INTRODUCTION

The Paralympic Movement continues to evolve with larger events and more competing athletes. With increased participation in competitive sport, there is growing awareness to understand the epidemiology of sports-related injuries and illnesses in Paralympic sport (SRIIPS). Over the past decade, several studies have assessed the incidence of SRIIPS during the Paralympic Games and reported higher incidence proportions compared to able-bodied athletes.
athletes. However, these studies have been performed during short and intense competitions periods. Studies examining SRIIPS over many months including athletes’ training periods are lacking. Thus, there is a need for prospective studies that assess the incidence of SRIIPS over a longer time. In addition, risk factors and mechanisms of SRIIPS specific to Paralympic athletes need to be investigated, as their impairments may influence the risk.

To increase our knowledge of the health status and risks in this understudied population, we initiated a prospective longitudinal study of SRIIPS. In the study protocol, we adapted definitions of SRIIPS to accommodate Paralympic athletes’ pre-existing medical conditions. To enable weekly data collection of SRIIPS in a heterogeneous and geographically spread population, we developed and evaluated an eHealth-based self-report application adapted to Paralympic athletes with physical impairment (PI), visual impairment (VI), and intellectual impairment (II). Self-reports have been shown to be sensitive in monitoring changes in athletes health, and it has been recommended to monitor such changes on a regular basis. Subsequently, 107 Swedish Paralympic athletes prospectively self-reported SRIIPS every week during 52 weeks.

The aim of this study was to describe the annual incidence, type, and severity of injuries and illnesses among Swedish Paralympic athletes and to assess risk factors.

2 | METHODS

2.1 | Study design and definition

This was a 52-week prospective cohort study assessing self-reported incidence of SRIIPS, which is part of the epidemiological study “The sports-related injury and illness in Paralympic Sport Study” (SRIIPSS). The SRIIPSS was developed and pursued in collaboration with athletes, coaches, and staff in the Swedish Paralympic Committee.

The study follows the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines, is approved by the Regional Ethical Review Board in Lund, Sweden (Dnr 2016/169), follows the WMA Declaration of Helsinki Ethical Principles for Medical Research Involving Human Subjects, and is registered at ClinicalTrials.gov [NCT02788500]. Participation in the study was voluntary, and informed consent was collected from all participants. The definition of SRIIPS was: “Any new musculoskeletal pain, feeling, injury, illness, or psychological complaint that caused changes in normal training or competition to the mode, duration, intensity, or frequency, regardless of whether or not time was lost from training or competition”.

2.2 | Participants

All athletes with PI, VI, and II from the Swedish Paralympic program (N = 150 athletes) were invited to participate. The athletes had been participating at a previous Paralympic Games or were candidates for a future Paralympic Games. The following inclusion criteria were used: (a) being able to communicate in Swedish; (b) age 18-65 years; and (c) having the ability to respond to the eHealth application. In total, 107 (71%) athletes accepted to participate (Figure 1).

2.3 | Data collection

Data on the incidence of new SRIIPS and sports exposure were collected weekly throughout 2017 using Briteback® survey tool and an eHealth-based self-report application adapted to Paralympic athletes. Prior to this study, the data collection procedure was evaluated in a four-week pilot feasibility usability study. Once every week, the athletes received a web survey through email and/or text message with questions regarding their previous training week. If reporting a new injury, the athletes were asked about body location, injury type, and mechanism, involvement of their impairment and diagnosis. For a new illness, questions regarding symptoms, affected body system, contribution of the impairment, and diagnosis were asked. Exposure was reported as the number of training minutes. Data were followed up every week by (KF). Closing reports regarding diagnosis, contact with medical personnel, time loss from sport, and preventive possibilities were sent to those reporting being back in training.

2.4 | Data categorization

Injuries were categorized in a matrix for classification of musculoskeletal diagnoses according to body location, injury type, and diagnosis from the 10th International Statistical Classification of Disease and Related Health Problems (ICD-10). Two authors (KF and JJ) independently formed ICD-10 codes. The reported illnesses were categorized into affected body system and ICD-10 diagnoses independently formed by KF and JL. The severity of SRIIPS was determined by time loss (days) from regular sports participation: slight (0-3 days), minor (4-7 days), moderate (8-20 days), severe (≥21 days), and long-term (≥3 months). A total training load rank index (TLRI) was calculated for each athlete by multiplying the rate of perceived exertion (RPE) with minutes of training per week throughout the year. TLRI was categorized into low, middle, and high according to percentiles.
2.5  Statistical analysis

Descriptive statistics were used to present data. To estimate the total onset of new SRIIPS, the incidence rate (IR) was calculated by dividing all reported incidents by the total time of exposure in each category.\textsuperscript{20} The Mann-Whitney \textit{U} test or the Kruskal-Wallis test \textsuperscript{21} were used to compare IR between different variables, such as sex, age, type of sport (team vs individual, summer vs winter), impairment (physical vs intellectual vs visual; central neurological vs intellectual vs les autres vs limb deficiency vs spinal cord injury (SCI) vs visual; and wheelchair users vs ambulatory participants), TLRI (low vs middle vs high), and previous severe injury or illness last year. Chi-square statistics were used to compare any differences between the subgroups in the proportion of incidents by affected body location and body system, respectively.

To determine the probability for an athlete to sustain a new SRIIPS, the incidence proportion (IP) was calculated by dividing the number of athletes that sustained a SRIIPS by the total number of athletes followed.\textsuperscript{20} Survival analyses using the Kaplan-Meier method were conducted to estimate the cumulative survival probability (SP) and the primary endpoints: median time to the first injury and illness, respectively.\textsuperscript{22} Log-rank tests assessing the hazard function were used to compare differences in survival times between the subgroups, and Cox proportional hazard regression with corresponding hazard ratios (HR) were performed to analyze the actual risk of sustaining a first SRIIPS.\textsuperscript{18} Univariate models assessing risks associated with each variable were first tested. To account for covariates and differences in risk between different subgroups, multivariate models with two explanatory variables and their interactions were examined. Significance levels of \textit{P} < .05 and 95% confidence intervals were used. Throughout, data were analyzed using IBM SPSS version 25.

