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Epidemiology and Burden of Injuries Among Iranian Paralympic Athletes at the Paris 2024 Summer Games: A Prospective Cohort Study

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Abstract

Background: Paralympic athletes are at risk for multiple and complex injuries that can be related to their impairment-specific biomechanical risk. However, the evidence of injury patterns and burden at the national level during the Olympic Games is limited. The purpose of this study is to describe the incidence, characteristics, and burden of injuries sustained by Iranian Paralympic athletes during the Paris 2024 Summer Paralympic Games.

Methods

This prospective cohort study analyzed 64 Iranian athletes representing 10 different sports. The new injuries were recorded by assigned medical staff and documented utilizing the web-based injury and illness surveillance system which was provided by International Paralympic committee. Injuries were classified by sex, age, sport, type, and anatomical site. Calculated incidence and burden were reported per 1,000 athlete-days.

Results

In total, there were 21 new injuries reported, for an overall injury incidence of 21.9 per 1,000 athlete-days (95% Confidence Interval [CI]: 12.5–31.2), and an average time loss of 42.7 days per 1,000 athlete-day (95% CI 29.6 to 55.8). The male athletes with 85.7% of injuries were more likely to be injured than women. 52.4% of injuries occurred in athletes who were 26-34 years old. 76.2% of injuries were acute, and the greatest proportion of injuries occurred in the Shoulder (47.6%). The most common injury was the shoulder injuries (n=10), and involved most (n=5) in sitting volleyball and goalball.

Conclusion: The results of this study show that while the incidence of injury among Iranian Paralympians at the Paris 2024 Summer Paralympic Games was moderate, the burden of time-loss was considerable. This was especially true for the athletes that rely on the upper limb strength in the overhead sports and throwing sports. Therefore, the injury prevention strategies should target shoulder injuries in those sports like sitting volleyball and goalball.

Introduction

Participation in parasports has grown around the world, bringing increased physical, psychological, and social health benefits to people with disabilities [1]. Nevertheless, para-athletes stand at an increased risk of injury, because of the specific demands of sport, altered biomechanics, and assistive technology use [2]. Therefore, monitoring and assessing sports injury is vital for optimizing performance, and injury prevention [3, 19]. There remains a significant lack of epidemiological data on sports injuries concerning para-athletes, both nationally and internationally [4, 22]. International efforts aside, there is a substantial glaring need for national research in this field.

During the last Paralympic Games (London 2012, Rio 2016, Tokyo 2020), the International Paralympic Committee (IPC) collaborated with international researchers to systematically monitor and record injury

and illness incidence in Paralympic athletes [5]. Injury surveillance data from the three most recent Paralympic Games revealed a clear downward trend in incidence rates (IR). The IR was 18 injuries per 1000 athlete-days at the London 2012 Games, decreased to 12.4 at the Rio 2016 Games, and further declined to 5.8 at the Tokyo 2020 Games.[6–8] Notably, only one serious injury was recorded in Tokyo, with no high time-loss injuries reported.[6].While these findings may suggest improved safety and a progressive reduction in injury occurrence across recent Games at the Paralympic level, the lack of national injury epidemiology studies prevents evaluation of whether this downward trend is reflected across other countries and sport system.

A few sport-specific epidemiological studies have been conducted among Iranian Para athletes. For instance, In sitting volleyball for super league, the injury proportion (IP) was 53.6%, with an overall injury incidence of 16.2 per 1000 athlete-days; fingers, wrists, and shoulders were the most frequently affected areas, and most injuries were re-injuries [9]. In wheelchair basketball players, overall injury incidence was 132 per 100 athletes, with fingers/hands (35.13%) being the most affected body part and contusions (30.63%) the most common injury type, primarily caused by quick wheelchair pushing (29.72%) [10]. In para table tennis, the overall injury prevalence was higher on the right side of the body, with 64.8% affecting the shoulder and 61.4% the elbow; the predominant mechanism was non-contact, mainly due to incorrect technique [11]. However, these investigations do not adequately represent the overall injury profile of Iranian Paralympic athletes and are insufficient to evaluate broader trends.

