4% were multiple substantial health problems (n=9). Further characterizations of the reported health problems can be found in Table 1. The most often specified localizations of acute and overuse injuries were the shoulder (18%), hand (17%) and the lower back (10%) followed by foot, head and trunk (6% each). Disease categories were mostly reported for respiratory illnesses (49%), other unspecified infectious diseases (14%), genitourinary (13%) and gastrointestinal (10%).

The weekly incidence of reported health problems over ten months of surveillance is illustrated in figure 1. A season effect with higher incidences of illnesses can be seen during the winter months in late 2019 and early 2020. Total incidence rates categorized per health problem and subgroups are displayed in Table 2. Multiple substantial health problems were included in the total calculation of Table 2 but were not listed as a separate category due to low numbers.

## Discussion

This prospective, longitudinal study evaluated health problems over 10 months in elite German Paralympic Athletes preparing for the 2020 Tokyo Paralympic Games. Half of the reported health problems were illnesses. Acute injuries resulted in three folded time loss in days and their duration was twice as long compared to the other reported health problems. Females and athletes with visual impairment showed two times high total incidence rates as males and as the other impairments groups.

The combined injury incidence rate per 1000 exposure hours of acute and overuse injuries in the present study was similar to incidence rates reported in elite wheelchair fencer (3.9/1000 hours) and non-disabled hockey players (3.7/1000 hours) (3,18). A longitudinal study of Swedish Paralympic athletes, however, showed higher incidence rates of 6.9/1000 hours. Differences within the described injury incidence rates might be due to variations in sample size and monitoring time (23). Further, the athletes were contacted by medical personal to offer help regarding treatment options and, if necessary, were referred to a specialist immediately when reporting a health problem. This might have reduced the duration and the frequency of health problems.

Previous results on incidence rates of injuries between male and female athletes have been confirmed in the present study (6, 7). Females showed higher total incidence rates in the subgroup comparison of acute and overuse injuries. Incidence rates in the group over 35 years of age were lower compared to both younger age groups. Higher incidences of acute injuries were found in the middle-aged athletes (26-43 years of age) and higher incidences of overuse injuries in the younger athletes (14-25 years

of age). During the Paralympic Games and in a longitudinal study, the middle and oldest age groups showed the highest injury incidence rates (6, 7, 11). The increased incidence of overuse injuries within the youngest in the present study is alarming, considering potential severe and longtime consequences. High prevalences of severe injuries in younger Paralympic athletes have been reported elsewhere, too (12). Young Para athletes are often inexperienced with a) their disability and b) their body's response to high loads. A special focus in injury prevention should, therefore, be set on young elite Paralympic athletes. In the last decade, injury and illness surveillance was implemented in youth multisport tournaments and

Youth Olympic games (25). However, young Paralympic athletes are underrepresented in these studies (27).

Impairment type showed a clear impact on the health problem incidence rates. Athletes with visual impairment, followed by participants with extremity impairment, reported high numbers of acute and overuse injuries. Visual impaired football has shown the highest overall injury rates during Paralympic Games (7). Fagher et al. point out that more multiple and traumatic injuries were reported in athletes with visual impairment. They discuss the generally higher risk of unintentional injuries and request further studies investigating injury mechanisms in this impairment group (11). The obtained data of the present studies support this demand.

Epidemiological data of the last Paralympic Summer and Winter Games have shown, that differences between the sports are present (6, 7). In the present study, a more detailed comparison among some of the sports was dismissed due to the small number of athletes. Nonetheless, team and individual sports were compared, showing similar total incidence rates and higher acute injuries among the individual sports participants. In contrast, higher incidences of injuries in team sports were found during the Paralympic Games and in a prospective surveillance study (7, 11). Subgroup analysis on the performance of sports in a wheelchair or ambulatory demonstrated higher injury incidence rates among ambulatory sports. These findings are in line with previously published data (11). Higher injuries in ambulatory sports might arise from the combination with the type of sports. Data of the Paralympics 2016 showed significantly higher incidences of injury in contact sports, e.g. football 5 or 7 a-side or judo (7). Therefore, subgroup analysis of contact and non-contact sports might provide a further understanding of injury pattern and incidences.