3  RESULTS

The weekly response rate was 72%. The median number of completed weekly reports per athlete was 45 (IQR 25-52, min-max 1-52). The mean time of weekly sports exposure was 6.8 ± 4.8 hours. Four athletes dropped out during the year and were right censored in the survival analysis from the week of drop out.

3.1  Injury incidence rates

In total, 179 injuries were reported, resulting in an overall IR of 6.9 injuries/1000 hours of sports exposure. No significant differences in IR were present between the subgroups. Of all injuries, 41% were primary, 37% new subsequent, and 21% recurrent. The median number of reported injuries per athlete was 2 (IQR 1-3, min–max 0-7) (Table 1).

Fifteen percent of all injuries occurred during competition, 53% during sport-specific training, 17% during other training, and 16% outside sport. The onset of injury was as follows: 32% traumatic, 16% overuse with sudden onset, and 52% overuse with gradual onset. ICD-10 diagnoses related to inflammation,
Table 1. Annual injury incidence proportions, time to first new injury, and injury incidence rates among Swedish Paralympic athletes (n = 107) by gender, age, impairment, sport, training load, and injury history.

|                        | Incidence proportion (IP) (n, %) | Mdn time to injury (weeks) (95% CI) | Log-rank test (p-value) | Total number of injuries | Incidence rate (IR)/1000 hours of exposure (95% CI) | Comparisons of IR based on exposure (p-value) | Number of injuries/athlete (mdn) | Comparisons of multiple injuries (p-value) |
|------------------------|----------------------------------|------------------------------------|-------------------------|--------------------------|----------------------------------------------------|---------------------------------------------|-------------------------------|------------------------------------------|
| **All injuries**       |                                  |                                    |                         |                          |                                                    |                                             |                               |                                          |
| Overall                | 73 (68%)                         | 19 (10.6-27.4)                    | 0.024                   | 179                      | 6.9 (6.0-8.0)                                      | -                                           | 2                             | -                                        |
| **Sex**                |                                  |                                    |                         |                          |                                                    |                                             |                               |                                          |
| Male (n = 70)          | 52 (74%)                         | 16 (10.3-21.7)                    | 0.024                   | 120                      | 6.9 (2.0-23.7)                                     | 0.29                                         | 2                             | 0.41                                     |
| Female (n = 37)        | 21 (57%)                         | 43 (23.9-62.1)                    |                         | 59                       | 6.9 (1.2-40.1)                                     |                                             |                               |                                          |
| **Age**                |                                  |                                    |                         |                          |                                                    |                                             |                               |                                          |
| 18-25 (n = 35)         | 20 (57%)                         | 41 (27.1-54.9)                    | 0.140                   | 38                       | 5.4 (1-30.1)                                      | 0.13                                         | 1.5                           | 0.092                                    |
| 26-34 (n = 38)         | 30 (79%)                         | 18 (15.4-20.6)                    |                         | 75                       | 8.1 (1.3-50.7)                                     |                                             |                               | 2                                        |
| 35-63 (n = 34)         | 23 (67%)                         | 14 (10.6-27.4)                    |                         | 66                       | 6.8 (1.3-35.1)                                     |                                             |                               | 3                                        |
| **Impairment**         |                                  |                                    |                         |                          |                                                    |                                             |                               |                                          |
| Visual (n = 22)        | 17 (77%)                         | 19 (0-39.6)                       | 0.830                   | 63                       | 9.8 (0.9-110.2)                                    | 0.055                                        | 4                             | 0.004                                    |
| Intellectual (n = 6)   | 4 (67%)                          | 26 (16.4-35.6)                    |                         | 6                        | 6.7 (0.5-1426.9)                                   |                                             |                               | 1.5                                      |
| Physical (n = 79)      | 52 (66%)                         | 19 (8.4-29.7)                     |                         | 110                      | 5.9 (2.0-17.8)                                     |                                             | 2                             |                                          |
| Central neurological (n = 18) | 10 (56%) | 14 (0-32.7) | 0.310 | 26 | 4.7 (0.8-28.6) | 0.54 | 2.5 | 0.56 |
| Les autres (n = 14)    | 6 (43%)                          | 36 (26.7-46.7)                    |                         | 11                       | 3.1 (0.5-19.4)                                     |                                             | 1                             |                                          |
| Limb deficiency (n = 11) | 9 (82%) | 19 (11.5-26.6) |                     | 17 | 7.8 (0.2-318.0) |                                             | 2 |                                          |
| Spinal cord injury (n = 36) | 27 (75%) | 14 (0-31.6) |                     | 56 | 7.5 (1.1-53.5) |                                             | 2 |                                          |
| **Sport**              |                                  |                                    |                         |                          |                                                    |                                             |                               |                                          |
| Summer vs Winter       |                                  |                                    |                         |                          |                                                    |                                             |                               |                                          |
| Summer (n = 88)        | 58 (66%)                         | 21 (11.8-30.2)                    | 0.254                   | 140                      | 6.7 (2.2-20.3)                                     | 0.66                                         | 2                             | 0.60                                     |
| Winter (n = 19)        | 15 (79%)                         | 17 (3.1-30.9)                     |                         | 39                       | 7.4 (0.7-75.5)                                     |                                             |                               | 2                                        |
| Team vs Individual     |                                  |                                    |                         |                          |                                                    |                                             |                               |                                          |
| Team (n = 47)          | 38 (81%)                         | 14 (1.9-26.1)                     | 0.005                   | 103                      | 8.3 (1.7-41.2)                                     | 0.20                                         | 2                             | 0.18                                     |
| Individuall (n = 60)   | 35 (58%)                         | 33 (25.4-40.6)                    |                         | 76                       | 5.6 (1.6-19.7)                                     |                                             | 2                             |                                          |
| **Training load**      |                                  |                                    |                         |                          |                                                    |                                             |                               |                                          |
| Low vs Middle vs High  |                                  |                                    |                         |                          |                                                    |                                             |                               |                                          |
| Low (n = 34)           | 23 (68%)                         | 19 (6.2-31.8)                     | 0.262                   | 45                       | 8.1 (0.8-86.4)                                     | 0.40                                         | 2                             | 0.10                                     |
| Middle (n = 35)        | 28 (80%)                         | 14 (3.6-24.4)                     |                         | 59                       | 7.3 (1.1-47.0)                                     |                                             | 2                             |                                          |

(Continues)
pain, and soft tissue disorders were most common (47%), followed by sprain, strain, and rupture (15%) (Appendix 1).

