Incidence of Paralympic Sports Injuries in Para Athletes: Systematic Review

Lingga Vitasari[1](✉), Suryo Saputra Perdana[1], and Amalia Nur Azizah[2]

[1] Department of Physiotherapy, Health Science Faculty, Universitas Muhammadiyah Surakarta, Sukoharjo, Central Java, Indonesia
J120190182@student.ums.ac.id

[2] Department of Physiotherapy, National Paralympic Committee of Indonesia, Surakarta, Indonesia

Abstract. Paralympic is the term referred to as an international sports competition for top athletes with disabilities who have experienced increased participation and development in sports. Consequently, it is difficult to understand injury patterns in the winter and summer Paralympics due to the rapid evolution of sporting events. The purposes of this research were to identify the overall injury incidence rate based on gender, age, anatomical region, sport, competition season, and injury onset, or what can be called the pattern of sports injury in para-athletes at the winter paralympics and summer paralympics. This systematic review research was obtained through four databases, namely PubMed, Google Scholar, Scopus, and Science Direct. Assessment of article quality employed the Newcastle-Ottawa Scale (NOS) and then obtained six articles involving a population of paralympic para-athletes. Four articles represent injury rates for the winter Paralympics, and the other two are for the summer Paralympics. The results showed that the highest injury incidence rate was in men aged 35 years, shoulder area, competition period, and with acute traumatic injuries. There were developments and differences in sports in the winter paralympic and summer paralympic, therefore the incidence rate shown varies based on each paralympic season. However, 5-side football in the summer Paralympics and alpine skiing in the winter Paralympics are the sports that consistently show the highest number of injuries in every Paralympic match. Differences in outcome measures and heterogeneity in para-athletes and sports were set as the limitations of this study.

Keywords: Sports Injury · Winter Paralympic · Summer Paralympic · Para Athletes

1 Introduction

Athletes with disabilities, or para-athletes, have shown they are interested in participating in elite sports competitions in recent years [1–3]. Athletes with physical, visual, and intellectual disabilities have access to a wide range of sports opportunities as part of the global movement for persons with disabilities, namely the Paralympic Movement [4–6].

B. Ichsan et al. (Eds.): ICHWB 2022, AHSR 61, pp. 392–409, 2023.
https://doi.org/10.2991/978-94-6463-184-5_35

People with disabilities, who have lower levels of physical fitness, can enjoy several health benefits from participation in sports fields [4, 7]. Sports participation entails various advantages, however, there is also the potential for musculoskeletal injuries to occur [8–10]. One of the reasons for musculoskeletal injuries is the result of excessive activities carried out repeatedly in incorrect movements [11]. According to Fagher & Lexell (2014), Paralympic sports have a high injury prevalence [12] compared to sports for athletes with healthy body [13].

Despite the trend of participation of those with disabilities in sports, the understanding of injury type is the least [14–17]. All athletes may encounter sports injuries, yet athletes with disabilities have difficulties with their complex limitations [18–20]. The prevailing of an injury allows the athlete to rest or makes the athlete unable to compete permanently (early retirement) [21, 22]. In this case, preventing injuries is the first measure in understanding the extent of sports injury problems [8, 23, 24].

In recent years, the literature on the epidemiology of sports medicine for those with disabilities has experienced a slowdown [25, 26]. The epidemiology of injuries in Olympic sports has been intensively studied, but Paralympic sports have not been pursued further [27, 28]. Overcoming these deficiencies, the Injury Surveillance System (ISS) International Paralympic Committee (IPC) conducts injury monitoring to maintain the conditions of para-athletes [25, 29, 30]. Long-term injury surveillance provides much-needed epidemiological data to identify and subsequently reduce injury and disease in the sports [31, 32]. Observing the results of monitoring injuries at the Paralympic shows several patterns of injuries formed, including patterns of injuries based on gender, age, area of anatomy, and sports in each season [33–35].

Longitudinal studies should be ongoing in several events, given the importance of identifying the health of para-athletes who require further attention, intervention, and monitoring [36, 37]. According to the previous studies that discussed the incidence of paralympic injuries, it was limited only to the population of para-athletes from certain countries [38–40], one paralympic event [41–43] or certain sports [5, 44, 45].

In light of the above discussion, the authors should conduct a systematic review of various paralympic populations, including the winter and summer paralympic. This study aimed to identify overall injury incidence rates by type, group, and location commonly referred to as sports injury patterns of para-athletes during the Paralympic Games to help develop and implement more effective para-athletes injury prevention programs in the Paralympic Games.

2 Method

2.1 Search Strategy

The data were collected by PubMed, Google Scholar, Scopus, and Science Direct. Search articles by entering the keywords “Sports Injury” OR “Sports Injuries” AND “Winter Paralympic” AND “Summer Paralympic” AND “Athletes”.