The most-reported locations of injuries were the shoulder followed by the hand. Locations prone to frequent injury during Paralympic Games were identified in the upper extremity, as well (6, 7, 21). The greater number of participants in wheelchair sports and the dependence on the upper limbs in daily life show

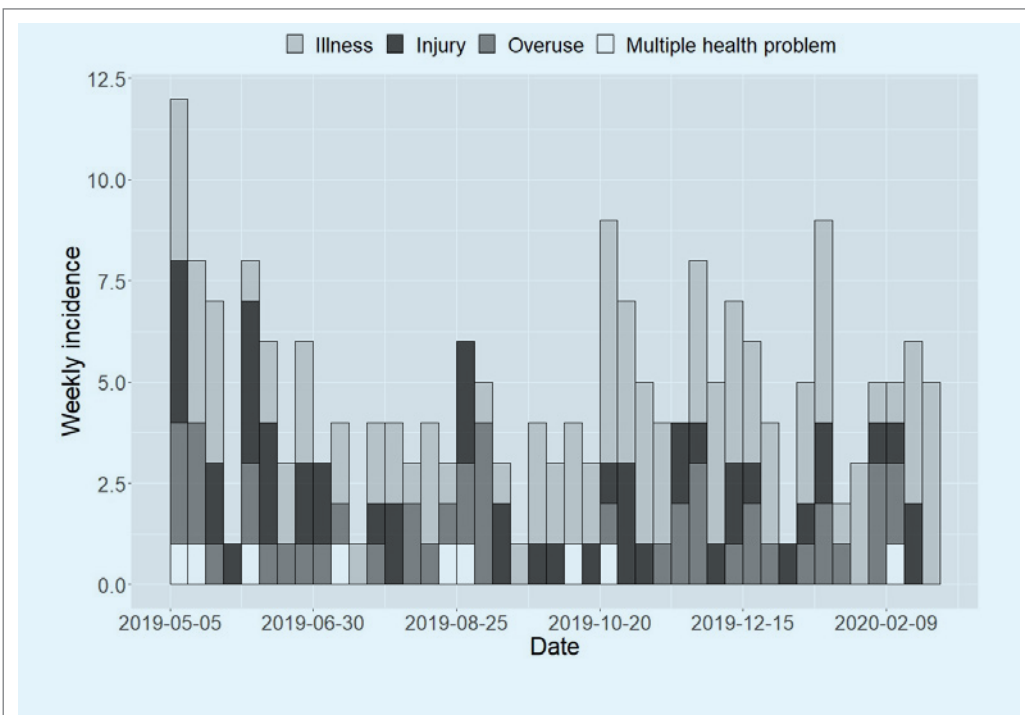


Figure 1

Weekly incidence of health problems of all participants over 10 months.

the necessity of preventive strategies to maintain the athlete's self-sufficiency (14).

Illness incidence rates were reported per 100 athlete days according to the IOC consensus statement (1). The incidence rate of illness was lower in the present study than Paralympic data, with 18.7 and 10/1000 athlete days for the Winter Games 2014 and Summer Games 2016, respectively (9, 10).

The gender comparison showed higher incidences in females, which was also reported in Paralympic data and the one-year monitoring of the Swedish Paralympic athletes (9, 11). Further, a higher incidence rate of illness was detected in wheelchair sports, supporting the findings by Fagher et al. (11). Athletes with impairments of the spinal cord and impairments requiring the use of a wheelchair were identified as high prevalence groups of illnesses, particularly urinary tract infections (9). Therefore, fast strategies in diagnoses and treatment, especially in the vulnerable impairment groups, might reduce this illness (11). In the present study, the most reported diagnoses of illnesses were respiratory infections. A season effect during the colder winter months with higher numbers of reported illnesses and presumably respiratory infections was present. Thus, athlete education on hygiene during training/competition and the protection of the immune system in winter month might have preventive effects. It will be interesting to see the comparison dates of the winter month 2020/2021, where infection presumably will be reduced due to Corona contra measures.

