# Prevalence and incidence of injuries in para athletes: a systematic review with meta-analysis and GRADE recommendations

Larissa Santos Pinto Pinheiro ,[1] Juliana Melo Ocarino,[1] Fernanda Oliveira Madaleno ,[1] Evert Verhagen ,[2] Marco Túlio de Mello ,[3] Maicon Rodrigues Albuquerque,[3] André Gustavo Pereira Andrade,[3] Carla Patrícia da Mata,[3] Rafael Zambelli Pinto,[1] Andressa Silva,[3] Renan Alves Resende [1]

► Additional material is published online only. To view please visit the journal online (http://dx.doi.org/10.1136/bjsports-2020-102823).

[1]School of Physical Education, Physical Therapy and Occupational Therapy, Department of Physical Therapy. Rehabilitation Sciences Graduate Program, Universidade Federal de Minas Gerais, Belo Horizonte, MG, Brazil
[2]Amsterdam Collaboration on Health & Safety in Sports, Department of Public and Occupational Health, Amsterdam Movement Sciences, Amsterdam UMC, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands
[3]School of Physical Education, Physical Therapy and Occupational Therapy, Department of Sports, Universidade Federal de Minas Gerais, Belo Horizonte, MG, Brazil

**Correspondence to**
Dr Renan Alves Resende, Universidade Federal de Minas Gerais, Belo Horizonte 31270-901, Brazil; renan.aresende@gmail.com

Accepted 26 October 2020
Published Online First 23 November 2020



**To cite:** Pinheiro LSP, Ocarino JM, Madaleno FO, *et al*. *Br J Sports Med* 2021;**55**:1357–1365.

## ABSTRACT

**Objective** To investigate prevalence, incidence and profile of musculoskeletal injuries in para athletes.

**Design** Systematic review.

**Data sources** Searches were conducted in MEDLINE, EMBASE, AMED, SPORTSDiscus, CINAHL and hand searching.

**Eligibility criteria** Studies were considered if they reported prevalence or incidence of musculoskeletal injuries in para athletes. Study selection, data extraction and analysis followed the protocol. Meta-analyses were conducted to estimate the prevalence and incidence rate among studies and subgroup analyses investigated whether methodological quality and sample size of the studies influenced on the estimated injury prevalence and incidence. The Grading of Recommendations Assessment, Development and Evaluation system determined the strength of evidence.

**Results** Forty-two studies were included. The prevalence of musculoskeletal injuries was 40.8% (95% CI 32.5% to 49.8%). Because of imprecision, indirectness and inconsistency, the strength of evidence was very low quality. The incidence of musculoskeletal injuries was 14.3 injuries per 1000 athlete-days (95% CI 11.9 to 16.8). The strength of evidence was low quality because of imprecision and indirectness. The subgroup analyses revealed that the sample size influenced on estimated injury prevalence and methodological quality influenced on estimated incidence. Injuries were more prevalent in the shoulder, for non-ambulant para athletes, and in the lower limbs, for ambulant para athletes.

**Summary/conclusion** Para athletes show high prevalence and incidence of musculoskeletal injuries. Current very low-quality and low-quality evidence suggests that future high-quality studies with systematic data collection, larger sample size and specificities of para athletes are likely to change estimates of injury prevalence and incidence in para athletes.

**PROSPERO registration number** CRD42020147982.

## INTRODUCTION

Since the first Paralympic Games in Rome in 1960, with 400 athletes with spinal cord injury from 23 countries,[1] the number of athletes with disabilities competing at major sports events has grown exponentially, reaching 4328 athletes from 160 countries in 22 sports at the Rio 2016 Summer Paralympic Games.[2] Especially for individuals with a disability, sports practice has a positive impact on cardiovascular fitness, self-efficacy, self-perceived quality of life and community participation.[3 4] Although sport participation is beneficial, it also comes with a risk of musculoskeletal injuries.[5 6]

Comparison of the injury incidence rates between Paralympic Games and the Olympic Games shows to which extent sports injuries need attention in athletes with disabilities, henceforward defined as para athletes. During the 2016 summer Paralympic Games, a total of 510 injuries were reported in 441 athletes, with an injury incidence rate of 10 injuries per 1000 athlete-days.[7] This incidence rate was almost twice as high when compared with the 5.7 injuries per 1000 athlete-days during the 2016 summer Olympic Games.[8] In addition to a high incidence rate, the profile of Paralympic sports injuries is extremely variable.[9] The different levels of para athletes' classification favour the participation of athletes with different types and degrees of disabilities in the same sport modality. This wider presentation of disability may help explain the great variety of injury profiles in Paralympic sports.[10 11]

The consequences of injuries in para athletes are often not limited to sports time loss or reduced sports performance. Injuries also frequently pose an additional barrier to activities of daily living in para athletes.[6] For example, an upper limb muscle injury in a disabled wheelchair javelin thrower can also affect his or her ability for independent locomotion during daily living.[4] Thus, to prevent these injuries, the first step is to understand the extent of the sports injury problem.[12] Weiler *et al*[13] conducted a systematic review of sports injuries in athletes with disabilities but the wide variability in reported injury rates prevented the authors to conduct a meta-analysis. The inclusion of studies without clear definition of sports injury might have contributed to this wide variability. Furthermore, another methodological shortcoming in this area is that estimates of prevalence and incidence comes from studies with small samples. Since the publication of this previous review in 2016,[13] new large studies on Paralympic sports injuries have been conducted, including longitudinal studies. Therefore, the primary aim of this systematic review with meta-analysis was to

investigate the prevalence, incidence and profile of musculoskeletal injuries in para athletes. As a secondary aim, we investigated whether methodological quality and sample size influenced the prevalence and incidence reported.

## METHODS

### Search strategy

For this systematic review, we followed recommendations from the Joanna Briggs Institute Reviewers' Manual,[14] the Cochrane Collaboration[15] and Preferred Reporting Items for Systematic Reviews and Meta-Analyses reporting guidelines.[16] The review's protocol was registered at PROSPERO (CRD42020147982). Search strategies were conducted in August 2019 and updated in May 2020 in MEDLINE, EMBASE, AMED, SPORTSDiscus and CINAHL. In addition, we handsearched the reference list of previous reviews on the topic. There was no date or language restriction. Our sensitive search strategy included the combination of the following terms 'prevalence', 'incidence', 'epidemiology', 'injury' and 'para athlete'. Online supplemental material 1 shows a detailed search strategy for each database.

### Eligibility criteria

We included published studies that reported the prevalence or incidence of musculoskeletal injuries in para athletes, including prospective, and retrospective cohort studies, without language, sample size, age or publication date restrictions. Para athlete is a general term used for athletes with an impairment who participate at any competitive level.[10] To be included, studies should report the prevalence or incidence of musculoskeletal injury in para athletes, along with a clear definition of musculoskeletal injury. Given that definitions of musculoskeletal injuries are extremely variable in the literature, any type of definition was accepted. When studies reported data from the same cohort or event, with similar methodology and the same definition of injury, only the study with global data on prevalence and incidence of injury was included.

### Study selection and data extraction

Two reviewers (LSPP and FOM) independently screened titles and abstracts and assessed potential full texts. A third reviewer (RR) solved any between-reviewer disagreements.