2.2 Eligibility Criteria

The data criteria comprise; (1) a full-text article in English, (2) a cohort study, (3) participants in the winter and summer paralympic games, (4) the injury referred to a paralympic-related sports injury, and (5) beyond the intended time range.

The exclusion criteria in this study were: (1) e-books and (2) articles in the press.

2.3 Study Selection

The database articles were selected with Mendeley software. The selection process was conducted by removing irrelevant and unmatch duplicates, studies, titles, and abstracts to the intended inclusion criteria.

2.4 Data Extraction

Data were independently extracted to be reviewed in terms of author, year, study, number of samples, population, and study outcomes in the form of injury patterns according to gender, age, anatomical region, sport, competition season, and injury onset (Table 1 and Table 3).

2.5 Assessment of Study Quality

Assessment studies in this study used the Newcastle-Ottawa Scale (NOS) to collect data from all cohort study articles to be reviewed (Table 2). NOS is the result of an ongoing collaboration between the University of Newcastle (Australia) and the University of Ottawa (Canada). The NOS methodological quality assessment tool is the most frequently used for cohort studies and subject-specific Fields [46].

NOS in the cohort study contains eight items. And is categorized into three dimensions, encompassing selection, comparability, and outcome. A maximum of one star was assigned to each item number in the selection and outcome categories, and a maximum of two stars was given to each item number in the comparability category. Based on AHRQ standards, NOS assessment quality is ‘good’ if the selection domain has 3 or 4 stars, the comparability domain has 1 or 2 stars, and the outcome domain has 2 or 3 stars, ‘fair quality’ selection domain has 2 stars, comparability domain has 1 or 2 stars, outcome domain has 2 or 3 stars, ‘poor quality’ selection domain has 0 or 1 stars, comparability domain has 0 or 1 stars, and outcome domain has 0 or 1 stars.

3 Result

3.1 Search Results

The articles were searched through four databases, and a total of 293 results were gathered; however, duplicate articles were removed from the four databases to yield 272. Article selection was continued by removing articles excluded from the criteria. A total of 162 titles/abstract articles and 17 non-full texts in English were issued, leaving 93 full-text articles. However, 4 of them could not be retrieved due to limited access. Of the remaining 89 full texts, they were re-selected and only 6 articles containing research data were sought.

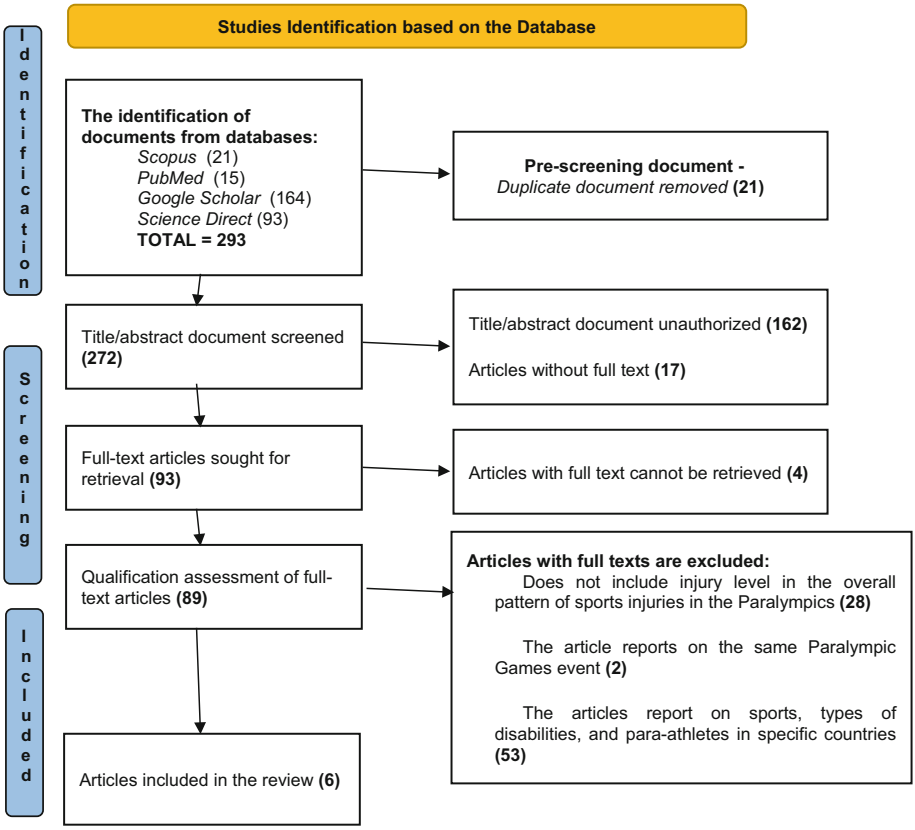

Fig. 1. New systematic review flow diagram that includes a database search for PRISMA 2020

Six articles were selected based on the PRISMA database, which included the incidence of paralympic injuries based on gender, age, anatomical area, sports branch, competition season, and injury onset in paralympic matches both in winter and summer (Fig. 1).