Some limitations should be discussed as well. The conducted prospective study using a validated questionnaire (4) demanded a relatively short recall time of the last week. However, there might be a bias due to self-reporting of the health problems. On the one hand, participants might not want to share their health problems and report no injuries or illnesses. On the other hand, a weekly questionnaire and possible subsequent contacting may enhance awareness and sensibility for health problems, resulting in over-reporting by the athletes. Nonetheless, an overall response rate of above 70% could lead to the assumption that reports were given truthful or they were dismissed for

that week. A rather small sample size limits the significance of the analysis, especially in the comparison of impairments. Although the characterizations of the participating athletes were described, further information on classification level or use of assistive devices and the cause of the impairments could enhance the understanding of health problem profiles (23). By forming smaller subgroups, specific risk factors may be better identified. Nonetheless, sample size in national monitoring projects are limited. An international collaboration might be valuable to combine data sets and to gain further explanations in health monitoring and recommendations in prevention.

Injury and illness surveillance in Paralympic athletes provide information on incidences, patterns and risk factors of specific health problems. This study showed illnesses take up to half of the reported health problems, but acute injuries imply the longest time loss for the athlete. Females, younger age, visual impairment and participation in ambulatory sports might affect the incidence rates of health problems, needing further evaluation to implement preventive strategies. ■

#### Acknowledgement and Indications of Support and Cooperation

The study was funded by the Bundesinstitut für Sportwissenschaft (BiSp) (project No: ZMVI4-070404)