Well-structured epidemiological studies play a critical role in identifying risk factors and designing targeted injury prevention strategies, contributing to reductions in injury rates over time. Despite international surveillance efforts, generating national, sport-inclusive epidemiological data remains essential, not only to benchmark domestic injury patterns against IPC-reported trends but also to develop evidence-based preventive strategies tailored to the unique biomechanical and functional demands of para-athletes. Accordingly, the aim of this study is to present comprehensive epidemiological evidence on injuries among Iranian Paralympic athletes to support experts in optimizing prevention protocols and ultimately reducing injury incidence.

Methods

Study Design

The present study is a descriptive, prospective study that examines the epidemiology of sports injuries of the members of the Iranian Paralympic team who participated in the 2024 Summer Paralympic Games in Paris.

Participants

All Paralympians (N = 64) in Iran delegation who participated in various competitions at the Paris 2024 Summer Paralympic Games.

Injury Data Collection

The injury data were gathered, documented and validated by the team's sports medicine physician.

Data Collection

Data was collected by using International Paralympic Committee (IPC) standard injury report forms. The IPC form contains information that includes gender, sport discipline, disability type, anatomical site of injury, injury mechanism, injury timing (pre-competition or competition), and estimated duration of time loss due to injury. According to IPC Guidelines [5], each injury event must be considered as an independent event even if the same athlete suffered repeated injuries.

Injury Definitions

An injury was defined [5] as any physical either acute or chronic injury sustained during training or competition that requires medical attention in this study. Injury was taken to include injuries that resulted in time loss from training/competition and those that did not.

Statistical Analysis

The analytical framework followed the methodological approach applied in the Tokyo 2020 Paralympic Games injury surveillance study by Derman et al. (2023)[6]. Descriptive statistics were used to summarize athlete characteristics (sex, age group, and sport discipline) and injury-related variables, including injury onset (acute vs. repetitive) and the competition phase (pre-competition vs. competition). Each injury was considered an independent event in line with the International Paralympic Committee (IPC) injury surveillance guidelines.

Athlete exposure was quantified in athlete-days, calculated by multiplying the number of participating athletes by the duration of the surveillance period (15 days). Exposure was also computed separately for the pre-competition (3 days) and competition (12 days) phases. Injury proportion (IP) was defined as the percentage of athletes sustaining at least one injury. Injury incidence rates (IR) were expressed as the number of injuries per 1000 athlete-days, with 95% confidence intervals (CI) estimated using Poisson distribution–based methods. Injury burden (IB) was calculated as the total number of days lost due to injury per 1000 athlete-days.

Comparisons of incidence rates across subgroups (sex, age category, sport discipline, injury onset, and competition period) were conducted using generalized linear models with a Poisson distribution and log-link function. Athlete-days were included as an offset term to adjust for differences in exposure. A scale parameter was applied to correct for mild overdispersion. Incidence rate ratios (IRR) and their corresponding 95% CIs were derived from exponentiated model coefficients, with statistical significance set at $p < 0.05$. All analyses were performed using IBM SPSS Statistics (version 26).

Results

Participants

Sixty-four Iranian Paralympic athletes (male: n = 52; female: n = 12) participated in the study. Participants competed in 10 different sports including sitting volleyball, goalball, athletics (throwing and jumping events), taekwondo, archery, swimming, and powerlifting. All athletes were monitored in a prospective manner during the 15-day time-frame prior to and during the actual competition of the Paris 2024 Paralympic Games. The injury data was gathered by the national medical team using established surveillance forms consistent with IPC reporting systems (Table 1).

Table 1
Number of athletes participating in each of the sports of Iranian athletes at the Paris 2024 Paralympic Games

Sport	Male	Female	Total
Athletics	15	4	19
Sitting Volleyball	12	0	12
Archery	4	2	6
Powerlifting	6	0	6
Goalball	6	0	6
Taekwondo	3	2	5
Shooting	1	3	4
Swimming	2	0	2
Paracanoe	1	1	2
Judo	2	0	2
Total	**52**	**12**	**64**

Overall Incidence of Injury

A cumulative 21 injuries were identified for 64 athletes while on surveillance. The overall injury incidence was 21.9 injuries per 1000 athlete-days (95% CI 12.5 to 31.2). The injury proportion (IP) of the sample was 31.2% and included 18 injuries to male athletes (85.7%) and 3 injuries to female athletes (14.3%). The estimated injury burden came to 42.7 days loss per 1000 athlete-days (95% CI 29.6 to 55.8). Most injuries occurred during the competition period, with acute injuries more common than repetitive injuries.