Two reviewers (LSPP and FOM) also independently extracted descriptive and outcome data of all included studies. A third reviewer (RR) solved any discrepancies between data extractions. Descriptive information included data collection setting, sample characteristics (eg, sex, age, sport, disability, years of practising in para sports), injury characteristics (eg, injury definition, professional responsible for injury diagnosis and record, number of sports injuries), the prevalence and incidence rate of injuries with 95% CIs per study. When these data were not provided, we estimated prevalence and incidence rate using the number of athletes injured, reported number of injuries, total sample and time frame of the competition. For incidence rate, if the time frame of the competition was not reported we contacted authors or performed an internet search to clarify the start and closing dates of the competition, considering the number of days of the competition. When a study reported more than one competition, the injury incidence rate was calculated for each competition. Prevalence was estimated as the proportion of athletes affected by injury at any given time,[17] and incidence rate was estimated as the number of injuries divided by the total person-time at risk (athlete exposures).[18]

### Assessment of the methodological quality

Two independent reviewers (LSPP and FOM) assessed the methodological quality of included studies using 'The Joanna Briggs Institute Prevalence Critical Appraisal Tool'.[14] A third reviewer (RR) solved potential disagreements regarding the risk of bias scoring. Each item was rated as 'yes', 'no', 'unclear' or 'not applicable' according to information available in each study, with a maximum score of nine points. One of the items in this tool is sample size. To evaluate if the sample size of each included study was appropriate, we used the following equation: sample size$=\frac{Z_{1-\alpha/2}}{d^2}^{2}p(1-p)$

where p was the expected prevalence (12.1%), defined based on a previous study,[7] Z was the confidence level (1.96), and d was the precision (5.0%).[19] The sample size estimation resulted in a minimum required sample size of 163 participants. A third reviewer (RR) solved potential disagreements regarding the risk of bias scoring.

### Data analysis

Descriptive statistics were used to summarise data in meta-analysis. The prevalence and in incidence rate estimated from individual studies were pooled, using a random-effects model.[15] Studies that reported injury prevalence and incidence from the same subgroups of a larger sample during the same competitive event were excluded from the analysis. $I^2$ was used to explain what proportion of the observed variance was attributed to the variance in true effects rather than to sampling error.[20] A prediction interval was used to access the heterogeneity, that is, how much effect size varies across studies.[20]

### Quality of evidence

To summarise the overall quality of the evidence the Grading of Recommendations Assessment, Development and Evaluation (GRADE system)[21] was used for the meta-analysis pooling prevalence and incidence data from all included studies. Scoring of evidence started at high-quality evidence which was downgraded one level if one of the following prespecified criteria was present: (1) poor methodological quality (downgraded if ≥25% of the studies included in the meta-analysis used inappropriate sampling method or statistical analyses (ie, items 2 and 8 in The Joanna Briggs Institute Prevalence Critical Appraisal Tool)); (2) imprecision (downgraded if ≥25% of the included studies did not present minimum required sample size of 163 participants); (3) indirectness (downgraded if ≥25% of the included studies did not use valid and reliable methods for data collection, for example, validated questionnaires previously described in the literature or standardised systems for recording sports injuries) and (4) inconsistency (downgraded if prediction interval has a variation ≥0.5 between upper and lower limits). These prespecified criteria were defined considering the items of Joana Briggs that correspond to the GRADE system criterion, for example, items 2 and 8 for poor methodological quality, and the corresponding index of the meta-analysis, such as the prediction interval for indirectness criterion.

We performed subgroup analyses to investigate whether methodological quality and sample size influenced overall estimates of prevalence and incidence. For the subgroup analysis, the criteria used to classify studies in high and lower methodological quality was the median score of The Joanna Briggs Institute Prevalence Critical Appraisal Tool. Studies that presented median risk of bias ≤6 points out of 9 were pooled as lower methodological quality. For the sample size subgroup analysis, the cut-off sample of 163 para athletes were used to classify studies into small and

large sample size. For the subgroup analyses, if there was no overlap between 95% CIs between subgroups, we interpreted that each subgroup provided different estimates. All analyses were performed using Comprehensive Meta-Analysis, V.2.0 (Biostat, Englewood, New Jersey, USA).

## RESULTS

### Flow of studies

The electronic search strategy identified 4092 records from the selected databases after excluding duplicates. After screening titles, abstracts and reference lists, 74 potentially relevant records underwent full-text review, including one additional study found by handsearching. Twenty-three studies failed to meet the inclusion criteria, eight studies did not provide information after contact and one study was excluded because it reported data from the same event, using similar methodology, and using the same injury definition than another included study. Thereby, 42 studies were included in this review. Figure 1 shows the flow chart of studies through the review.

### Characteristics of included studies

Twenty-five out of 42 studies included reported both injury prevalence and incidence rates,[7 22–45] 7 studies only reported prevalence data[46–52] and 10 studies only reported incidence rates.[3 53–61] Of the 35 studies with incidence data, 20 studies reported injury incidence rate per days,[3 22–29 33 39 41–44 53 55–58] 5 studies reported incidence per hours,[31 32 34 59 60] 5 studies reported injury incidence rate in different competitions,[35–37 45 54] three studies differentiated the injury incidence rate between precompetitive and competitive periods,[7 30 40] one study reported injury incidence rate per 1000 athlete exposures,[61] and one study reported injury incidence rate per 100 athlete competitions.[38] The number of participants ranged from 11[32] to 3657,[7] with a mean of 390.9 participants and median of 135.5. Regarding sex, 2 (4.8%) studies were conducted with females,[47 50] 4 (9.5%) with males[22 33 36 58] and 36 (85.7%) with both sexes.[3 7 23–32 34 35 37–46 48 49 51–57 59–61] Six studies were performed with wheelchair para athletes,[22 27 33 47 50 59] 11 studies with ambulant para athletes[25 32 34–38 41 44 52 58] and 25 studies with both wheelchair