3.2 Quality Assessment Results

The six articles collected displayed adequate article quality results based on the said assessment criteria per the results of the article quality assessment with the NOS.

3.3 Article Search Sample and Populations

Few articles cover the entire occurrence of paralympic injuries to para-athletes. In the 2002 Salt Lake City Winter Paralympics and in the 2012 London Summer Paralympics, assessments of paralympic injuries were made for the first time [47]. The review of articles will be based on the sample and overall population of Paralympians. Stoke Mandeville Games held in 1960 were the first paralympic games, however, only six articles show paralympic injury monitoring data on para-athletes (Table 1).

Table 1. Article Search Sample and Populations

No	Author	Year	Sampel	Populasi
1.	Derman et al.	2016	547 athletes and 4 sports	Athletes participating at the Sochi 2014 Winter Paralympic Games
2.	Derman et al.	2018	3657 athletes and 22 sports	Athletes participating in each sport at the Rio 2016 Summer Paralympic Games
3.	Derman et al.	2020	567 athletes and 5 sports	Athletes participating at the Pyeongchang 2018 Paralympic Winter Games
4.	Webborn et al.	2006	416 athletes and 3 sports	Athletes participating at the Salt Lake City 2002 Paralympic Winter Games
5.	Webborn et al.	2012	505 athletes and 4 sports	Athletes participating at the Vancouver 2010 Paralympic Winter Games
6.	Willick et al.	2013	4176 athletes and 21 sports	Athletes participating at the London 2012 Summer Paralympic Games

3.4 Article Search Result by Gender

The injury incidence rate (IR) by gender did not show a significant difference within a single Paralympic event. Nonetheless, total injuries at each Paralympic were dominated by men. The highest injury in men was in the summer paralympic in London 2012 with 437 injuries with IR 13.3 and the winter paralympic in Sochi 2014 with 134 injuries with IR 26.7.

3.5 Article Search Result by Age

Para athletes aged $\leq$ 25 years showed the lowest injury rate at any Paralympic Games. There was only a slight difference in injury rates between ages 26–34 years and $\geq$ 35 years. The Winter Paralympics suggests a higher incidence of injury than the Summer Paralympics for all ages. The 2014 Sochi Winter Paralympic Games dominated the highest number of injuries for para-athletes aged $\geq$ 35 years.

3.6 Article Search Result by Anatomical Region

The upper extremity was the most frequently injured anatomical region in every Paralympic competition and more dominant in the shoulder area. There were limited articles that discuss injuries by anatomic region. There were only three articles containing injuries by region out of the six articles collected at the Paralympic. Two of them were the winter paralympic, meanwhile, the summer paralympic was only in Rio 2016.

Based on the selected articles, the summer paralympic appears to have lower injuries compared to the winter paralympic in the anatomical region. By comparing the two winter Paralympics, the incidence rate of several anatomical regions in Pyeong Chang 2018 showed a decrease in injuries, even so, the dominant lower extremity was higher.

3.7 Article Search Result by Sports

Two of the four articles discussing the winter paralympics presented the results of research on injury rates based on the total number of injuries. Four of the six articles submitted presented injury outcomes based on incidence rates. The winter paralympic has grown in popularity each year, and the sport in the winter paralympic is also expanding yearly; thus, four articles discussed para-athletes' injuries in various sports at the winter paralympic.

With the addition of sports in each Paralympic competition, the highest and lowest injury incidents also have different results in each match. The Sochi Winter Paralympic 2014 showed the highest injury rate in two sports, namely ice sled hockey and wheelchair curling based on the frequency results. The Salt Lake City Winter Paralympic 2002 and Vancouver Winter Paralympic 2010 showed a very significant difference in the total number of injuries, which was more than double in each sport. Nordic skiing had the lowest number of injury incidents based on the total number of injuries, and based on the incidence rate, wheelchair curling was the sport that suffered the least injuries during matches. Alpine skiing and snowboarding had the highest injury rates in every winter Paralympic.

Football 5-a-side is the sport with the highest number of injuries from the two summer Paralympics, namely London 2012 and Rio 2016. Uniquely, Judo in these two summers Paralympic has the same incidence rate, which was 15.5. There was no significant difference in wheelchair tennis, wheelchair basketball, and sitting volleyball. The lowest injury rate in the summer paralympic was in London in 2012 and boccia in Rio in 2016.