The most frequently injured body location was the shoulder (23%), followed by the lumbar spine (12%) and the elbow/forearm (11%) (Table 2). The time loss from sport due to injury (severity) was as follows: 0-3 days (33%), 4-7 days (24%), 8-20 days (10%), ≥21 days (23%), and ≥3 months (11%). Wheelchair users and athletes with SCI reported more injuries in the upper extremities and the shoulder ($P < .001$). Ambulatory individuals reported more injuries in the lower extremities ($P = .012$), with VI athletes reporting more injuries to the lower leg/calf ($P = .018$). Athletes with VI reported more multiple injuries ($P = .004$) (Table 1) and also more traumatic injuries ($P = .008$). For 59% of the injuries, the athletes reported that the impairment was a contributing factor in the injury mechanism. For 68% of all injuries, the athletes sought medical care and the diagnosis was confirmed by a medical professional. The athletes reported that 32% of the injuries could have been prevented.

### 3.2 | Injury incidence proportions and risk factors

In total, 73 (68%) athletes reported a new injury. The median time to first injury was 19 weeks (95% CI 10.5-27.4). Log-rank tests showed statistically significant variations in SP with regard to gender ($P = .024$), type of sport ($P = .005$), and previous severe injury ($P \leq 0.001$). Men had lower SP (26%) compared to women (43%), and athletes in team sports had a lower SP (19%) compared to individual sports (42%). Twelve percent of the athletes with a previous severe injury remained injury free compared to 39% without a history of severe injury (Table 1; Figure 2).

Results from the Cox regression analyses using univariate models showed that athletes with a previous severe injury had more than twice the risk (HR = 2.37; 95% CI 1.47-3.83) of sustaining a new injury. Also, male athletes (HR = 1.76; 95% CI 1.06-2.93) and athletes participating in team sports (HR = 1.88; 95% CI 1.19-2.99) had a significantly higher risk (Table 3). No multivariate models were statistically significant.

### 3.3 | Illnesses incidence rates

In total, 241 illnesses were reported, resulting in an IR of 9.3 illnesses/1000 h of sports exposure. Athletes with a middle TLRI reported a significantly ($P = .019$) higher IR (22 illnesses/1000 hours). No other significant differences were found between the subgroups. The median number of reported illnesses per athlete was 2 (IQR 1-4, min–max 0-11) (Table 4).
### TABLE 2 Distribution of injuries and illnesses sustained by Paralympic athletes (n = 107) during one year by body region, body system and impairment