Incidence of Injury by Sport

Injuries were sustained in 10 different sports. The highest number of injuries occurred in men's sitting volleyball (n = 4) and men's goalball (B2 and B3 combined; n = 4). Every other injury (n = 13) was sustained by a single athlete in a variety of sports (athletics [throwing and jumping events], swimming, taekwondo, archery, or powerlifting). This distribution highlights that while sitting volleyball and goalball accounted for the largest share, sports with upper-limb dominance or overhead demands were overrepresented. Based on the results of multiple regression, sport type was not significant as an independent risk factor for injury rate overall (p = 0.096). However, the taekwondo showed a trend towards increased risk and the mean time-loss was approximately 5 days longer, with a significance level close to the threshold (p = 0.062).

Injury Incidence by Sex, Age group

Of the 21 reported injuries, 18 occurred in male athletes (85.7%) and 3 in female athletes (14.3%). The largest percentage of injuries (n = 11; 52.4%) occurred in athletes aged 26–34 years, then, 7 injuries (33.3%) in the 35–46-year-old group and 3 injuries (14.3%) in the 19–25-year-old group. The majority of injuries in the 26-34-year (Table 2). There were no significant differences between sex and age group with regard to injury rate in the overall Games period.

Table 2

Incidence of injury by sex and age group for Iranian athletes at the Paris 2024 Paralympic Games

Sex/Age Group	Total No. of Injuries (%)	No. of Athletes with Injury	Total No. of Athletes Competing	Estimated Athlete-Days*	Proportion with Injury (%)	Injury incidence per 1000 athlete-days (95% CI)
All	21 (100%)	20	64	960**	31.2%	21.9 (12.5–31.2)
Women	3 (14.3%)	3	12	180	25.0%	16.7†
Men	18 (85.7%)	17	52	780	32.7%	23.1 (13.4–35.6)
Age 19–25 years	3 (14.3%)	3	10 (est.)	150	30.0%	20.0†
Age 26–34 years	11 (52.4%)	11	30 (est.)	450	36.7%	24.4 (12.2–43.7)
Age 35–46 years	7 (33.3%)	6	25 (est.)	375	25.0%	19.4 (7.5–38.4)

* Estimated athlete-days were calculated based on an average participation of 15 days per athlete.

** Total athlete-days for the overall group (All) were computed by summing the estimated athlete-days across all age and sex categories

† 95% confidence intervals (CI) are not reported for some subgroups due to small sample sizes and unstable variance estimates.

Incidence of Injury in the 3-day pre-competition and 12-day Competition Periods

Injuries were tracked over a 15-day period consisting of 3 days of pre-competition, and 12 days of competition. While The number of injuries that occurred during competition (n = 17; 81.0%) was higher than the pre-competition injuries (n = 4; 19.0%). There was no significant difference between the pre-competition and competition periods (pre-competition IR ≈ 20.51 vs competition ≈ 21.79 per 1000 athlete-days; RR ≈ 1.06, 95% CI 0.36–3.16, p = 0.913).

Incidence of Injury by Onset

Among the 21 injuries reported, 16 (76.2%) were categorized as acute (sudden onset), while 5 (23.8%) were classified as repetitive (gradual onset) injuries. The incidence rate (IR) for acute injuries was significantly higher than for gradual/repetitive injuries (acute IR ≈ 16.41 vs repetitive ≈ 5.13 per 1000 athlete-days; rate ratio RR ≈ 3.20, 95% CI 1.17–8.74, p = 0.023).

Anatomical Location of Injuries

The shoulder was the most frequently affected anatomical region (n = 10). This was followed by the knee (n = 2) and the hip/groin region (n = 2). The remaining injuries were distributed across other anatomical locations (n = 11) (Table 3).