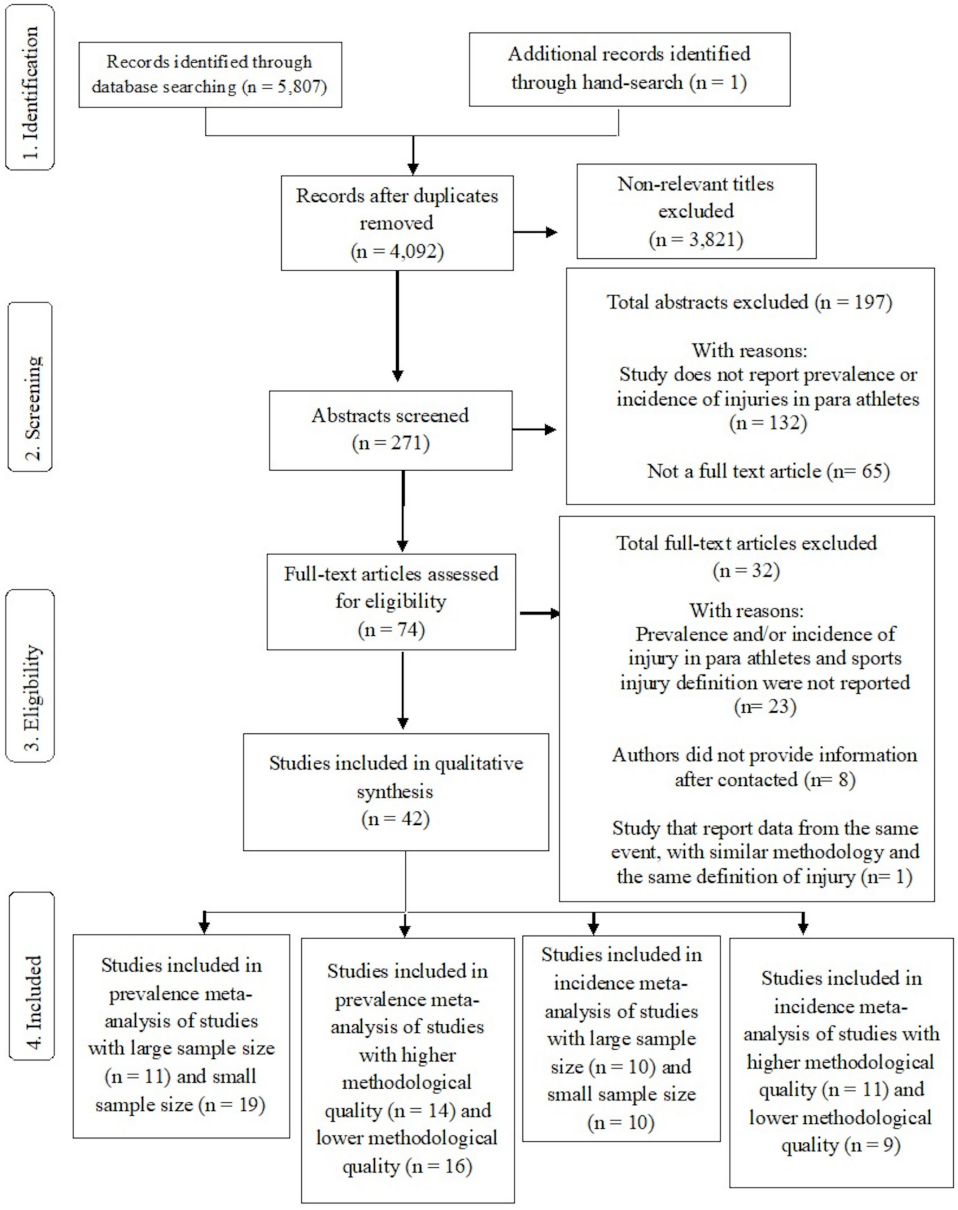


**Figure 1** PRISMA flow chart of studies through the review. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

**Table 1** Methodological quality of the included studies (n=42)

| Study | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Overall score (0–9) |
|---|---|---|---|---|---|---|---|---|---|---|
| Antonietti *et al*, 2008[22] | Y | Y | N | Y | Y | Y | Y | Y | Y | 8 |
| Bauerfeind *et al*, 2015[33] | Y | Y | N | Y | N | Y | U | Y | N | 5 |
| Bernardi *et al*, 2003[46] | Y | Y | Y | Y | Y | Y | Y | Y | Y | 9 |
| Blauwet *et al*, 2016[3] | Y | Y | Y | Y | Y | Y | Y | Y | Y | 9 |
| Chung *et al*, 2012[59] | Y | Y | N | Y | N | U | U | Y | N | 4 |
| Curtis *et al*, 1999[47] | Y | Y | N | Y | U | Y | U | Y | U | 5 |
| Derman *et al*, 2016[39] | Y | Y | Y | Y | Y | Y | Y | Y | Y | 9 |
| Derman *et al*, 2018[7] | Y | Y | Y | Y | Y | Y | Y | Y | Y | 9 |
| Derman *et al*, 2020[40] | Y | Y | Y | Y | Y | Y | Y | Y | Y | 9 |
| Fagher *et al*, 2019[41] | Y | Y | N | Y | Y | Y | Y | Y | Y | 8 |
| Fagher *et al*, 2020[48] | Y | Y | N | Y | Y | Y | Y | Y | Y | 8 |
| Fagher *et al*, 2020[31] | Y | Y | N | Y | Y | Y | Y | Y | Y | 8 |
| Ferrara *et al*, 1992[53] | Y | Y | N | Y | N | U | N | U | U | 3 |
| Ferrara *et al*, 1992[42] | Y | Y | Y | Y | U | Y | Y | Y | U | 7 |
| Ferrara and Davis, 1994[43] | Y | Y | Y | Y | Y | Y | U | Y | U | 7 |
| Ferrara and Buckley, 1996[61] | Y | Y | Y | Y | Y | Y | U | Y | U | 7 |
| Ferrara *et al*, 2000[54] | Y | Y | Y | U | U | U | U | U | U | 3 |
| Gajardo *et al*, 2019[44] | Y | Y | N | Y | Y | N | Y | Y | Y | 7 |
| Gawroński *et al*, 2013[45] | Y | Y | N | Y | Y | Y | U | Y | U | 6 |
| Haykowsky *et al*, 1999[32] | Y | Y | N | Y | N | Y | U | N | N | 4 |
| Hollander *et al*, 2019[55] | Y | Y | N | Y | Y | Y | Y | Y | U | 7 |
| Kubosch *et al*, 2017[23] | Y | Y | N | Y | U | Y | Y | Y | U | 6 |
| Lankhorst *et al*, 2019[34] | Y | Y | N | Y | Y | N | Y | Y | Y | 7 |
| Magno e Silva *et al*, 2013[35] | Y | Y | N | Y | Y | N | U | Y | U | 5 |
| Magno e Silva *et al*, 2013[36] | Y | Y | N | Y | Y | N | U | Y | U | 5 |
| Magno e Silva *et al*, 2013[37] | Y | Y | N | Y | Y | N | U | Y | U | 5 |
| Marqueta *et al*, 2005[24] | Y | Y | N | Y | N | U | U | N | U | 3 |
| McCormick *et al*, 1990[25] | Y | Y | Y | Y | Y | Y | U | Y | N | 7 |
| Nyland *et al*, 2000[56] | Y | Y | Y | Y | Y | N | N | Y | U | 6 |
| Ona Ayala *et al*, 2019[26] | Y | Y | Y | Y | Y | Y | Y | Y | U | 8 |
| Patatoukas *et al*, 2011[49] | Y | Y | N | Y | U | N | N | Y | U | 4 |
| Ramirez *et al*, 2009[60] | Y | Y | Y | Y | Y | N | N | Y | Y | 7 |
| Saffarian *et al*, 2019[38] | Y | Y | Y | Y | U | N | N | Y | N | 5 |
| Shimizu *et al*, 2017[50] | Y | Y | N | Y | Y | Y | U | Y | N | 6 |
| Taylor and Williams, 1995[27] | Y | Y | N | Y | N | U | N | Y | U | 4 |
| Tenforde *et al*, 2019[51] | Y | Y | Y | Y | Y | N | U | Y | N | 6 |
| Webborn *et al*, 2006[29] | Y | Y | Y | Y | N | N | U | N | N | 4 |
| Webborn *et al*, 2012[57] | Y | Y | Y | U | U | U | U | Y | U | 4 |
| Webborn *et al*, 2016[58] | Y | Y | Y | U | Y | Y | Y | Y | Y | 8 |

Continued

**Table 1** Continued

| Study | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Overall score (0–9) |
|---|---|---|---|---|---|---|---|---|---|---|
| Willick *et al*, 2013[30] | Y | Y | Y | Y | Y | Y | Y | Y | U | 8 |
| Willick *et al*, 2016[28] | Y | Y | Y | Y | Y | Y | Y | Y | U | 8 |
| Zwierzchowska *et al*, 2020[52] | Y | Y | N | Y | Y | N | U | Y | Y | 6 |
| Total 'yes' scores | 42 | 42 | 20 | 39 | 28 | 24 | 18 | 37 | 14 | |

1. Was the sample frame appropriate to address the target population?
2. Were study participants sampled in an appropriate way?
3. Was the sample size adequate?
4. Were the study subjects and the setting described in detail?
5. Was the data analysis conducted with sufficient coverage of the identified sample?
6. Were valid methods used for the identification of the condition?
7. Was the condition measured in a standard, reliable way for all participants?
8. Was there appropriate statistical analysis?
9. Was the response rate adequate, and if not, was the low response rate managed appropriately?