| Injuries by body region | All incidents (n = 107) | Physical Impairment\(^a\) n = 79 (n (%)) | Central neurological injury n = 18 (n (%)) | Limb deficiency n = 11 (n (%)) | Les autres n = 14 (n (%)) | Spinal cord injury n = 36 (n (%)) | Visual Impairment n = 22 (n (%)) | Intellectual Impairment n = 6 (n (%)) | Wheelchair user n = 53 (n (%)) | Ambulatory n = 54 (n (%)) |
|-------------------------|------------------------|------------------------------------------|------------------------------------------|-------------------------------|-----------------------------|---------------------------------|---------------------------------|---------------------------------|-----------------------------------|----------------------------------|
| **All injuries**        | 179 (100)              | 110 (100)                                 | 26 (100)                                 | 17 (100)                      | 11 (100)                    | 56 (100)                       | 63 (100)                        | 6 (100)                         | 79 (100)                          | 100 (100)                        |
| Head/face (ear, eyes, jaw) | 13 (7)                 | 5 (5)                                     | -                                        | -                             | -                           | 5 (9)                          | 8 (13)                          | -                               | 5 (6)                             | 8 (8)                            |
| Vertebral column        | 40 (22)                | 27 (25)                                   | 5 (19)                                   | 6 (35)                        | 5 (46)                      | 11 (20)                        | 11 (18)                         | 2 (33)                          | 17 (22)                           | 24 (24)                          |
| Cervical               | 4 (2)                  | 4 (4)                                     | 1 (4)                                    | 1 (6)                         | -                           | 2 (4)                          | 0 (0)                           | -                               | 4 (5)                             | 1 (1)                            |
| Thoracic/rib             | 10 (6)                 | 7 (6)                                     | 1 (4)                                    | 2 (12)                        | 2 (18)                      | 2 (4)                          | 3 (5)                           | -                               | 3 (4)                             | 7 (7)                            |
| Lumbar                  | 22 (12)                | 12 (11)                                   | 2 (8)                                    | 3 (18)                        | 3 (27)                      | 4 (7)                          | 8 (13)                          | 2 (33)                          | 6 (8)                             | 16 (16)                          |
| Pelvis/sacrum           | 4 (2)                  | 4 (4)                                     | 1 (4)                                    | -                             | -                           | 3 (5)                          | -                               | -                               | 4 (5)                             | -                                |
| **Upper extremities**   | 72 (40)                | 56 (51)                                   | 9 (35)                                   | 7 (41)                        | 5 (46)                      | 35 (63)\(^b\)                  | 14 (22)                         | 4 (67)                          | 45 (57)\(^b\)                     | 27 (27)                          |
| Shoulder girdle, upper arm | 41 (23)              | 38 (35)                                   | 8 (31)                                   | 6 (35)                        | 2 (18)                      | 22 (39)\(^b\)                 | 3 (5)                           | 2 (33)                          | 30 (38)\(^b\)                     | 11 (11)                          |
| Elbow/forearm           | 19 (11)                | 13 (12)                                   | -                                        | 1 (6)                         | 2 (18)                      | 10 (18)                        | 4 (6)                           | 2 (33)                          | 11 (14)                           | 8 (8)                            |
| Wrist/hand/finger       | 12 (7)                 | 5 (5)                                     | 1 (4)                                    | -                             | 1 (9)                       | 3 (5)                          | 7 (11)                          | -                               | 4 (5)                             | 8 (8)                            |
| **Lower extremities**   | 54 (30)                | 22 (20)                                   | 12 (46)                                  | 4 (24)                        | 1 (9)                       | 5 (9)                          | 30 (48)\(^b\)                  | -                               | 12 (15)                           | 42 (42)\(^b\)                    |
| Hip/groin/high          | 10 (6)                 | 4 (4)                                     | 2 (8)                                    | 1 (6)                         | -                           | 1 (2)                          | 6 (10)                          | -                               | 4 (5)                             | 6 (6)                            |
| Knee                    | 11 (6)                 | 6 (6)                                     | 4 (15)                                   | 2 (12)                        | -                           | -                              | 5 (8)                           | -                               | 2 (3)                             | 9 (9)                            |
| Lower leg/calf          | 16 (9)                 | 5 (5)                                     | 4 (15)                                   | -                             | -                           | 1 (2)                          | 11 (18)\(^b\)                  | -                               | 3 (4)                             | 13 (13)\(^b\)                    |
| Ankle/foot/toe          | 17 (10)                | 7 (6)                                     | 2 (8)                                    | 1 (6)                         | 1 (9)                       | 3 (5)                          | 8 (13)                          | -                               | 3 (4)                             | 14 (14)\(^b\)                    |
| **Illnesses by body system** | 241 (100)            | 149 (100)                                 | 36 (100)                                 | 18 (100)                      | 39 (100)                    | 56 (100)                       | 80 (100)                        | 12 (100)                       | 96 (100)                          | 145 (100)                        |
| Upper respiratory tract | 164 (68)               | 102 (68)                                  | 31 (86)                                  | 13 (72)                       | 32 (82)                     | 26 (46)                        | 54 (68)                        | 8 (67)                          | 60 (63)                           | 104 (72)                         |
| Lower respiratory tract | 4 (2)                  | 1 (1)                                     | -                                        | -                             | 1 (3)                       | -                              | 3 (4)                           | -                               | 1 (1)                             | 3 (2)                            |
| Skin/Dermatological     | 3 (1)                  | 2 (1)                                     | -                                        | 1 (6)                         | -                           | 1 (2)                          | 1 (1)                           | -                               | 1 (1)                             | 2 (1)                            |
| Digestive/Gastrointestinal | 23 (10)              | 12 (8)                                     | 3 (8)                                    | 2 (11)                        | 2 (5)                       | 5 (9)                          | 8 (10)                          | 3 (25)                          | 7 (7)                             | 16 (11)                          |
| Urogenital/Gynecological | 17 (7)                 | 13 (9)                                    | -                                        | -                             | 13 (23)\(^b\)               | 3 (4)                          | 1 (8)                           | 13 (14)\(^b\)                    | 4 (3)                             |                                  |
| Neurological/Nervous system | 7 (3)                  | 7 (5)                                     | 1 (3)                                    | -                             | 1 (3)                       | 5 (9)                          | -                               | -                               | 6 (6)                             | 1 (1)                            |
| Psychiatric/Psychological | 6 (2)                 | 4 (3)                                     | -                                        | 2 (11)                        | 1 (3)                       | 1 (2)                          | 2 (3)                           | -                               | 2 (2)                             | 4 (3)                            |
| Eye/adnexa              | -                      | -                                         | -                                        | -                             | -                           | -                              | -                               | -                               | -                                 | -                                |

(Continues)
The most common affected body system was upper respiratory tract (68%), followed by digestive/gastrointestinal (10%) and urogenital/gynecological (UG) (7%) (Table 2). Most illnesses were categorized as infections (84%). The severity (time loss) of illnesses were as follows: 0-3 days (38%), 4-7 days (42%), 8-20 days (14%), ≥21 days (5%), and ≥ 3 months (2%). Wheelchair athletes and athletes with SCI reported a higher proportion of illnesses in the UG system (P = .002) (Table 2). Ambulatory athletes reported more multiple illnesses (P = .046) (Table 4).

For 22% of the illnesses, the athletes sought medical care and obtained a diagnosis. The athletes reported that the cause of illness was due to overtraining and stress (45%), the impairment and/or associated medications (28%), and transmission (17%).

### 3.4 Illness incidence proportions and risk factors

In total, 82 (77%) athletes reported a new illness. The median time to first illness was 9 weeks (95% CI 1.40-16.60). Logrank tests revealed a statistically variation in SP, showing that athletes in team sports had a lower SP (11%) compared to athletes in individual sports (35%) (P = .022) (Table 4; Figure 2).

Univariate Cox regression analysis revealed that athletes in team sports had a higher risk of illness (HR = 1.64; 95% CI 1.05-2.54). Results from the multivariate analyses accounting for interactions showed that athletes in a summer team sport (goalball, wheelchair rugby, and basketball) had twice the risk of illness (HR = 2.01; 95% CI 1.29-3.29). Also, male athletes with a previous severe illness had a higher risk (HR = 2.13; 95% CI 1.04-4.36) (Table 3).