#### Conflict of Interest

*The authors have no conflict of interest.*

## References

- (1) **BAHR R, CLARSEN B, DERMAN W, DVORAK J, EMERY CA, FINCH CF, HÄGGLUND M, JUNGE A, KEMP S, KHAN KM, MARSHALL SW, MEEUWISSE W, MOUNTJOY M, ORCHARD JW, PLUIM B, QUARRIE KL, REIDER B, SCHWELLNUS M, SOLIGARD T, STOKES KA, TIMPKA T, VERHAGEN E, BINDRA A, BUDGETT R, ENGBRETTSEN L, ERDENER U, CHAMARI K.** International Olympic Committee consensus statement: Methods for recording and reporting of epidemiological data on injury and illness in sport 2020 (including STROBE Extension for Sport Injury and Illness Surveillance (STROBE-SIIS)). *Br J Sports Med.* 2020; 54: 372-389. doi:10.1136/bjsports-2019-101969
- (2) **BUSCH A, FASSBENDER K, LEONHART R, KUBOSCH EJ, DALLMANN P, MEIDL V, WROBEL NLM, HIRSCHMÜLLER A.** Implementation of a web-based questionnaire to record injuries, illnesses and mental health of athletes with disabilities - a pilot phase. *Sport-Orthop-Traumatol.* 2019; 35: 290-295. doi:10.1016/j.orthtr.2019.05.002
- (3) **CHUNG WM, YEUNG S, WONG AY, LAM IF, TSE PT, DASWANI D, LEE R.** Musculoskeletal injuries in elite able-bodied and wheelchair foil fencers - a pilot study. *Clin J Sport Med.* 2012; 22: 278-280. doi:10.1097/JSM.0b013e31824a577e
- (4) **CLARSEN B, BAHR R, MYKLEBUST G, ANDERSSON SH, DOCKING SI, DREW M, FINCH CF, FORTINGTON LV, HARØY J, KHAN KM, MOREAU B, MOORE IS, MØLLER M, NABHAN D, NIELSEN RO, PASANEN K, SCHWELLNUS M, SOLIGARD T, VERHAGEN E.** Improved reporting of overuse injuries and health problems in sport: An update of the Oslo Sport Trauma Research Center questionnaires. *Br J Sports Med.* 2020; 54: 390-396. doi:10.1136/bjsports-2019-101337
- (5) **CLARSEN B, MYKLEBUST G, BAHR R.** Development and validation of a new method for the registration of overuse injuries in sports injury epidemiology: The Oslo Sports Trauma Research Centre (OSTRC) Overuse Injury Questionnaire. *Br J Sports Med.* 2013; 47: 495-502. doi:10.1136/bjsports-2012-091524
- (6) **DERMAN W, RUNCIMAN P, JORDAAN E, SCHWELLNUS M, BLAUWET C, WEBBORN N, LEXELL J, VAN DE VLIET P, KISSICK J, STOMPHORST J, LEE YH, KIM KS.** High incidence of injuries at the Pyeongchang 2018 Paralympic Winter Games: a prospective cohort study of 6804 athlete days. *Br J Sports Med.* 2020; 54: 38-43. doi:10.1136/bjsports-2018-100170
- (7) **DERMAN W, RUNCIMAN P, SCHWELLNUS M, JORDAAN E, BLAUWET C, WEBBORN N, LEXELL J, VAN DE VLIET P, TUAKLI-WOSORNU Y, KISSICK J, STOMPHORST J.** High precompetition injury rate dominates the injury profile at the Rio 2016 Summer Paralympic Games: A prospective cohort study of 51 198 athlete days. *Br J Sports Med.* 2018; 52: 24-31. doi:10.1136/bjsports-2017-098039
- (8) **DERMAN W, SCHWELLNUS M, JORDAAN E, BLAUWET CA, EMERY C, PIT-GROSHEIDE P, MARQUES NA, MARTINEZ-FERRER O, STOMPHORST J, VAN DE VLIET P, WEBBORN N, WILICK SE.** 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-ISS) for team medical staff. *Br J Sports Med.* 2013; 47: 420-425. doi:10.1136/bjsports-2013-092375
- (9) **DERMAN W, SCHWELLNUS MP, JORDAAN E, RUNCIMAN P, BLAUWET C, WEBBORN N, LEXELL J, VAN DE VLIET P, TUAKLI-WOSORNU Y, KISSICK J, STOMPHORST J.** Sport, sex and age increase risk of illness at the Rio 2016 Summer Paralympic Games: A prospective cohort study of 51 198 athlete days. *Br J Sports Med.* 2018; 52: 17-23. doi:10.1136/bjsports-2017-097962
- (10) **DERMAN W, SCHWELLNUS MP, JORDAAN E, RUNCIMAN P, VAN DE VLIET P, BLAUWET C, WEBBORN N, WILICK S, STOMPHORST J.** 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: 1064-1068. doi:10.1136/bjsports-2016-096215
- (11) **FAGHER K, DAHLSTRÖM Ö, JACOBSSON J, TIMPKA T, LEXELL J.** Injuries and illnesses in Swedish Paralympic athletes—A 52-week prospective study of incidence and risk factors. *Scand J Med Sci Sports.* 2020; 30: 1457-1470. doi:10.1111/sms.13687
- (12) **FAGHER K, DAHLSTRÖM Ö, JACOBSSON J, TIMPKA T, LEXELL J.** Prevalence of Sports-Related Injuries and Illnesses in Paralympic Athletes. *PM R.* 2020; 12: 271-280. doi:10.1002/pmrj.12211
- (13) **FAGHER K, JACOBSSON J, TIMPKA T, DAHLSTRÖM Ö, LEXELL J.** The Sports-Related Injuries and Illnesses in Paralympic Sport Study (SRIIPSS): a study protocol for a prospective longitudinal study. *BMC Sports Sci Med Rehabil.* 2016; 8: 28. doi:10.1186/s13102-016-0053-x