N, no; NA, not applicable; U, unclear; Y, yes.

and ambulant para athletes.[3 7 23 24 26 28–31 39 40 42 43 45 46 48 49 51 53–57 60 61] Twenty studies were sport-specific,[3 22–24 26–28 32 33 35–37 41 44 47 50 52 53 55 59] 19 were multisport[7 25 29–31 38–40 42 43 45 46 48 49 54 56–58 60] and 3 studies did not report para sport modality.[34 51 61] Ten studies did not report para athlete disabilities,[26 28–30 39 42 54 57 59 61] 22 studies presented information about classification level of para athletes,[3 7 22 24 26 32 63 135–41 43 44 48 50 52 55 57–59] 23 studies specified the assistive devices used by para athletes,[3 7 22 24 26–28 30 31 33 39 40 46–48 50 51 53 55–57 59 60] and in 30 studies the injury diagnosis was confirmed by a medical practitioner.[3 7 23 25 26 28–31 33–40 45 46 48 50 51 54–61] Only five studies presented longitudinal prospective design,[23 31 34 59 60] while 37 studies reported retrospective or competitive events data.[3 7 22 24–30 32 33 35–58 61] Online supplemental material 2 shows the characteristics of the included studies and demonstrates the level of inconsistency in injury definitions and the report of para athletes' exposure (days, hours or competition).

## Quality assessment

Methodological quality issues are reported in table 1. None of the studies had a negative or unclear answer to item 2, 22 studies did not present appropriate sample size,[22–24 27 31–37 41 44 45 47–50 52 53 55 59] 18 studies did not use valid methods for data collection or did not clearly present the methods used for data collection,[24 27 29 34–38 44 49 51–54 56 57 59 60] and 5 studies had a negative or unclear answers to item 8.[24 29 32 53 54] Twenty-one studies scored ≤6 out of 9.[23 24 27 29 32 33 35–38 45 47 49–54 56 57 59] Mean (SD) methodological quality of the included studies was 6.3 (1.8) out of 9 (ranging from 0 to 9).

## Prevalence of musculoskeletal injuries in para athletes

The pooled prevalence estimates including data from 30 studies (n=12 151)[7 22–25 27 29–52] found was 40.8% (95% CI 32.5% to 49.8%; $I^2$: 97.7%; prediction interval: 0.1–0.8). The overall quality of evidence was rated as very low quality (ie, downgraded due to imprecision, indirectness and inconsistency) (table 2). The subgroup analysis based on higher and lower methodological quality revealed no significant difference. The pooled estimate for studies with higher methodological quality (n=10 408)[7 22 25 30 31 34 39–44 46 48] was injury prevalence of 34.7% (95% CI 25.4% to 45.4%; $I^2$: 98.2%; prediction interval: 0.1–0.8) and for studies with lower methodological quality (n=1743)[23 24 27 29 32 33 35–38 45 47 49–52] was 47.4% (95% CI 32.1% to 63.3%; $I^2$: 95.8%; prediction interval: 0.1–0.9) (figure 2). For the subgroup analysis based on study sample size, studies with large sample size showed significantly lower prevalence estimate than studies with small sample size. While studies with large sample size (n=11 068)[7 25 29 30 38–40 42 43 46 51] showed injury prevalence of 18.5% (95% CI 12.7% to 26.1%; $I^2$: 98.3%; prediction interval: 0.1–0.6), the prevalence estimate from studies with small sample size (n=1083)[22–24 27 31–37 41 44 45 47–50 52] was 58.3% (95% CI 48.2% to 67.8%; $I^2$: 88.1%; prediction interval: 0.2–0.9) (online supplemental material 3).

## Incidence rate of musculoskeletal injuries in para athletes

For incidence rate, the pooled estimate including data from 20 studies (n=11 608)[7 22–25 27 29 30 33 39–45 53 55–57] that reported injury incidence rate per days and also the number of injuries, sample size and exposure in days. The incidence rate was 14.3 injuries per 1000 athlete-days (95% CI 11.9 to 16.8; $I^2$: 98.4%; prediction interval was 0.1–0.2). The overall quality of evidence was rated as low quality (ie, downgraded due to imprecision and indirectness) (table 2). The subgroup analysis showed a significant lower incidence rate in studies of higher methodological quality

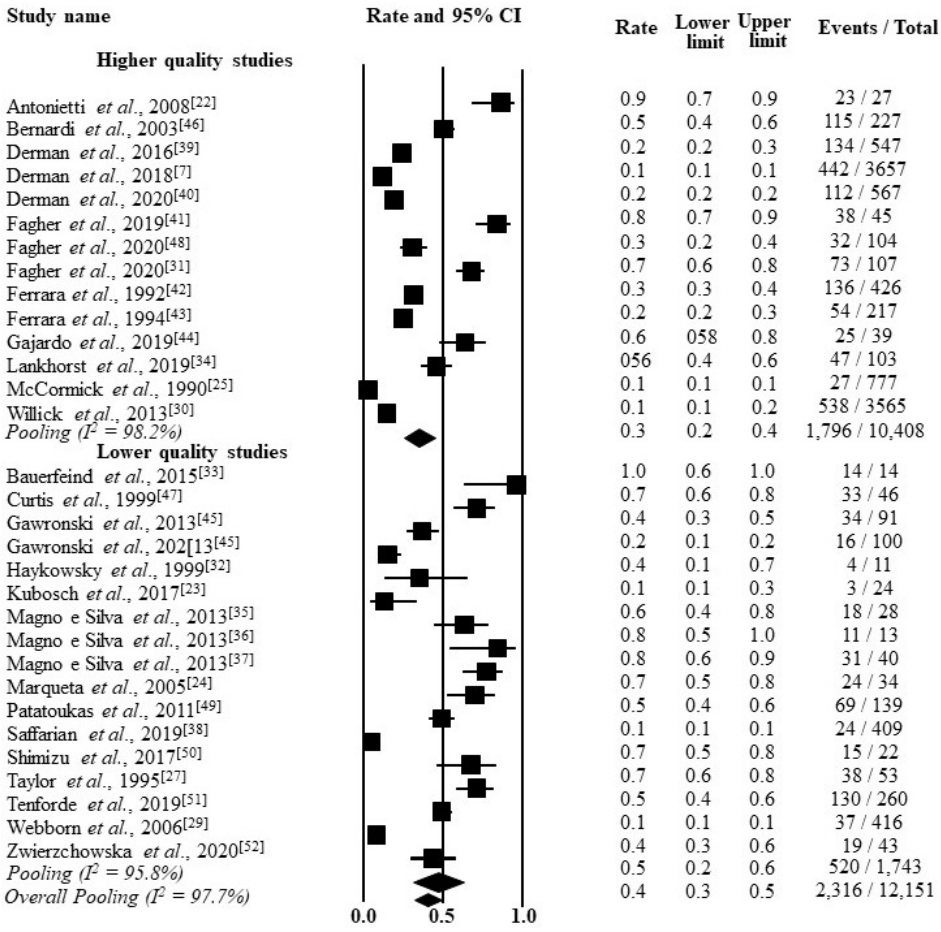


**Figure 2** Meta-Analysis for overall injuries prevalence in para athletes and subgroup analysis for studies with higher and lower methodological quality.

as compared with studies with lower methodological quality. The pooled estimate for studies with higher methodological quality (n=9999)[7 22 30 39–44 55] was injury incidence rate of 11.7 per 1000 athlete-days (95% CI 8.9 to 14.5; $I^2$: 98.6%; prediction interval was 0.1–0.4) and pooling of 1609 para athletes from studies with lower methodological quality[23 24 27 29 33 45 53 56 57] estimated the injury incidence of 23.1 per 1000 athlete-days (95% CI 17.1 to 29.2; $I^2$: 98.4%; prediction interval was 0.1–0.4) (figure 3). The subgroup analysis showed no clear difference with regards to sample size. While studies with large sample size (n=10 981)[7 25 29 30 39 40 42 43 56 57] estimated an injury incidence rate of 14.4 per 1000 athlete-days (95% CI: 11.1 to 17.7; $I^2$: 98.8%; prediction interval was 0.1–0.2) studies with small sample size (n=627)[22–24 27 33 41 44 45 53 55] showed an incidence rate of 14.7 per 1000 athlete-days (95% CI: 11.1 to 18.5; $I^2$: 97.4%; prediction interval: 0.1–0.3) (online supplemental material 4).