### 4 DISCUSSION

To the best of our knowledge, this is the first long-term prospective study of incidence and risk factors of injuries and illnesses in Paralympic sport. There was a high incidence of both injuries and illnesses reported by Swedish Paralympic athletes during one year. In total, 34% of the injuries were classified as severe and most injuries occurred outside competition. Athletes with VI reported significantly more multiple and traumatic injuries, ambulatory athletes reported a higher proportion of lower extremity injuries, and athletes with SCI reported a higher proportion of shoulder injuries. A majority of the illnesses were infections, and athletes with SCI had a higher proportion of illnesses in the urogenital system. Athletes in team sports, males, and those with a previous incident had a higher risk and should be particular targets for future prevention.

| Physical Impairment | All incidents (n (%)) | Central neurological injury (n (%) | Limb deficiency (n (%) | Les autres (n (%)) | Other infections (n (%)) | Endocrine/metabolic (n (%)) | Hematological/immunological (n (%)) | Dental (n (%)) | Headache/migraine (n (%)) |
|---------------------|-----------------------|----------------------------------|-----------------------|-------------------|-------------------------|-------------------------------|-------------------------------|----------------|--------------------------|
| Ambulatory          | 79 n (%)              | 1 (1)                            | 0 (0.4)               | 0 (0.4)           | 1 (0.4)                 | 1 (0.4)                       | 1 (0.4)                       | 1 (2)          | 1 (2)                    |
| Wheelchair user     | 54 n (%)              | 1 (1)                            | 0 (0.4)               | 0 (0.4)           | 1 (0.4)                 | 1 (0.4)                       | 1 (0.4)                       | 1 (2)          | 1 (2)                    |
| SCI                 | 53 n (%)              | 2 (2)                            | 2 (4)                 | 1 (2)             | 3 (5)                   | 12 (5)                        | 4 (3)                         | 9 (18)        | 3 (6)                    |
| Les autres          | 56 n (%)              | 3 (5)                            | 1 (1)                 | 1 (1)             | 1 (1)                   | 1 (1)                         | 1 (1)                         | 1 (1)          | 1 (1)                    |
| Central neurological injury | 48 n (%)     | 2 (4)                            | 2 (4)                 | 1 (2)             | 3 (5)                   | 12 (5)                        | 4 (3)                         | 9 (18)        | 3 (6)                    |
| Physical Impairment | 79 n (%)              | 3 (4)                            | 1 (1)                 | 1 (1)             | 1 (1)                   | 1 (1)                         | 1 (1)                         | 1 (2)          | 1 (2)                    |

*Significantly higher proportion of a particular event (P < .05).*
4.1 Sports-related injuries

The observed injury IR is similar, or even higher, than corresponding rates among able-bodied athletes. The only comparable study of injuries over time in Paralympic athletes reported an IR of 3.9/1000 hours among wheelchair fencers. In the present study, also a high IP was reported (68%). The studies from the Paralympic Games have reported considerably lower IPs ranging from 11.6% to 23.8%. Noteworthy is that 85% of the injuries in the present study occurred outside competition and that one-third were classified as severe. This is a concern as most athletes do not have on-site medical support outside competition. Also, the proportion of overuse injuries was higher compared to the Paralympic Games, suggesting that overuse injuries and inaccurate training are more common throughout the training season. Risk factors for injuries are dynamic and depend on intrinsic and extrinsic factors as well as the inciting event. Thus, it is recommended to continue conducting athlete health surveillance in different contexts to better understand the etiology of injuries.

In the present study, athletes in team sports had a higher risk for injury. It is possible that athletes in team sports, such as goalball, para ice hockey, wheelchair rugby, and basketball, are more prone to injuries because of high intensities and collisions. Athletes in team sports had high IRs also during the Paralympic Games, and these sports should be targets for future prevention. Moreover, male athletes had a higher risk of injury, even when adjusting for team sports. Risk-taking behavior has been identified as a possible explanation in other areas of injury research. More research is needed to establish gender-specific risk factors. Finally, athletes with a previous severe injury had a higher risk of injury, emphasizing the importance of primary and secondary prevention.

In agreement with previous studies, the shoulder was the most injured body region, and wheelchair users in

FIGURE 2 Kaplan-Meier curves for time to first injury (a-c) and illness (d) during the study period displayed by categories with a significant difference revealed by log-rank tests ($P<.05$)
particular reported higher proportions of shoulder injuries. These athletes are commonly exposed to overuse of the shoulder both during sport and in daily life.\textsuperscript{32} Preserving the shoulder in wheelchair athletes may be particularly difficult because of lack of rest, altered seating positions, and configuration of sports equipment.\textsuperscript{32,33} Given these findings, it is recommended that shoulder injury prevention programs are implemented and that the impact from sports equipment is further addressed.

Notably, athletes with VI reported more multiple injuries and more traumatic injuries. Among persons with VI, the risk of unintentional injuries is generally higher.\textsuperscript{34} Further studies are needed to assess injury mechanisms among VI athletes.

### 4.2 Sports-related illnesses

The illness IR was higher than the injury IR, emphasizing the need to include illnesses in athlete health surveillance. A majority of the reported illnesses were infections. The basic etiology of infections is transmission of fungal, viral, and bacterial agents. Consequently, the primary prevention strategies are proper hygiene and social distancing.\textsuperscript{35} Especially, athletes in team sports had a higher risk of illness. Because of close encounters in teams, athletes more easily transmit infections.\textsuperscript{36} To prevent illnesses in Paralympic team sports, it is recommended to reduce skin contact, not return to sports until complete recovery, and to adopt regular cleaning of equipment, such as wheelchairs, balls, and arena floors.\textsuperscript{35} Again, male athletes (with a previous illness) had a higher risk, and it is recommended to further assess their increased susceptibility to illnesses.

Noteworthy, athletes with a middle TLRI had a higher IR. In the present study, athletes reported that a common reason for illness was overtraining and stress. In a recent study, we showed that 83% of the Paralympic athletes continued to train unwell and 77% felt guilt when missing training.\textsuperscript{3} It could be

---

**Table 3** Simple and multiple models of risk factors for injury and illness determined by time-to-event analyses (Cox proportional hazard regression models presented with hazard ratios (HR), \( p \)-values and 95% confidence intervals (CI)). Simple models show risks associated with variables separately. Multiple models with two explanatory variables and their interactions are reported as categorical variables with the possible subgroups as separate conditions.