3.8 Article Search Result by Pre-competition and Competition Period

The three Paralympic events saw the highest injury totals during the competition. The highest number of injuries happened in the 2016 Rio Summer Paralympic Games with 369 cases, while the pre-competition with the lowest was in the 2010 Vancouver Winter Paralympic Games.

3.9 Article Search Result by Onset

Each article presents different results on paralympic injury rates based on the onset, i.e. percentage, incidence rate (IR), or the total number of injuries. There were three of the six articles showed the results of both. Sochi 2014 Winter Paralympics showed the highest acute traumatic and acute chronic outcomes according to the total incidence rate.

The highest chronic overuse in the 2010 Vancouver Winter Paralympics was based on percentage and total injuries. According to the incidence rate results, there was no significant difference between acute chronic and chronic overuse at the Pyeong Chang Winter Paralympic 2018 and Rio Summer Paralympic 2016.

Table 2. Quality of studies

	Webborn et al.,2006	**Webborn et al.,2012**	**Derman et al., 2016**	**Derman et al., 2020**	**Willick et al., 2013**	**Derman et al., 2018**
SELECTION (MAXIMUM OF 4 STARS)						
1) Exposed cohort representativeness a. Absolutely representative (one star) b. Partially representative (one star) c. Preferred group d. Unable derivation description of the cohort	a*	a*	a*	a*	a*	a*
2) Non-exposed cohort selection a. Drawn from the same community as the exposed cohort (one star) b. Drawn from a different source c. Unable derivation description of the non exposed cohort	a*	a*	a*	a*	a*	a*
3) Exposure ascertainment a. Secure document (e.g., surgical record) (one star) b. Structured interview (one star) c. Written self report d. No description e. Other	a*	a*	a*	a*	a*	a*

(*continued*)

Table 2. (*continued*)

	Webborn et al.,2006	**Webborn et al.,2012**	**Derman et al., 2016**	**Derman et al., 2020**	**Willick et al., 2013**	**Derman et al., 2018**
4) Demonstration that outcome of interest was not present at onset of study a. Yes (one star) b. No	a*	a*	a*	a*	a*	a*
COMPARABILITY (MAXIMUM 2 STARS)						
1) Comparability of cohorts on the basis of the design or analysis controlled for confounders a. The study controls for age, sex and marital status (one star) b. Study controls for other factors (list) (one star) c. Cohorts are not comparable on the basis of the design or analysis controlled for confounders	a*	a*	a*	a*	a*	a*
OUTCOME (MAXIMUM 3 STAR)						
1) Outcome Assessment a. Independent blind assessment (one star) b. Record linkage (one star) c. Self report d. No description e. Other	a*	a*	a*	a*	a*	a*

(*continued*)

Table 2. (*continued*)

	Webborn et al.,2006	**Webborn et al.,2012**	**Derman et al., 2016**	**Derman et al., 2020**	**Willick et al., 2013**	**Derman et al., 2018**
2) Was follow-up long enough for outcomes to occur a. Yes (one star) b. No c. Indicate the median duration of follow-up and a brief rationale for the assessment above:_____	a*	a*	a*	a*	a*	a*
3) Adequacy of follow-up of cohorts a. Complete follow up- all subject accounted for (one star) b. Subjects lost to follow up unlikely to introduce bias- number lost less than or equal to 20% or description of those lost suggested no different from those followed. (one star) c. Follow up rate less than 80% and no description of those lost d. No statement	a*	a*	a*	a*	b*	b*
QUALITY OF STUDIES	Good	Good	Good	Good	Good	Good