## Injury profile in para athletes

Eighteen studies found that the shoulder was the body location most frequently affected by injuries,[7 22 23 26 28 30–33 39–42 44 46–48 59] mainly in sports with non-ambulant para athletes, like wheelchair basketball,[22] wheelchair rugby,[33] wheelchair foil fencer[59] and powerlifting.[26 28] In other four studies, most of the injuries occurred in upper limbs.[27 52 53 61] Nine studies reported that lower limbs injuries were the most common for ambulant para athletes,[24 34 36–38 43 51 58 60] and in three studies, the trunk was the most frequently injured region.[35 54 55] Four studies found similar prevalence of upper and lower limb injuries,[3 29 56 57] and four studies did not report injuries by body location.[25 45 49 50] In general, strain, sprains and contusions were the most common injuries in para athletes.[3 24 25 29 31 33–38 41 45 46 49 52 54 55 59–61] Most of the studies that included sudden and gradual onset injuries reported that sudden onset injuries are more frequent than

**Table 2** Evidence table for outcome measure

| Outcomes | Risk of bias* | Imprecision† | Indirectness‡ | Inconsistency§ | No of para athletes | Quality |
|---|---|---|---|---|---|---|
| Injuries prevalence in para athletes | No serious risk of bias | Serious imprecision | Serious indirectness | Serious inconsistency | 12 151 | Very low quality |
| Injuries incidence rate in para athletes | No serious risk of bias | Serious imprecision | Serious indirectness | No serious inconsistency | 11 608 | Low quality |

*More than 25% of studies with a risk of bias (ie, inappropriate sampling method or statistical analyses).
†More than 25% of studies with small sample size.
‡More than 25% of studies did not use valid and reliable methods for data collection.
§Heterogeneity across the studies (prediction interval has a variation ≥0.5 between upper and lower limits).

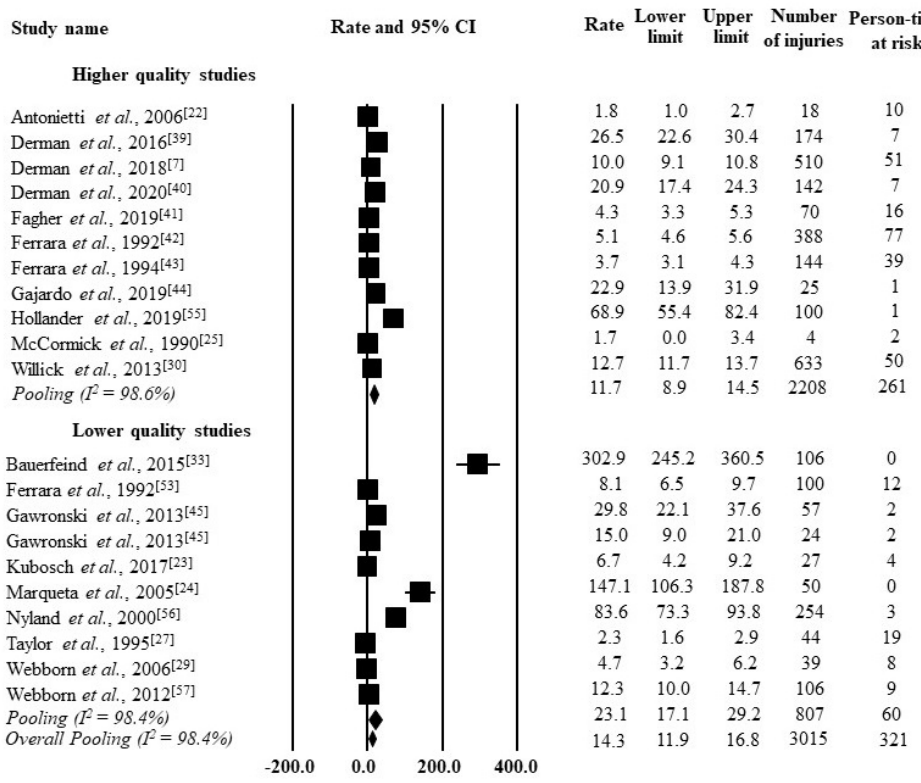


**Figure 3** Meta-Analysis for overall injuries incidence rate in para athletes and subgroup analysis for studies with higher and lower methodological quality.

gradual onset injuries and only one study reported similar data for gradual and sudden onset injuries.[45] Between winter sports, para alpine skiing/snowboard had a higher incidence rate of injuries,[39 40] while between summer sports, football 5-a-side had the highest injury incidence rates[7 30] (online supplemental material 5).

## DISCUSSION

The purpose of this systematic review with meta-analysis was to investigate the prevalence, incidence and profile of musculoskeletal injuries, including body location, type of injury and sports with the highest number of injuries, in para athletes. Our findings showed that musculoskeletal injury prevalence in para athletes was 40.8% (95% CI 32.5% to 49.8%) and musculoskeletal injury incidence rate was 14.3 injuries per 1000 athlete-days (95% CI 11.9 to 16.8). According to the GRADE system, pooling of studies on injury prevalence in para athletes provided very low-quality evidence, and pooling of studies on injury incidence rate provided low-quality evidence. The subgroup analysis based on study sample size showed a significant lower injury prevalence (18.5%, 95% CI 12.7% to 26.1%) in studies of large sample size in comparison to studies with small sample size (58.3%, 95% CI 48.2% to 67.8%). The subgroup analysis based on methodological quality showed a significant lower injury incidence (11.7 per 1000 athlete-days, 95% CI 8.9 to 14.5) in studies of higher methodological quality as compared with studies with lower methodological quality (23.1 per 1000 athlete-days, 95% CI 17.1 to 29.2). Sudden-onset injuries were more frequent than gradual onset injuries. Strains, sprains and contusions were the most common injury type and the body regions most frequently affected were the shoulder for wheelchair athletes and the lower limbs for ambulant para athletes.