| First injury | First illness |
|--------------|--------------|
| **Simple models** | | |
| HR | p-value | 95% CI | HR | p-value | 95% CI |
| Sex (male vs female) | 1.76 | 0.029 | 1.06-2.93 | 1.22 | 0.413 | 0.76-1.93 |
| Age (26-34 vs 18-25 or 35-63 years) | 1.13 | 0.668 | 0.65-1.94 | 1.24 | 0.408 | 0.74-2.08 |
| Impairment (VI vs II or PI) | 1.15 | 0.613 | 0.67-1.99 | 1.52 | 0.116 | 0.90-2.54 |
| Sport (Team vs Individual) | 1.88 | 0.007 | 1.19-2.99 | 1.55 | 0.048 | 1.01-2.40 |
| Sport (Winter vs Summer) | 1.38 | 0.266 | 0.78-2.44 | 1.00 | 0.995 | 0.58-1.73 |
| Training load\textsuperscript{a} (middle vs high or low) | 1.577 | 0.115 | 0.90-2.78 | 1.40 | 0.207 | 0.83-2.39 |
| Wheelchair user vs ambulatory | 1.08 | 0.729 | 0.69-1.72 | 0.92 | 0.693 | 0.59-1.41 |
| Previous injury/illness\textsuperscript{b} (yes vs no) | 2.37 | <0.001 | 1.47-3.83 | 1.18 | 0.591 | 0.64-2.19 |

| Multiple models (interactions)\textsuperscript{c} | | |
| Sex × Illness history | | |
| Female and No previous illness | 1 | | | | |
| Female and Previous illness | 0.18 | 0.097 | 0.03-1.36 | | | |
| Male and No previous illness | 0.93 | 0.781 | 0.57-1.53 | | | |
| Male and Previous illness | 2.13 | 0.040 | 1.04-4.36 | | | |

| Sport type × Paralympic sport category | | |
| Individual sport and Summer sport | 1 | | | | |
| Individual sport and Winter sport | 2.09 | 0.164 | 0.74-5.88 | | | |
| Team sport and Winter sport | 1.14 | 0.690 | 0.60-2.19 | | | |
| Team sport and Summer sport | 2.01 | 0.005 | 1.29-3.29 | | | |

\textsuperscript{a}Since middle differed significantly from both low and high, middle was examined using low and high as a combined reference category.\textsuperscript{b}Injury with time loss ≥ 21 days previous year analyzed for first injury and illness with time loss ≥ 21 days previous year analyzed for first illness. \textsuperscript{c}Variables in the simple models were also pairwise combined to test for interactions, that is, models where pairs of variables were tested in combination with their interaction. Finally, the effect of each covariate was tested and presented as above. Only models with significant interactions (\( P < .05 \)) are presented in this section of the table. Reference categories are shown in \textit{italics}. 

---

Since middle differed significantly from both low and high, middle was examined using low and high as a combined reference category.
### Table 4: Annual illness incidence proportions, time to first new illness, and illness incidence rates among Swedish Paralympic athletes (n = 107) by gender, age, sport, impairment, training load, and illness history

| First illness | All illnesses |
|---------------|---------------|
| **Incidence proportion** (IP) (n, %) | **Mdn time to illness** (weeks), (95% CI) | **Log-rank test** (p-value) | **Total number of illnesses** | **Incidence rate** (IR)/1000 hours of exposure, (95% CI) | **Comparisons of IR** (p-value) | **Number of illnesses/athlete (mdn)** | **Comparisons of multiple illnesses** (p-value) |
| Overall | 82 (77%) | 9 (1.4-16.6) | | 241 | 9.3 (8.2-10.6) | - | 2 | - |
| **Gender** | | | | | | | | |
| Male (n = 70) | 55 (79%) | 9 (4.9-13.1) | 0.405 | 155 | 8.9 (2.2-36.1) | 0.71 | 2 | 0.59 |
| Female (n = 37) | 26 (70%) | 12 (0.3-34.6) | | 86 | 10.1 (1.2-85.4) | | 2.5 | |
| **Age** | | | | | | | | |
| 18-25 (n = 35) | 23 (66%) | 16 (1.0-45.0) | 0.146 | 56 | 9.2 (0.8-118.6) | 0.59 | 2 | 0.169 |
| 26-35 (n = 38) | 32 (84%) | 7 (2.2-11.8) | | 114 | 12.9 (1.2-137.7) | | 3 | |
| 36-63 (n = 34) | 27 (79%) | 8 (0.3-1.1.8) | | 71 | 7.3 (1.3-39.9) | | 2 | |
| **Impairment** | | | | | | | | |
| Visual (n = 22) | 19 (86%) | 5 (2.2-7.8) | 0.150a | 80 | 12.4 (0.8-187.7) | 0.78a,c | 4 | 0.11a,c |
| Intellectual (n = 6)c | 3 (50%) | 5 | - | | 12 | 13.7 (0.5-318.4) | | 5 | |
| Physical (n = 79) | 60 (76%) | 12 (0.0-25.9) | | 149 | 8.0 (2.2-28.9) | | | 2 |
| Central neurological (n = 18) | 13 (72%) | 9 (3.5-14.5) | 0.247b | 36 | 6.6 (0.8-57.0) | 0.81b,c | 2 | 0.23b,c |
| Les autres (n = 14) | 12 (86%) | 7 (2.1-1.1.9) | | 39 | 11.0 (0.4-347.3) | | 2.5 | |
| Limb deficiency (n = 11) | 8 (73%) | 8 (0-16.6) | | 18 | 8.3 (0.9-384.0) | | 2 | |
| Spinal cord injury (n = 36) | 27 (75%) | 36 (15.4-56.6) | | 56 | 7.5 (1.1-53.5) | | 2 | |
| **Sport** | | | | | | | | |
| Summer vs Winter | | | | | | | | |
| Summer (n = 88) | 66 (75%) | 8 (3.8-12.2) | 0.995 | 195 | 9.4 (2.5-35.2) | 0.48 | 2 | 0.81 |
| Winter (n = 19) | 16 (84%) | 25 (0.0-56.3) | | 46 | 8.8 (0.7-111.9) | | 2 | |
| **Team Sport vs Individual** | | | | | | | | |
| Team (n = 47) | 42 (89%) | 8 (4.2-11.8) | 0.022 | 134 | 10.8 (1.7-67.2) | 0.88 | 2 | 0.24 |
| Individual (n = 60) | 39 (65%) | 12 (0.0-45.6) | | 107 | 7.9 (1.8-35.3) | | 2 | |
| **Training load** | | | | | | | | |
| Low vs Middle vs High | | | | | | | | |
| Low (n = 34) | 25 (74%) | 9 (0.1-20.4) | 0.764 | 20 | 3.7 (0.7-18.7) | 0.019d | 2 | 0.68d |
| Middle (n = 35) | 31 (89%) | 7 (4.5-9.5) | | 177 | 22.0 (0.0-562.4) | | 2.5 | |
| High (n = 34) | 25 (74%) | 12 (0.3-39.4) | | 44 | 3.5 (1.2-9.8) | | 2 | |

(Continues)
hypothesized that these behaviors are present among athletes with a middle TLRI compared to those that could maintain a high TLRI. As training and stress downregulate immune function, it is recommended to further educate athletes and coaches about training behavior and its impact on illness.