Table 3

Incidence of 21 sport-related injuries in each anatomical area for Iranian athletes at the Paris 2024 Paralympic Games

Anatomical Area	No. of Injuries (% of total)	No. of Athletes with Injury	Proportion of Athletes with Injury (%)	Injury incidence per 1000 athlete-days
Shoulder	**10 (47.6%)**	**9**	**14.1%**	**10.4**
Knee	2 (9.5%)	2	3.1%	2.1
Thigh	2 (9.5%)	2	3.1%	2.1
Ankle	1 (4.8%)	1	1.5%	1.0
Chest	1 (4.8%)	1	1.5%	1.0
Elbow	1 (4.8%)	1	1.5%	1.0
Hand & Fingers	1 (4.8%)	1	1.5%	1.0
Hip & Groin	1 (4.8%)	1	1.5%	1.0
Lumbosacral spine	1 (4.8%)	1	1.5%	1.0
Neck	1 (4.8%)	1	1.5%	1.0
Total	**21 (100%)**	**20**	**30.8%**	**21.9**

Injury Severity and Burden

Of the 21 total injuries reported during the surveillance period, 9 injuries (42.9%) required time loss from training or competition (greater than 1 day), and 12 injuries (57.1%) did not require time loss. Of the injuries that resulted in time loss, 55.6% (5 of the injuries) required more than 2 days away from training or competition. 22.2% of injuries were moderately serious (8–28 days lost), and 22.2% of injuries were serious (28 days to 3 months lost). 50% of serious injuries took approximately 4 weeks to recover from, and 50% of serious injuries took 6–8 weeks of rehabilitation. The three most serious injuries included rotator cuff tear, medial collateral ligament (MCL) sprain, and a severe adductor strain. These injuries occurred in sitting volleyball, goalball, and taekwondo. The total injury burden for the data was 42.7 days lost per 1000 athlete-days. There was no significant difference between male and female and age groups in terms of injury severity and injury burden.

Discussion

Overall incidence of injury

The overall injury incidence rate (IR) observed in our cohort was 21.9 injuries per 1000 athlete-days (95% CI: 12.5–31.2), which is markedly higher than the rates reported at the London 2012 (IR = 12.7; 95% CI:

11.7–13.7), Rio 2016 (IR = 10.0; 95% CI: 9.1–10.9), and Tokyo 2020 (IR = 5.8; 95% CI: 5.3–6.5) Summer Paralympic Games [6, 7, 8, 24]. Because the present study employed identical exposure metrics and surveillance definitions to those used in previous injury epidemiology reports of the paralympic games, methodological discrepancies can be excluded as a source of variance. Accordingly, the substantially higher incidence observed here likely reflects genuine differences in sport composition, athlete exposure, and impairment-specific biomechanical risk, rather than artefacts introduced by methodological or surveillance inconsistencies. The over-representation of contact-intensive and upper-limb dominant team sports, particularly sitting volleyball and goalball, appears to have contributed substantially to this elevated rate, consistent with previous findings linking higher training volume, collision exposure, and impairment-related asymmetries to increased injury risk among Paralympic athletes [12, 13]. These results reinforce the inference that sport mix and exposure profile are primary determinants of injury risk within Paralympic delegations. Therefore, future inter-games comparisons should stratify incidence data by sport discipline and impairment class to identify participation profiles most susceptible to injury, and to inform the design of delegation-specific, evidence-based prevention strategies.

Incidence of injury by sport

Analysis by sport revealed that the highest athlete-level injury proportions occurred in sitting volleyball (4/12 athletes, 33.3%) and goalball (4/6 athletes, 66.7%), together accounting for 38.1% of all recorded injuries in our cohort. Although these disciplines did not feature among the highest-risk sports reported in Rio 2016 (for example football 5-a-side: 22/70 athletes, 31.4%; judo: 21.7%; football 7-a-side: 21.4%) [24], their injury proportions in our data match or exceed those benchmarks. This observation aligns with Fagher et al (2020), who reported that Paralympic athletes in team contact sports face the highest injury risk [15]. Mechanistically, sports like sitting volleyball pose repetitive overhead/throwing demands and shoulder-loading combined with contact collisions, increasing shoulder and upper-limb injury risk, as similarly observed by Mahmoudkhani et al (2025), and Blauwet et al (2022), [9, 16]. Given these outcomes, we recommend that future surveillance reporting differentiate incidence rates (IRs) by both sport and athlete exposure (e.g, training vs competition) to permit more fine-grained benchmarking and prevention planning.