Table 3. Included Articles

NO	PARALYMPIC GAMES	TOTAL SAMPLE	TOTAL NUMBER OF INJURIES					
			GENDER	AGE	ANATOMICAL REGION	SPORTS	COMPETITION SESSION	ONSET
WINTER PARALYMPIC								
1.	Salt Lake City 2002 (Webborn et al., 2006)	416 athletes	**Female:** 8 injuries (9%) **Male:** 31 injuries (9%)			Alpine skiing: 24 injuries (62%) Nordic skiing: 3 injuries (8%) Sledge hockey: 12 injuries (31%)		**Acute traumatic:** 30 injuries (77%) **Chronic overuse:** 6 injuries (15%)
2.	Vancouver 2010 (Webborn et al., 2012)	505 athletes				Sledge hockey: 40 injuries Alpine skiing: 41 injuries Nordic skiing: 26 injuries Wheelchair curling: 9 injuries	**Pre-competition:** 31 injuries (25,8%) **Competition:** 39 injuries (32,5%)	**Acute traumatic:** 49 injuries (40,8%) **Acute on chronic:** 1 injuries (0,8%) **Chronic overuse:** 69 injuries (57,5%)
3.	Sochi 2014 (Derman et al., 2016)	547 athletes	**Female:** (n = 129) 40 injuries IR: 25,8 **Male:** (n = 418) 134 injuries IR: 26,7	**13–25 years old:** (n = 45) IR: 21,8 **26–34 years old:** (n = 1249) IR: 26,1 **> 35 years old:** (n = 1174) IR: 31,5	Upper limb: 8,5 Shoulder/arm/elbow: 6,4 Wrist/hand/ finger: 2,1 Lower limb: 8,4 Knee: 3,8 Ankle/foot/toe: 1,8 Lower leg: 1,1 Thigh/stump: 0,9 Hip/groin/pelvis: 0,8 Head/face/neck: 4,7 Spine: 2,9 Chest/trunk/ abdomen: 1,1	Alpine skiing/ snowboarding: 41,1 Cross-country skiing/ biathlon: 8,4 Ice sledge hockey: 26,5 Wheelchair curling: 16,7		**Acute traumatic:** 117 injuries IR: 17,8 **Acute on chronic:** 25 injuries IR: 4,9 **Chronic overuse:** 32 injuries IR: 3,8

(*continued*)

Table 3. (*continued*)

NO	PARALYMPIC GAMES	TOTAL SAMPLE	TOTAL NUMBER OF INJURIES					
			GENDER	AGE	ANATOMICAL REGION	SPORTS	COMPETITION SESSION	ONSET
4.	Pyeong Chang 2018 (Derman et al., 2020)	576 athletes	**Female:** (n = 134) 30 injuries IR: 24,3 **Male:** (n = 433) 82 injuries IR: 19,8	**13–25 years old:** (n = 161) IR: 17,6 **26–35 years old:** (n = 216) IR: 23,2 **36–75 years old:** (n = 190) IR: 21,2	Upper limb: 7,9 Shoulder/arm/elbow: 5,7 Wrist/hand/finger: 2,2 Lower limb: 7,1 Knee: 1,6 Ankle/foot/toe: 1,9 Lower leg: 1,0 Thigh/stump: 1,5 Hip/groin/pelvis: 1,0 Head/face/neck: 4,3 Spine: 0,9 Chest/trunk/abdomen: 0,7	Para snowboard: 40,5 Para alpine skiing: 23,1 Para ice hockey: 22,8 Para Nordic skiing: 13,6 Wheelchair curling: 6,9	**Pre competition:** 33 injuries IR: 19,4 **Competition:** 109 injuries IR: 21,4	**Acute traumatic:** IR: 16,2 **Acute on chronic:** IR: 1,5 **Chronic overuse:** IR: 3,2
SUMMER PARALYMPIC								
5.	London 2012 (Willick et al., 2013)	4176 athletes	**Female:** (n = 1218) 196 injuries IR: 11,5 **Male:** (n = 2347) 437 injuries IR: 13,3	**< 25 years old:** (n = 1142) IR: 11,3 **26–34 years old:** (n = 1249) IR: 14,5 **> 35 years old:** (n = 1174) IR: 12.1		Football 5-a-side: 22,4 Powerlifting: 19,3 Goalball: 19,5 Wheelchair fencing: 18,0 Wheelchair rugby: 16,3 Athletics: 15,8 Judo: 15,5 Wheelchair tennis: 12,8 Table tennis: 12,6 Wheelchair basketball: 12,0 Football 7-a-side: 11,2 Seated volleyball: 10,7 Cycling track: 9,3 Equestrian: 9,3 Swimming: 8,7 Archery: 8,4 Boccia: 8,0 Cycling road: 6,7 Sailing: 4,1 Rowing: 3,9 Shooting: 2,2	**Pre competition:** IR: 14,8 **Competition:** IR: 12,1	**Acute traumatic:** 51,5% **Acute on chronic:** 16,7% **Chronic overuse:** 31,8%

(*continued*)

Table 3. (*continued*)