Wheelchair users reported a higher proportion of illnesses in the UG system. Many wheelchair users have a neurogenic bladder and therefore are more susceptible to urinary tract infections (UTI). As symptoms of UTI can be diffuse and recurrent, they can be challenging to diagnose and treat. It is therefore recommended to adopt multimodal strategies that focus on optimal bladder management and rapid diagnostics to reduce such incidents. Few athletes seek medical care for illnesses, and it is recommended to educate them about healthcare use and to review resources. This may reduce the burden of illness and shorten the time loss.

### 4.3 Strengths and limitations

A strength of this study is the 52-week prospective design, which allowed us to monitor changes over time, identify events to exposure, exclude recall bias, and decrease over-reporting of incidents with long duration. A potential limitation is that TLRI was calculated based on measures during the year and therefore, to some extent, used retrospectively to predict SRIIPS (ie, a measure was used to predict something that has already occurred). However, this procedure is considered relevant under the assumption that training behavior is relatively constant over the year within individual athletes. Finally, a larger sample size would have allowed us to conduct more detailed sport-specific analyses.

### 4.4 Implications and future research

The high incidence and the fact that the athletes reported that many SRIIPS could have been prevented, emphasize the need to develop preventive strategies on a primary, secondary, and tertiary levels. Because of the wide variations of SRIIPS, impairments, and sports, it will be challenging to implement specific preventive strategies in each sport. In a qualitative study, we described that Paralympic athletes themselves thought that it is important to know how to prevent injuries, which should be considered as an asset. They also described that coaches’ knowledge could be improved as well as access to medical service and sport organizations’ expectations. Recent research has highlighted the complex nature of sports injuries and the importance of implementing multifactorial preventive strategies in a socioecological context involving organizations, coaches, medical staff, and athletes themselves. Thus, it is recommended that future research develop, implement, and evaluate preventive
strategies focusing on organizations’ policy enforcement, coaches’ education, medical staffs’ recognition, and athletes’ intrapersonal skills.29

5 | PERSPECTIVES

The results emphasize the need to develop preventive strategies adapted to Paralympic athletes and to optimize medical services throughout the entire season. As a variety of acute injuries, overuse injuries, and illnesses were reported, there is a need to develop and implement preventive strategies on a primary, secondary, and tertiary levels. Because of the complex variation of injuries and illnesses, future preventive strategies require both individualized and sport-specific strategies as well as educational interventions involving athletes, coaches, medical staff, and sport organizations. The results from this study can inform athletes, coaches, clinicians, and sports organizations about the epidemiology of sports-related injuries and illnesses in Paralympic athletes.

ACKNOWLEDGEMENT

This study is supported by a project grant and a PhD position grant from the Swedish National Centre for Research in Sports (grant numbers F2016-0024 and P2019-0010).

ORCID

Kristina Fagher https://orcid.org/0000-0002-9524-7553
Örjan Dahlström https://orcid.org/0000-0002-3955-0443
Jenny Jacobsson https://orcid.org/0000-0002-1551-1722
Toomas Timpka https://orcid.org/0000-0001-6049-5402
Jan Lexell https://orcid.org/0000-0001-5294-3332

REFERENCES

1. Vanlandewijck YC, Thompson WR. Training and coaching the Paralympic Athlete. Chichester, West Sussex, UK: John Wiley & Sons, Ltd: 2016.
2. 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.
3. Fagher K, Dahlstrom O, Jacobsson J, Timpka T, Lexell J. Prevalence of sports-related injuries and illnesses in Paralympic athletes. PM&R. 2020;12:271–280.
4. Fagher K, Hassan Ahmed O, Pernheim N, Varkey E. Prevalence of sports-related injuries in paralympic judo: An exploratory study. J Sci Med Sport. 2019;22(8):902-906.
5. 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(1):24-31.
6. 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. Br J Sports Med. 2013;47(7):420-425.
7. Derman W, Schwellnus MP, Jordaan E, et al. 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(1):17-23.
8. Webborn N, Willick S, Emery CA. The injury experience at the 2010 winter paralympic games. Clin J Sport Med. 2012;22(1):3-9.
9. Derman W, Runciman P, Jordaan E, et al. Incidence rate and burden of illness at the Pyeongchang 2018 Paralympic Winter Games. Br J Sports Med. 2019;53(17):1099-1104.
10. 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(17):1265-1271.
11. Fagher K, Lexell J. Sports-related injuries in athletes with disabilities. Scand J Med Sci Sports. 2014;24(5):e320-331.
12. Fagher K, Jacobsson J, Timpka T, Dahlstrom O, 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(1):28.
13. Fagher K, Jacobsson J, Dahlstrom O, Timpka T, Lexell J. An eHealth Application of Self-Reported Sports-Related Injuries and Illnesses in Paralympic Sport: Pilot Feasibility and Usability Study. JMIR Hum Factors. 2017;4(4):e30.
14. Saw AE, Main LC, Gastin PB. Monitoring the athlete training response: subjective self-reported measures trump commonly used objective measures: a systematic review. Br J Sports Med. 2016;50(5):281-291.
15. Fagher K, Forsberg A, Jacobsson J, Timpka T, Dahlstrom O, Lexell J. Paralympic athletes’ perceptions of their experiences of sports-related injuries, risk factors and preventive possibilities. Eur J Sport Sci. 2016;16(8):1240-1249.
16. Jacobsson J, Timpka T, Kowalski J, et al. Injury patterns in Swedish elite athletics: annual incidence, injury types and risk factors. Br J Sports Med. 2013;47(15):941-952.
17. Timpka T, Alonso JM, Jacobsson J, et al. Injury and illness definitions and data collection procedures for use in epidemiological studies in Athletics (track and field): consensus statement. Br J Sports Med. 2014;48(7):483-490.
18. Verhagen E, van Mechelen W. Sports injury research. New York, USA: Oxford University Press; 2010.
19. Gabbett TJ, Jenkins DG. Relationship between training load and injury in professional rugby league players. J Sci Med Sport. 2011;14(3):204-209.
20. Epidemiology RK. an introduction, Vol. 2nd edn. New York, USA: Oxford University Press; 2012.
21. Bland M. An introduction to medical statistics. Vol. 4th edn. Oxford, UK: Oxford University Press; 2015.
22. Nielsen RO, Bertelsen ML, Ramskov D, et al. Time-to-event analysis for sports injury research part 2: time-varying outcomes. Br J Sports Med. 2019;53(1):70-78.
23. Ekstrand J, Hagglund M, Walden M. Injury incidence and injury patterns in professional football: the UEFA injury study. Br J Sports Med. 2011;45(7):553-558.
24. 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(17):1091-1096.
25. Bromley SJ, Drew MK, Talpey S, McIntosh AS, Finch CF. A systematic review of prospective epidemiological research into injury and illness in Olympic combat sport. *Br J Sports Med*. 2018;52(1):8-16.