Prevalence and incidence rates of musculoskeletal injuries in para athletes are higher than in able-bodied athletes. For example, during the last summer Paralympic Games (Rio 2016), the prevalence of injuries was 12.1%,[7] while in the Olympic Games in the same year it was 8%.[8] Incidence of injuries followed the same pattern, with 10 injuries per 1000 athlete-days in Paralympic Games[7] and 5.7 injuries per 1000 athlete-days during the Olympic Games.[8] The high injury prevalence and incidence rates in para athletes show that the mechanisms of occurrence of musculoskeletal injuries in this population need to be better understood. Para athletes can be categorised in different groups, varying between para athletes with loss of muscle strength and para athletes with intellectual impairment.[11] Then, these different profiles of para athletes require different approaches to treat and prevent the occurrence of musculoskeletal injuries. Furthermore, para athletes use different equipment to compete, such as a wheelchair or prosthetic devices, which increases the complexity of strategies designed to reduce injury risk.[4] Sports injuries in para athletes, unlike able-bodied athletes, can also be related to their own disability or to the assistive device they use in their daily lives. For this reason, to better understand para athletes' injuries and related factors, full knowledge of the specificities of the sport modality and the para athlete classification level are required to design and implement more individualised approaches. However, some studies still do not report this type of information.[13 62 63] Although most of the included studies reported the type of disability (76%) and had injury diagnosis confirmed by a medical practitioner (70%), almost half did not provide information about the para athlete classification level or the use of assistive devices. One of the few studies that provided this information demonstrated that para athletes that did not use any assistive devices had a higher injury

prevalence.[48] Thus, future studies should report this information to allow better understanding on para athlete injuries profile and related factors.

The subgroup analysis showed that the estimated prevalence and incidence of musculoskeletal injuries in para athletes was influenced by the studies' sample size and methodological quality, respectively. More specifically, studies with small sample size overestimated the injury prevalence (58.3%) in comparison to studies with large sample sizes (18.5%). For injury incidence rate, studies with higher methodological quality showed significantly lower incidence (11.7 per 1000 athlete-days) than studies with lower methodological quality (23.1 per 1000 athlete-days). This also was observed in previous systematic review with athletes with disability that reported a lower injury risk in studies with larger sample populations and higher methodological quality.[13] There are fewer large competitions in para athlete sports in comparison to able-bodied sports, which may help to explain the small number of studies with appropriate sample size to estimate prevalence and incidence of musculoskeletal injuries in para athletes.[64] Most of these large sample studies were performed during Paralympic games,[7 29 30 39 40] which might not represent injuries rates in non-elite para athletes. Large para athletes training centres and national organisations are key to the development of future studies with large samples, high methodological quality and including prospective data collection throughout different seasons, which will provide more consistent information regarding musculoskeletal injuries in para athletes. Nevertheless, the high prevalence and incidence rates data showed by the present review highlight the need to better understand and hopefully prevent the occurrence of musculoskeletal injuries in para athletes.

The shoulder was the most affected body region in wheelchair para athletes, which can be explained by the higher demands of the upper limbs in their daily activities[4] and during sports practice. Studies that assessed scapular kinematics in wheelchair para athletes demonstrated scapular asymmetries during wheelchair propulsion[65 66] that, along with muscle imbalance and excessive training load, may increase the occurrence of shoulder injuries.[67 68] Most of the ambulant para athletes were from sport modalities that have the highest injury incidence rates in summer Paralympic Games, such as football 5-a-side and athletics, which might help to explain why the lower limbs were the body regions most frequently affected in these para athletes.[7 30] In the present review, sudden onset injuries were more frequent than gradual onset injuries. This may be related to the fact that gradual-onset injuries are often under-reported, since most of the injury definitions are based on 'time-loss' or 'medical attention'[13] and few studies performed a longitudinal follow-up,[23 31 34 59 60] so consequently might not detect most of the gradual-onset injuries.

Our results regarding location and type of musculoskeletal injuries are in agreement with the results of non-systematic reviews.[9 10 69] The heterogeneity in para sports, due to a large number of modalities and also to the different athlete classification levels for the same modality, increases the inconsistency of information about prevalence and incidence of musculoskeletal injuries in para athletes. In addition, the heterogeneity in the methods used by studies with para athletes, compromises pooling of data. One of the main problems is the different musculoskeletal injury definitions. Similar to Olympic sports, para sports also has a wide variety of injuries definition.[70] As an attempt to solve this problem, the International Olympic Committee very recently established a consensus statement about methods for recording and reporting of epidemiological data on injury and illness in sport.[71] A similar consensus should be developed for Paralympic sports and their specificities. Finally, most of the studies used different procedures to report prevalence and incidence rate data, did not mention a clear definition of these variables, and did not present all information used to compute these data, such as number of injuries, number of athletes injured, the total number of athletes and exposure.[18] As well as data records, studies should use valid and reliable methods to assess injuries rate, such as the Oslo Sports Trauma Research Center Questionnaire on Health Problems .[23 72]

Weiler *et al*[13] conducted a systematic review of sports injuries in athletes with disabilities and also demonstrated high variability in reported injury rates. They suggested that future studies should better define injury, use standardised methods of data collection and report para athletes demographic data to improve quality of injury epidemiological data. Following these steps and focusing on para athletes specificities, future researches will allow the construction of a more consistent and robust knowledge about musculoskeletal injuries in para athletes that will allow para athletes, sport teams and institutional boards to elaborate more effective approaches to the injury in para sport problem.

This study had some limitations. First, age or level of sports participation were not defined as exclusion criteria, which allowed a wider range of included studies and consequently increased heterogeneity levels in the data. However, as studies with para athletes are less common, we had to use less restricted inclusion criteria to review data on musculoskeletal injuries in this population. Level of competition, classification levels, injury severity and type of injury might also influence on estimated prevalence and incidence rates of injuries in para athletes and were not controlled in this review. However, this was not possible because most of the studies did not report this information. The strength of the current evidence was downgraded due to imprecision, indirectness and inconsistency about injury prevalence and downgraded due to imprecision and indirectness about injury incidence rate in para athletes, presenting very low-quality and low-quality evidence, respectively.

Future high-quality studies with consistent information on the parameters used to calculate the injury prevalence and incidence rate, and valid and reliable methods for data collection are likely to impact on the estimated prevalence and incidence of musculoskeletal injuries in para athletes. To improve the quality of injury epidemiological data in para athletes, studies must properly define injury, including their type of presentation (sudden or gradual onset), severity and also follow the recommendations in the scientific literature regarding the appropriate methods to report athlete exposure and to inform about injuries risk and burden.[71] In addition, studies should report para athlete's demographic data, including type of disability, equipment used for sport practice or during daily activities, level of competition and other relevant daily demands, such as side jobs. Finally, more prospective studies that investigate the relationship between modifiable factors and injuries occurrence in para athletes, such as use of equipment and training and competition volume and intensity may form the basis for the design of more effective strategies to prevent and manage injuries in para athletes.

## CONCLUSION

The reviewed studies demonstrated that musculoskeletal injury prevalence in para athletes was 40.8% (95% CI 32.5% to 49.8%) and injury incidence rate was 14.3 injuries per 1000 athlete-days (95% CI: 11.9 to 16.8). The subgroup analysis based on study sample size showed a significant lower injury prevalence

in studies of large sample size as compared with studies with small sample size. For the incidence rate, studies with higher methodological quality showed a significant lower injury incidence rate in comparison to studies with lower methodological quality. Sudden-onset injuries are more frequent than gradual onset injuries in para athletes. Shoulder was the body region most commonly injured for non-ambulant para athletes, while lower limbs were the most frequently injured region for ambulant para athletes. The heterogeneity between para athletes and the poor methodological quality of the studies promote greater inconsistency in the information on the injury prevalence and incidence in para athletes. Therefore, current very low-quality and low-quality evidence suggests that prevalence and incidence rate, respectively, are likely to change with future high-quality studies, observing a large sample size, systematic data collection with reliable and validated methods and with attention to the specificities of para athletes. Findings of this systematic review demonstrate that para athletes, sports teams and para sport institutional boards should be aware of the high prevalence and incidence levels of musculoskeletal injuries in para athletes.