Injury incidence by sex and age group

In our dataset, no statistically significant differences emerged in overall injury incidence by sex (female vs male) or across age bands (19–25, 26–34, 35–46 years). This corresponds to findings from Rio 2016 concerning sex differences [7], but contrasts with Tokyo 2020 where the 26–34-year age group evidenced a significantly higher incidence (IR = 1.6; 95% CI 1.2–2.1; p = 0.0014) [6]. The lack of sex difference in our cohort is consistent with meta-analytic data suggesting that sex effects in Paralympic injury incidence are sport-dependent and not universally present [17]. However, we advise caution in relatively small and heterogeneous samples, null findings may reflect limited power or residual confounding by sport, impairment type or exposure level. We therefore recommend that future studies employ multivariable regression models adjusting for sport discipline, impairment class, and sport-

specific exposure volume (i.e, total athlete-days per discipline), and, where possible, report age-by-sport stratified incidence to inform age-targeted prevention.

Incidence of injury in the 3-day pre-competition and 12-day competition periods

In our cohort the majority of injuries occurred during the competition period (n = 17; 81.0%) compared with the pre-competition period (n = 4; 19.0%). This differs from the pattern in Rio 2016, where pre-competition injury incidence was significantly higher (IR = 12.9 vs 9.2 per 1000 athlete-days; RR = 1.40; 95% CI 1.51–1.71; p = 0.003) and Tokyo 2020, which also reported higher pre-competition incidence (99 injuries in 95 athletes; IR = 7.5 vs 5.4 per 1000 athlete-days; RR = 1.4; 95% CI 1.1–1.7; p = 0.0053)[6, 7]. Given we used a very short 3-day pre-competition window, combined with the relatively small sample size and specific sport-mix, the absence of a significant difference in our study likely reflects limited statistical power rather than absence of a true effect. Nevertheless, the broader evidence continues to support that ramp-up in training load during pre-competition periods represents a critical injury risk window [20, 23]. We thus suggest that future surveillance protocols adopt a standardised pre-competition window (e.g, 7–14 days), collect session-level load metrics and distinguish exposure by phase (training vs competition) to better elucidate load-related injury risk.

Incidence of injury by onset (acute vs overuse)

In accordance with prior Paralympic data, acute injuries dominated in our cohort (16/21 injuries; 76.2%), with a markedly higher incidence rate for acute compared with overuse injuries (IR = 16.41 vs 5.13 per 1000 athlete-days; 95% CI 1.17–8.74; p = 0.023). This pattern mirrors the Rio 2016 profile, where acute injuries substantially outnumbered overuse cases (IR = 3.9 vs 1.3 per 1000 athlete-days; p < 0.0001) [7]. The predominance of acute injuries likely reflects the high-intensity, short-duration competition schedule and the cumulative physical and psychological stress inherent in Paralympic performance contexts. Supporting this interpretation, Pinheiro et al (2021), and Harrington et al (2021) both reported that heightened competition demands and performance pressure significantly increase the risk of sudden-onset injuries in para-athletes [4, 14], while Fagher et al (2020), emphasized the influence of competition conditions on acute injury risk and the importance of integrating contextual factors into prevention frameworks [15].

In contrast, Tokyo 2020 surveillance noted a smaller gap between acute and overuse injuries in certain sports, possibly reflecting improved load monitoring and the gradual adoption of individualized preventive interventions. Taken together, the acute predominance observed here underscores the necessity of prevention strategies focused on collision protection, neuromuscular warm-up, and rapid-load adaptation protocols in elite paralympic athletes. Furthermore, systematic recording of injury mechanisms (contact vs non-contact; training vs match) would strengthen causal inference and inform more targeted prevention programs in future surveillance cycles.