26. Chung WM, Yeung S, Wong AY, et al. Musculoskeletal injuries in elite able-bodied and wheelchair foil fencers—a pilot study. *Clin J Sport Med*. 2012;22(3):278-280.

27. Willick SE, Webborn N, Emery C, et al. The epidemiology of injuries at the London 2012 Paralympic Games. *Br J Sports Med*. 2013;47(7):426-432.

28. 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(17):1069-1074.

29. Bahr R, Holme I. Risk factors for sports injuries—a methodological approach. *Br J Sports Med*. 2003;37(5):384-392.

30. Turner C, McClure R. Age and gender differences in risk-taking behaviour as an explanation for high incidence of motor vehicle crashes as a driver in young males. *Inj Cont Safety Promot*. 2003;10(3):123-130.

31. Jacobsson J, Timpka T. Classification of prevention in sports medicine and epidemiology. *Sports Med*. 2015;45(11):1483-1487.

32. Diaz R, Stoll AH, Rho ME, Blauwet CA. Preserving the shoulder function of an elite paratriathlete. *Am J Phys Med Rehabil*. 2018;97(8):e69-e72.

33. Heyward OW, Vegter RJK, de Groot S, van der Woude LHV. Shoulder complaints in wheelchair athletes: a systematic review. *PLoS ONE*. 2017;12(11):e0188410.

34. Legood R, Scuffham P, Cryer C. Are we blind to injuries in the visually impaired? A review of the literature. *Inj Prev*. 2002;8(2):155-160.

35. Davies HD, Jackson MA, Rice SG. Infectious diseases associated with organized sports and outbreak control. *Pediatrics*. 2017;140(4):e20172477.

36. Ahmadinejad Z, Alijani N, Mansori S, Ziaee V. Common sports-related infections: a review on clinical pictures, management and time to return to sports. *Asian J Sports Med*. 2014;5(1):1-9.

37. Walsh NP. Recommendations to maintain immune health in athletes. *Eur J Sport Sci*. 2018;18(6):820-831.

38. McKibben MJ, Seed P, Ross SS, Borawski KM. Urinary tract infection and neurogenic bladder. *Urol Clin North Am*. 2015;42(4):527-536.

39. Register-Mihalik J, Baugh C, Kroshus E, Y Kerr Z, Valovich McLeod TC. A multifactorial approach to sport-related concussion prevention and education: application of the socioecological framework. *J Athl Train*. 2017;52(3):195-205.

How to cite this article: 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;00:1–14. https://doi.org/10.1111/sms.13687
APPENDIX 1

Diagnoses (ICD-10) by body region and onset of injury* (n = 179)

| Body region       | Overuse injury (68%) | Sudden Onset Injury (16%) | Traumatic injury (32%) |
|-------------------|----------------------|---------------------------|------------------------|
|                   | Gradual Onset Injury (52%) | Sprain, strain, rupture | Fracture |
|                   | Inflammation, pain, soft tissue disorder | Joint derangement | Distortion, ligament injury |
|                   | Stress fracture       |                          | Luxation, dislocation  |
|                   |                      |                          | Contusion, laceration  |
| Total (n = 179)   | 84 (47%)             | 27 (15%)                  | 6 (3%)                 |
| Vertebral column  | 21 (12%)             | 8 (4%)                    | 1 (0.6%)               |
| Head/face         | 21 (12%)             | 8 (4%)                    | 1 (0.6%)               |
| Cervical          | 1                    | 2                         | 1                      |
| Thoracic/ribs     | 5                    | 1                         | 1                      |
| Lumbar            | 13                   | 1                         | 1                      |
| Pelvis/sacrum     | 3                    | 2                         | 2                      |
| Upper extremities | 42 (23%)             | 12 (7%)                   | 3 (2%)                 |
| Shoulder/upper arm| 26                   | 9                         | 1                      |
| Elbow/forearm     | 13                   | 2                         | 4                      |
| Wrist/hand/finger | 3                    | 1                         | 5                      |
| Lower extremities | 21 (12%)             | 7 (4%)                    | 2 (1%)                 |
| Hip/groin/thigh   | 7                    | 2                         | 1                      |
| Knee              | 2                    | 2                         | 4                      |
| Lower leg/calf    | 7                    | 1                         | 2                      |
| Ankle/foot/toe    | 5                    | 2                         | 1                      |