## What is already known

- The heterogeneity in para sports increases the inconsistency of information about prevalence and incidence of musculoskeletal injuries in para athletes.
- There is still a need for consensus on epidemiological research methodology, including sports injury definition in para sports.
- In para athletes, shoulder is the most frequently affected body location by injuries in non-ambulant para athletes, and lower limbs injuries are the most common in ambulant para athletes.

## What are the new findings

- This was the first systematic review with meta-analysis on injury prevalence and incidence in para athletes that uses Grading of Recommendations Assessment, Development and Evaluation recommendations to assess the overall quality of evidence.
- The subgroup analyses revealed that the sample size influenced the estimated injury prevalence and methodological quality influenced the injury incidence rate.
- Between winter sports, para alpine skiing/snowboard had the highest incidence of injuries, while between summer sports, football 5-a-side had the highest incidence of injuries.

**Twitter** Evert Verhagen @Evertverhagen

**Acknowledgements** The authors thank the support given by Secretaria Especial do Esporte do Ministério da Cidadania (Governo Federal, Brasília, Brazil—protocol number 58000.008978/2018-37), Comitê Paralímpico Brasileiro (CPB), CTE/EEFFTO/UFMG, FEPE-UFMG (Fundação de Apoio ao Ensino, Pesquisa e Extensão-UFMG), Pró-Reitoria de Pesquisa (PRPq)—UFMG.

**Contributors** All authors were fully involved in the study and preparation of the manuscript and agreed with the content in the final manuscript.

**Funding** Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq)—428735/2018-5, Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG)—CDS - APQ-01017-17, Coordenação de Aperfeiçoamento de Pessoal de Nível Superior—Brasil (CAPES)—Finance Code 001.

**Competing interests** None declared.

**Patient consent for publication** Not required.

**Provenance and peer review** Not commissioned; externally peer reviewed.



**ORCID iDs**
Larissa Santos Pinto Pinheiro http://orcid.org/0000-0001-5927-2893
Fernanda Oliveira Madaleno http://orcid.org/0000-0001-5531-390X
Evert Verhagen http://orcid.org/0000-0001-9227-8234
Marco Túlio de Mello http://orcid.org/0000-0003-3896-2208
Renan Alves Resende http://orcid.org/0000-0002-1609-3278

## REFERENCES

1 Brittain I. The Paralympic Games explained. *Paralympic Games Explain* 2009:1–172.
2 Committee P. Annual report 2016. *Am J Pharm Educ* 2016;80:S9.
3 Blauwet CA, Cushman D, Emery C, *et al*. Risk of injuries in Paralympic track and field differs by impairment and event discipline: a prospective cohort study at the London 2012 Paralympic Games. *Am J Sports Med* 2016;44:1455–62.
4 Van de Vliet P. Paralympic athlete's health. *Br J Sports Med* 2012;46:458–9.
5 Johnson CC. The benefits of physical activity for youth with developmental disabilities: a systematic review. *Am J Health Promot* 2009;23:157–67.
6 Martin JJ. Benefits and barriers to physical activity for individuals with disabilities: a social-relational model of disability perspective. *Disabil Rehabil* 2013;35:2030–7.
7 Derman W, Runciman P, Schwellnus M, *et al*. 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.
8 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 11274 athletes from 207 countries. *Br J Sports Med* 2017;51:1265–71.
9 Fagher K, Lexell J. Sports-Related injuries in athletes with disabilities. *Scand J Med Sci Sports* 2014;24:e320–31.
10 Tuakli-Wosornu YA, Mashkovskiy E, Ottesen T, *et al*. Acute and chronic musculoskeletal injury in para sport: a critical review. *Phys Med Rehabil Clin N Am* 2018;29:205–43.
11 IPC IPC. Athlete classification code 2015:1–21.
12 van Mechelen W, Hlobil H, Kemper HC. Incidence, severity, aetiology and prevention of sports injuries. A review of concepts. *Sports Med* 1992;14:82–99.
13 Weiler R, Van Mechelen W, Fuller C, *et al*. Sport injuries sustained by athletes with disability: a systematic review. *Sports Med* 2016;46:1141–53.
14 Munn Z, Moola S, Lisy K, *et al*. Methodological guidance for systematic reviews of observational epidemiological studies reporting prevalence and cumulative incidence data. *Int J Evid Based Healthc* 2015;13:147–53.
15 Higgins J, Thomas J, Chandler J, *et al*. Cochrane Handbook for systematic reviews of interventions | Cochrane training, 2019. Available: https://training.cochrane.org/handbook [Accessed 8 May 2020].
16 Moher D, Stewart L, Shekelle P. Implementing PRISMA-P: recommendations for prospective authors. *Syst Rev* 2016;5:15.
17 Bahr R. No injuries, but plenty of pain? on the methodology for recording overuse symptoms in sports. *Br J Sports Med* 2009;43:966–72.
18 Knowles SB, Marshall SW, Guskiewicz KM. Issues in estimating risks and rates in sports injury research. *J Athl Train* 2006;41:207–15.
19 Charan J, Biswas T. How to calculate sample size for different study designs in medical research? *Indian J Psychol Med* 2013;35:121–6.
20 Borenstein M. Research note: in a meta-analysis, the I2 index does not tell us how much the effect size varies across studies. *J Physiother* 2020:2–6.
21 Guyatt G, Oxman AD, Akl EA, *et al*. Grade guidelines: 1. Introduction-GRADE evidence profiles and summary of findings tables. *J Clin Epidemiol* 2011;64:383–94.
22 Antonietti LS, Costa RA, Gondo FLB, *et al*. Avaliação comparativa em lesados medulares sedentários E praticantes de basquetebol em cadeira de rodas. *Rev Neurociencias* 2008;16:90–6.
23 Kubosch EJ, Fassbender K, Steffen K, *et al*. Implementation of an injury and illness surveillance system in Paralympic athletes (ISSPA) – a study in German PARACYCLING athletes. *Br J Sports Med* 2017;51:347.1–347.
24 Marqueta P, Martínez M, Fernández R, *et al*. Incidencia lesional en competición de atletismo de Alto nivel de deportistas paralímpicos. *Arch Med del Deport* 2005;22:371–9.
25 McCormick DP, Niebuhr VN, Risser WL. Injury and illness surveillance at local special Olympic Games. *Br J Sports Med* 1990;24:221–4.
26 Ona Ayala KE, Li X, Huang P, *et al*. Injury epidemiology and preparedness in powerlifting at the Rio 2016 Paralympic games: an analysis of 1410 athlete-days. *Transl Sports Med* 2019;2:358–69.
27 Taylor D, Williams T. Sports injuries in athletes with disabilities: wheelchair racing. *Paraplegia* 1995;33:296–9.