NO	PARALYMPIC GAMES	TOTAL SAMPLE	TOTAL NUMBER OF INJURIES					
			GENDER	AGE	ANATOMICAL REGION	SPORTS	COMPETITION SESSION	ONSET
6.	Rio 2016 (Derman et al., 2018)	3657 athletes	**Female:** (n = 1389) 183 injuries IR: 10,7 **Male:** (n = 2268) 258 injuries IR: 9,5	**12–15 years old:** (n = 996) 104 injuries IR: 8,6 **26–34 years old:** (n = 1320) 168 injuries IR: 10.4 **35–75 years old:** (n = 1341) 169 injuries IR: 10.6	Head and face: 0,1 Neck: 0,7 Shoulder: 1,8 Upper arm: 0,1 Elbow: 0,4 Forearm: 0,2 Wrist, hand and finger: 1,0 Chest wall: 0,2 Trunk and abdomen: 0,1 Thoracic spine: 0,2 Lumbar spine: 0,6 Pelvis/buttock: 0,2 Hip/groin: 0,2 Thigh: 0,6 Stump: 0,0 Knee: 0,7 Lower leg: 0,5 Ankle/foot/toe: 0,9	Football 5-a-side: 22,5 Wheelchair fencing: 15,9 Judo: 15,5 Football 7-a-side: 15,3 Wheelchair rugby: 14,9 Wheelchair basketball: 12,8 Sitting volleyball: 11,8 Wheelchair tennis: 11,4 Para Powerlifting: 11,1 Para Athletics: 10,1 Archery: 10,1 Triathlon: 9,9 Canoe: 9,6 Tabble tennis: 8,6 Sailing: 8,5 Rowing: 7,3 Para Swimming: 7,1 Cycling (track and road): 7,0 Equestrain: 7,0 Shooting Para Sport: 6,6 Goalball: 5,6 Boccia: 4,3	**Pre competition:** 141 injuries IR: 12,9 **Competition:** 369 injuries IR: 9,2	**Acute traumatic:** IR: 5,2 **Acute on chronic:** IR: 1,4 **Chronic overuse:** IR: 3,4

4 Discussion

The purposes of this research were to identify the overall injury incidence rate based on gender, age, anatomic region, sport, competition season, and injury onset, or commonly referred to as the 'pattern of sports injury' in para-athletes at the Winter Paralympic and Summer Paralympic.

The pattern of injuries obtained in this study showed that injuries based on age and gender do not have a significant difference in each game. However, overall, men have a higher injury rate than women in the Paralympics. Each article classifies age into 3, comprising $\leq$ 25 years, 26–34 years, and $\geq$ 35 years. Age $\geq$ 35 years experienced more injuries, while those $\leq$ 25 years experienced only a few injuries. The results of this research data can be a reflection of the IPC and various sports federations in governing minimum and maximum age limits for paralympic competitions [41].

Paralympic competition often results in injuries to the upper extremities, especially the shoulders. This is because there are greater demands on the use of the extremities during sports [28].

According to the development and differences between the winter and summer paralympic sports, there was an indication of the paralympic season's incident rate. In the winter paralympic, alpine skiing, and snowboarding are the sports with the highest injuries, while the lowest injuries are in nordic skiing and wheelchair curling. This is expected because alpine skiing and snowboarding are high-speed sports (sitting or standing) so there is a higher probability of injury rates and injury severity [19, 48].

Football 5-a-side showed the highest injury yields in the summer Paralympic, while the lowest injuries occurred in shooting and boccia. Five-a-side football participants are para-athletes who are visually impaired. Collisions and paralympic-related acute traumatic injuries in elite 5-a-side football are likely to predominate in the lower extremity [41, 49]. As a result, the types of injuries in disabled and able-bodied footballers are equal [50]. There was no change in the incidence of injuries to the sport of judo in both summer Paralympic, in line with research suggesting that 84% of the blind athlete population participating in the sport of judo experienced many injuries [51]. Also, the data collected through the questionnaire contained as many as 45 Paralympic judokas who responded that they had experienced traumatic injuries and half of these injuries caused a loss of more than 21 days. Judo injuries with visual impairments must be investigated further to determine the severity and location of the injury, which might result in severe consequences for the athlete.

Based on the IPC, sports injuries are musculoskeletal complaints during competition or training that require medical treatment [31]. According to Igolnikov's research [24], there are three classifications of sports injuries related to the onset, namely; (1) acute traumatic injury, which is a single event leading to macrotrauma to previously healthy tissue; (2) acute on chronic, the same type of injury at the previous injury site; and (3) chronic overuse, a manifestation of an acute traumatic injury or acute on the chronic injury that previously occurred. The injury treatment is different for each type. Acute injuries are the most common type of injury experienced by paralympic athletes, while the other two types of injuries are not significantly distinct.

The study of winter sports needs to be expanded to encompass more than just common injuries, but also paraathletes' injuries resulting from disability, sports rules, and

regulations, as well as the use of prosthetics and adaptive equipment [52]. Based on the findings of one study, one of the prevention efforts has shown that periodic health evaluations performed prior to the summer paralympics can reduce overall injury rates and improve performance in para-athletes [53].