Anatomical location of injuries

The shoulder emerged as the most frequently injured anatomical region in our cohort (10/21 injuries; 47.6%). This mirrors the Rio 2016 and Tokyo 2020 data, where shoulder injuries accounted for the largest proportion (90/440 injuries; 20.5%, and 46/342 sport-related injuries; 13.5%) [6, 7], as well as previous literature highlighting the high prevalence of shoulder injuries in Paralympic athletes participating in upper-limb dominant sports [4, 15]. Given the biomechanics of parasports with high upper-limb demands, such as sitting volleyball and goalball, athletes are exposed to repetitive overhead actions, including spiking and blocking, frequent shoulder loading, and compensatory strategies for lower-limb impairments. These factors make the high incidence of shoulder injuries biologically plausible. Accordingly, we recommend establishing sport-specific shoulder screening and preventive conditioning programs (e.g, scapular control, rotator cuff endurance, core stability) for athletes in these disciplines.

Injury severity and burden

We estimated an injury burden of 42.7 days lost per 1000 athlete-days, reflecting a substantially measurable impact on training and competition availability. This figure is higher than the burden reported at Rio 2016 (28.6 days/1000 athlete-days) yet lower than that at Tokyo 2020 (78.9 days/1000 athlete-days) [6, 7]. The elevated burden in contact/striking sports such as taekwondo (introduced at Tokyo (IB 78.9 days lost per 1000 athlete-days; 95% CI 52.1–84.1)) highlights how severity (time-loss) as well as incidence must be addressed in preventive strategies [6]. Thus, prevention must encompass both frequency reduction (incidence) and severity mitigation (time-loss) by implementing sport-specific rule modifications, pre-season conditioning, regular and comprehensive pre-season medical examinations combined with athlete performance assessments, and standardized return-to-play pathways. Moreover, reporting both incidence and burden side-by-side in future studies will enhance resource-allocation and planning for national paralympic delegations.

Conclusion

The primary aim of this study was to report, for the first time, the epidemiological profile of injuries among Iranian Paralympic athletes using standardized exposure and surveillance definitions comparable to those employed in previous Paralympic Games. These findings represent an important first step toward establishing a systematic national database for recording and monitoring injuries across both training and competition periods in elite para-athletes. Understanding sport- and impairment-specific injury patterns provides a foundation for developing evidence-based, context-sensitive prevention strategies tailored to the Iranian Paralympic context.

Moreover, consistent with the International Paralympic Committee (IPC) framework, integrating ongoing medical surveillance, regular health screening, and structured injury-prevention programs could meaningfully reduce injury risk and optimize athletic performance. Given the paucity of epidemiological data on Iranian para-athletes, future multicenter prospective studies employing IPC-standardized injury and illness reporting forms, and incorporating detailed sport-specific exposure data, are warranted. Such

efforts will enable the development of targeted preventive measures and support long-term athlete health and performance sustainability.

Limitations

This study has several limitations. First, all athletes were assumed to have a uniform exposure duration of 15 days, regardless of variations in arrival, departure, and sport-specific schedules. This assumption may have introduced exposure misclassification, leading to potential overestimation of both injury incidence and burden. Second, the relatively small sample size (n = 64) increases the influence of outlier cases, particularly time-loss injuries with long recovery periods, on mean burden estimates. Third, although standardized injury-surveillance procedures were used, the absence of sport-specific exposure data precluded the use of multivariable regression models adjusting for sport discipline, impairment class, and exposure volume. Finally, the lack of imaging confirmation or specialist diagnostic verification may have resulted in minor classification bias in injury type or severity. These limitations highlight the need for larger, longitudinal studies using individualized exposure tracking and medical verification to refine future injury-risk models in Paralympic populations.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval for the use of the data in this research was obtained from the Ethics Committee of Shahid Beheshti University (Approval letter No. 600/859).

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Consent for publication

Not applicable

Clinical trial number

Not applicable

Availability of data and materials

The datasets generated and analyzed during the current study are available upon reasonable request.

Competing interests

The authors declare no competing interests.

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Authors' contributions

AHB: Conceptualization, methodology, Data collection, supervision.
MS: Data collection, analysis, interpretation, manuscript drafting.
MRM: Methodology, validation, critical revision.
All authors read and approved the final manuscript.

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