28 Willick SE, Cushman DM, Blauwet CA, *et al*. The epidemiology of injuries in powerlifting at the London 2012 Paralympic games: an analysis of 1411 athlete-days. *Scand J Med Sci Sports* 2016;26:1233–8.
29 Webborn N, Willick S, Reeser JC. Injuries among disabled athletes during the 2002 winter Paralympic Games. *Med Sci Sports Exerc* 2006;38:811–5.
30 Willick SE, Webborn N, Emery C, *et al*. The epidemiology of injuries at the London 2012 Paralympic Games. *Br J Sports Med* 2013;47:426–32.
31 Fagher K, Ö D, Jacobsson J, *et al*. Injuries and illnesses in Swedish Paralympic athletes – a 52-week prospective study of incidence and risk factors. *Scand J Med Sci Sports* 2020;13687.
32 Haykowsky MJ, Warburton DER, Quinney HA. Pain and injury associated with powerlifting training in visually impaired athletes. *J Vis Impair Blind* 1999;93:236–41.
33 Bauerfeind J, Koper M, Wieczorek J, *et al*. Sports Injuries in Wheelchair Rugby - A Pilot Study. *J Hum Kinet* 2015;48:123–32.
34 Lankhorst K, de Groot J, Takken T, *et al*. Sports participation related to injuries and illnesses among ambulatory youth with chronic diseases: results of the health in adapted youth sports study. *BMC Sports Sci Med Rehabil* 2019;11:36.
35 Magno e Silva M, Bilzon J, Duarte E, *et al*. Sport injuries in elite Paralympic swimmers with visual impairment. *J Athl Train* 2013;48:493–8.
36 Magno e Silva MP, Morato MP, Bilzon JLJ, *et al*. Sports injuries in Brazilian blind footballers. *Int J Sports Med* 2013;34:239–43.
37 Magno E Silva MP, Winckler C, Costa E Silva AA, *et al*. Sports injuries in Paralympic track and field athletes with visual impairment. *Med Sci Sports Exerc* 2013;45:908–13.
38 Saffarian MR, Swampillai JJ, Andary MT, *et al*. Incidence of injury and illness during the 2013 world dwarf games. *Inj. Epidemiol.* 2019;6:1–9.
39 Derman W, Schwellnus MP, Jordaan E, *et al*. High incidence of injury at the Sochi 2014 winter Paralympic games: a prospective cohort study of 6564 athlete days. *Br J Sports Med* 2016;50:1069–74.
40 Derman W, Runciman P, Jordaan E, *et al*. 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.
41 Fagher K, Hassan Ahmed O, Pernheim N, *et al*. Prevalence of sports-related injuries in Paralympic judo: an exploratory study. *J Sci Med Sport* 2019;22:902–6.
42 Ferrara MS, Buckley WE, McCann BC, *et al*. The injury experience of the competitive athlete with a disability. *Med Sci Sports Exerc* 1992;24:184???188–8.
43 Ferrara MS, Davis RW. Relationship of sport classification and gender to injury for the athlete with cerebral palsy. *Sports Medicine, Training and Rehabilitation* 1994;5:115–20.
44 Gajardo R, Aravena C, Fontanilla M, *et al*. Injuries and illness prevalence prior to competition in Goalball players. *J Vis Impair Blind* 2019;113:443–51.
45 Gawroński W, Sobiecka J, Malesza J. Fit and healthy Paralympians--medical care guidelines for disabled athletes: a study of the injuries and illnesses incurred by the Polish Paralympic team in Beijing 2008 and London 2012. *Br J Sports Med* 2013;47:844–9.
46 Bernardi M, Castellano V, Ferrara MS, *et al*. Muscle pain in athletes with locomotor disability. *Med Sci Sports Exerc* 2003;35:199–206.
47 Curtis KA, Black K. Shoulder pain in female wheelchair basketball players. *J Orthop Sports Phys Ther* 1999;29:225–31 https://www.ncbi.nlm.nih.gov/pubmed/10322595
48 Fagher K, Dahlström Örjan, Jacobsson J, *et al*. Prevalence of sports-related injuries and illnesses in Paralympic athletes. *Pm R* 2020;12:271–80.
49 Patatoukas D, Farmakides A, Aggeli V, *et al*. Disability-related injuries in athletes with disabilities. *Folia Med* 2011;53:40–6.
50 Shimizu Y, Mutsuzaki H, Tachibana K, *et al*. A survey of deep tissue injury in elite female wheelchair basketball players. *J Back Musculoskelet Rehabil* 2017;30:427–34.
51 Tenforde AS, Brook EM, Broad E, *et al*. Prevalence and anatomical distribution of bone stress injuries in the elite para athlete. *Am J Phys Med Rehabil* 2019;98:1036–40.
52 Zwierzchowska A, Rosołek B, Celebańska D, *et al*. The prevalence of injuries and Traumas in elite Goalball players. *Int J Environ Res Public Health* 2020;17. doi:10.3390/ijerph17072496. [Epub ahead of print: 06 Apr 2020].
53 Ferrara MS, Buckley WE, Messner DG, *et al*. The injury experience and training history of the competitive skier with a disability. *Am J Sports Med* 1992;20:55–60.
54 Ferrara MS, Palutsis GR, Snouse S, *et al*. A longitudinal study of injuries to athletes with disabilities. / Etude longitudinale des blessures CheZ des athletes handicapes. *Int J Sports Med* 2000;21:221–4 http://articles.sirc.ca/search.cfm?id=S-653077%5Cnhttp://search.ebscohost.com/login.aspx?direct=true&db=sph&AN=SPHS-653077&site=ehost-live%5Cnhttp://www.thieme.com
55 Hollander K, Kluge S, Glöer F, *et al*. Epidemiology of injuries during the wheelchair Basketball world Championships 2018: a prospective cohort study. *Scand J Med Sci Sports* 2020;30:199–207.
56 Nyland J, Snouse SL, Anderson M, *et al*. Soft tissue injuries to USA paralympians at the 1996 summer games. *Arch Phys Med Rehabil* 2000;81:368–73.
57 Webborn N, Willick S, Emery CA. The injury experience at the 2010 winter Paralympic Games. *Clin J Sport Med* 2012;22:1–9.
58 Webborn N, Cushman D, Blauwet CA, *et al*. The Epidemiology of Injuries in Football at the London 2012 Paralympic Games. *Pm R* 2016;8:545–52.
59 Chung WM, Yeung S, Wong AYL, *et al*. Musculoskeletal injuries in elite able-bodied and wheelchair foil fencers--a pilot study. *Clin J Sport Med* 2012;22:278–80.
60 Ramirez M, Yang J, Bourque L, *et al*. Sports injuries to high school athletes with disabilities. *Pediatrics* 2009;123:690–6.
61 Ferrara MS, Buckley WE. Athletes with disabilities injury registry. *Adapt Phys Act Q* 1996;13:50–60.
62 Webborn N, Van de Vliet P. Paralympic medicine. *Lancet* 2012;380:65–71.
63 Finch CF, Bahr R, Drezner JA, *et al*. Towards the reduction of injury and illness in athletes: defining our research priorities. *Br J Sports Med* 2017;51:1178–82.
64 Thompson WR, Vanlandewijck YC. Science and the Paralympic movement. *Br J Sports Med* 2013;47:811.
65 Mason BS, Vegter RJK, Paulson TAW, *et al*. Bilateral scapular kinematics, asymmetries and shoulder pain in wheelchair athletes. *Gait Posture* 2018;65:151–6.
66 Warner MB, Wilson D, Heller MO, *et al*. Scapular kinematics in professional wheelchair tennis players. *Clin Biomech* 2018;53:7–13.
67 Burnham RS, May L, Nelson E, *et al*. Shoulder pain in wheelchair athletes. The role of muscle imbalance. *Am J Sports Med* 1993;21:238–42.
68 Van Drongelen S, Van der Woude LH, Janssen TW, *et al*. Mechanical load on the upper extremity during wheelchair activities. *Arch Phys Med Rehabil* 2005;86:1214–20.
69 Webborn N, Emery C. Descriptive epidemiology of Paralympic sports injuries. *Pm R* 2014;6:S18–22.
70 Junge A, Engebretsen L, Alonso JM, *et al*. Injury surveillance in multi-sport events: the International Olympic Committee approach. *Br J Sports Med* 2008;42:413–21.
71 Bahr R, Clarsen B, Derman W, *et al*. 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;54:372–89.
72 Clarsen B, Bahr R, Myklebust G, *et al*. 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;54:390–6.