Understanding patterns of injury in sports is important for prevention, planning medical services, changing regulations and developing rules of the game, and adaptive tools for dealing with injuries in para-athletes. Heterogeneity within sports, the different modalities, and levels of classification of para-athletes for the same modality result in differences in information about the incidence of musculoskeletal injuries among athletes. Furthermore, this study may have also been restricted by the fact that some athletes may not have reported their injuries at all, while others may have had injuries treated by their team's medical staff. It cannot show the actual number of injuries that occurred on the field. As a result, the current evidence is limited to both the Winter Paralympic and Summer Paralympic incidence rates.

5 Conclusion

This study concludes that para-athletes, sports teams, coaches, and medical staff must be aware of the high incidence rate of musculoskeletal injury patterns in para-athletes and can be used as evaluation material for Paralympic in the future. This study is expected to be used as preliminary research to conduct research with high-quality studies, larger sample sizes, and more intense observations of each athlete in a particular sport. Additionally, these findings could serve as a baseline for research into how injury prevention strategies can help para-athletes with disabilities improve their quality of life and sports performance.

Acknowledgments. LV, SSP, and ANZ would like to thank Physiotherapy Study Program Universitas Muhammadiyah Surakarta and all parties involved in perfecting this research process until it becomes an article useful for readers.

Authors' Contributions. Each of the authors contributed significantly to the design of the research, the analysis, and the compilation of the manuscript throughout the research process.

References

1. O. A. Fapojuwo, R. O. Kareem, and O. H. Bejide, "Prevalence, Pattern, and Risk Factors of Musculoskeletal Injuries Among Wheelchair Athletes in Lagos, Nigeria," *Hum. Mov.*, vol. 23, no. 4, pp. 156–164, 2022, doi: https://doi.org/10.5114/hm.2022.108322.
2. N. Dehghansai, S. Lemez, N. Wattie, and J. Baker, "A systematic review of influences on development of athletes with disabilities," *Adapt. Phys. Act. Q.*, vol. 34, no. 1, pp. 72–90, 2017, doi: https://doi.org/10.1123/APAQ.2016-0030.
3. R. Gajardo, C. Aravena, M. Fontanilla, M. Barría, and C. Saavedra, "Injuries and Illness Prevalence Prior to Competition in Goalball Players," *J. Vis. Impair. Blind.*, vol. 113, no. 5, pp. 443–451, 2019, doi: https://doi.org/10.1177/0145482X19876478.