- (14) **HIRSCHMÜLLER A, FASSBENDER K, KUBOSCH J, LEONHART R, STEFFEN K.** Injury and Illness Surveillance in Elite Para Athletes: An Urgent Need for Suitable Illness Prevention Strategies. *Am J Phys Med Rehabil.* 2021; 100: 173-180. doi:10.1097/PHM.0000000000001501
- (15) **HIRSCHMÜLLER AK, KOSEL J, HÜBNER EJ, KAISER R, KÜPER R, MICHEL-LEUTHEUSER P, SCHMIEDER-VON WELCK U, SCHULTZ W, VATER H, VÖLPEL J, SÜDKAMP NP.** Verletzungen und Überlastungs-beschwerden der deutschen paralympischen Athleten bei den Sommerspielen 2012 in London. *Sport-Orthop-Traumatol.* 2014; 30: 41-46. doi:10.1016/j.orthtr.2014.01.001
- (16) **HIRSCHMÜLLER A, KOSEL J, SÜDKAMP NP, KUBOSCH EJ.** Epidemiology of injuries and illnesses in handicapped athletes competing at the paralympic games. *Dtsch Z Sportmed.* 2015; 66: 294-299. doi:10.5960/dzsm.2015.207
- (17) **HIRSCHMÜLLER A, STEFFEN K, FASSBENDER K, CLARSEN B, LEONHART R, KONSTANTINIDIS L, SÜDKAMP NP, KUBOSCH EJ.** German translation and content validation of the OSTRC Questionnaire on overuse injuries and health problems. *Br J Sports Med.* 2017; 51: 260-263. doi:10.1136/bjsports-2016-096669
- (18) **HOLLANDER K, WELLMANN K, EULENBURG CZ, BRAUMANN KM, JUNGE A, ZECH A.** Epidemiology of injuries in outdoor and indoor hockey players over one season: A prospective cohort study. *Br J Sports Med.* 2018; 52: 1091-1096. doi:10.1136/bjsports-2017-098948
- (19) **JOMBART T, KAMVAR ZN, CAI J, PULLIAM J, CHISHOLM S, FITZJOHN R, SCHUMACHER J, BHATIA S.** Incidence: Compute, handle, plot and model incidence of dated events. 2020. <https://doi.org/10.5281/zenodo.2584018> [11<sup>th</sup> May 2021].
- (20) **KUBOSCH EJ, FASSBENDER K, STEFFEN K, KUBOSCH D, SÜDKAMP N, HIRSCHMÜLLER A.** Implementation eines Injury and Illness Surveillance Systems im paralympischen Leistungssport - Machbarkeitsstudie am Beispiel des Nationalkaders Radsport. *Sport-Orthop-Traumatol.* 2017; 33: 148-156. doi:10.1016/j.orthtr.2017.02.003
- (21) **KUBOSCH EJ, KOSEL J, STEFFEN K, KONSTANTINIDIS L, KUBOSCH D, SÜDKAMP NP, HIRSCHMÜLLER A.** Upcoming Paralympic summer games in Rio: What did the German medical team learn from the London Games? *J Sports Med Phys Fitness.* 2017; 57: 1486-1493.
- (22) **NORDSTRØM A, BAHR R, TALSNES O, CLARSEN B.** Prevalence and Burden of Health Problems in Male Elite Ice Hockey Players: A Prospective Study in the Norwegian Professional League. *Orthop J Sports Med.* 2020; 8: 2325967120902407. doi:10.1177/2325967120902407
- (23) **PINHEIRO LSP, OCARINO JM, MADALENO FO, VERHAGEN E, DE MELLO MT, ALBUQUERQUE MR, ANDRADE AGP, DA MATA CP, PINTO RZ, SILVA A, RESENDE RA.** Prevalence and incidence of injuries in para athletes: A systematic review with meta-analysis and GRADE recommendations. *Br J Sports Med.* 2020; bjsports-2020-102823. <https://doi.org/10.1136/bjsports-2020-102823> [11<sup>th</sup> May 2021].
- (24) **R CORE TEAM.** R: a language and environment for statistical computing. 2017. [www.r-project.org](http://www.r-project.org) [11<sup>th</sup> May 2021].
- (25) **STEFFEN K, SOLIGARD T, MOUNTJOY M, DALLO I, GESSARA AM, GIURIA H, PEREZ ALAMINO L, RODRIGUEZ J, SALMINA N, VELOZ D, BUDGETT R, ENGBRETTSEN L.** How do the new Olympic sports compare with the traditional Olympic sports? Injury and illness at the 2018 Youth Olympic Summer Games in Buenos Aires, Argentina. *Br J Sports Med.* 2020; 54: 168-175. doi:10.1136/bjsports-2019-101040
- (26) **STEVENSON M.** epiR: tools for the analysis of epidemiological data. 2020. <https://cran.r-project.org/package=epiR> [11<sup>th</sup> May 2021].
- (27) **TUAKLI-WOSORNU YA, MASHKOVSKIY E, OTTESSEN T, GENTRY M, JENSEN D, WEBBORN N.** Acute and Chronic Musculoskeletal Injury in Para Sport: A Critical Review. *Phys Med Rehabil Clin N Am.* 2018; 29: 205-243. doi:10.1016/j.pmr.2018.01.014
- (28) **VALNLANDEWIJCK YC, THOMPSON WR.** Training and Coaching the Paralympic Athlete Wiley Blackwell, West Sussex. 2016.
- (29) **WILICK SE, WEBBORN N, EMERY C, BLAUWET CA, PIT-GROSHEIDE P, STOMPHORST J, VAN DE VLIET P, PATINO MARQUES NA, MARTINEZ-FERRER JO, JORDAAN E, DERMAN W, SCHWELLNUS M.** The epidemiology of injuries at the London 2012 Paralympic Games. *Br J Sports Med.* 2013; 47: 426-432. doi:10.1136/bjsports-2013-092374