4. K. Fagher, J. Jacobsson, T. Timpka, Ö. Dahlström, and J. Lexell, "The Sports-Related Injuries and Illnesses in Paralympic Sport Study (SRIIPSS): A study protocol for a prospective longitudinal study," *BMC Sports Sci. Med. Rehabil.*, vol. 8, no. 1, pp. 1–10, 2016, doi: https://doi.org/10.1186/s13102-016-0053-x.
5. A. Gutiérrez-Santiago, I. Prieto-Lage, A. Martín, and C. Ayán, "Sport Injuries in Elite Paralympic Judokas: Findings From the 2018 World Championship.," *J. Phys. Act. Health*, vol. 17, no. 11, pp. 1162–1170, Oct. 2020, doi: https://doi.org/10.1123/jpah.2020-0149.
6. P. Chandan and M. E. Dubon, "Clinical Considerations and Resources for Youth Athletes with Intellectual Disability: a Review with a Focus on Special Olympics International," *Curr. Phys. Med. Rehabil. Reports*, vol. 7, no. 2, pp. 116–125, Jun. 2019, doi: https://doi.org/10.1007/S40141-019-0209-1.
7. J. J. Martin, "a social-relational model of disability perspective," vol. 35, no. 24, pp. 2030–2037, 2013, doi: https://doi.org/10.3109/09638288.2013.802377.
8. L. S. P. Pinheiro *et al.*, "Prevalence and incidence of injuries in para athletes: A systematic review with meta-analysis and GRADE recommendations," *Br. J. Sports Med.*, vol. 55, no. 23, pp. 1357–1365, 2021, doi: https://doi.org/10.1136/bjsports-2020-102823.
9. M. Ebrahimi Varkiani, M. Hossien Alizadeh, R. Rajabi, H. Minoonejad, and M. E. Varkiani, "Comparing Two Sports Injury Surveillance Systems: A Novel Systematic Approach," *ptj.uswr.ac.ir*, vol. 10, no. 3, 2020, doi: https://doi.org/10.32598/ptj.10.3.421.1.
10. F. Rahman and I. S. Budi, "DAPATKAH LATIHAN INTENSITAS SEDANG MENGOPTIMALKAN SISTEM IMUN ? : DOES EXERCISE IMPROVE IMMUNE SYSTEM ?," *Med. Sains J. Ilm. Kefarmasian*, vol. 7, no. 1, pp. 145–154, 2022, doi: https://doi.org/10.37874/MS.V7I1.268.
11. A. Pristianto, R. Mutia Andini, and A. Faris Naufal, "Kejadian Cedera Muskuloskeletal Saat Melakukan Exercise Selama Masa Pandemi Covid-19," *Qual. J. Kesehat.*, vol. 16, no. 1, pp. 73–81, 2022, doi: https://doi.org/10.36082/qjk.v16i1.439.
12. W. Derman *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.*, vol. 54, no. 1, pp. 38–43, 2020, doi: https://doi.org/10.1136/bjsports-2018-100170.
13. T. Soligard *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.*, vol. 51, no. 17, pp. 1265–1271, 2017, doi: https://doi.org/10.1136/bjsports-2017-097956.
14. P. Van De Vliet, "Paralympic athlete's health," *Br. J. Sports Med.*, vol. 46, no. 7, pp. 458–459, 2012, doi: https://doi.org/10.1136/bjsports-2012-091192.
15. R. Bahr, B. Clarsen, and J. Ekstrand, "Why we should focus on the burden of injuries and illnesses , not just their incidence," vol. 0, no. 0, 2017.
16. K. Steffen *et al.*, "Illness and injury among Norwegian Para athletes over five consecutive Paralympic Summer and Winter Games cycles: prevailing high illness burden on the road from 2012 to 2020," *Br. J. Sports Med.*, vol. 56, no. 4, pp. 204–212, 2022, doi: https://doi.org/10.1136/bjsports-2021-104489.
17. B. Clarsen *et al.*, "Improved reporting of overuse injuries and health problems in sport : an update of the Oslo Sport Trauma Research Center questionnaires," pp. 390–396, 2020, doi: https://doi.org/10.1136/bjsports-2019-101337.
18. R. Weiler, W. Van Mechelen, C. Fuller, and E. Verhagen, "Sport Injuries Sustained by Athletes with Disability: A Systematic Review," *Sport. Med.*, vol. 46, no. 8, pp. 1141–1153, 2016, doi: https://doi.org/10.1007/s40279-016-0478-0.
19. Y. A. Tuakli-Wosornu, E. Mashkovskiy, T. Ottesen, M. Gentry, D. Jensen, and N. Webborn, "Acute and Chronic Musculoskeletal Injury in Para Sport: A Critical Review," *Phys. Med. Rehabil. Clin. N. Am.*, vol. 29, no. 2, pp. 205–243, 2018, doi: https://doi.org/10.1016/j.pmr.2018.01.014.

20. K. Fagher, Ö. Dahlström, J. Jacobsson, T. Timpka, and J. Lexell, "Injuries and illnesses in Swedish Paralympic athletes—A 52-week prospective study of incidence and risk factors," *Scand. J. Med. Sci. Sport.*, vol. 30, no. 8, pp. 1457–1470, 2020, doi: https://doi.org/10.1111/sms.13687.
21. Y. N. Hanief and F. Umar, "The characteristics of Indonesian para-cycling athletes' injuries," *Adv. Rehabil.*, vol. 34, no. 3, pp. 37–46, 2020, doi: https://doi.org/10.5114/areh.2020.99252.
22. B. Clarsen, O. Rønsen, G. Myklebust, T. W. Flørenes, and R. Bahr, "The Oslo Sports Trauma Research Center questionnaire on health problems: a new approach to prospective monitoring of illness and injury in elite athletes," *bjsm.bmj.com*, 2013, doi: https://doi.org/10.1136/bjsports-2012-092087.
23. C. F. Finch *et al.*, "Towards the reduction of injury and illness in athletes: Defining our research priorities," *Br. J. Sports Med.*, vol. 51, no. 16, pp. 1178–1182, 2017, doi: https://doi.org/10.1136/bjsports-2016-097042.
24. I. Igolnikov, R. M. Gallagher, and B. Hainline, *Sport-related injury and pain classification*, 1st ed., vol. 158. Elsevier B.V., 2018. doi: https://doi.org/10.1016/B978-0-444-63954-7.00039-2.
25. N. Webborn, S. Willick, and C. A. Emery, "The injury experience at the 2010 winter paralympic games," *Clin. J. Sport Med.*, vol. 22, no. 1, pp. 3–9, 2012, doi: https://doi.org/10.1097/JSM.0b013e318243309f.
26. P. W. Kong and J. W. Yam, "Shoulder biomechanics of para-table tennis: a case study of a standing class para-athlete with severe leg impairment," *BMC Sports Sci. Med. Rehabil.*, vol. 14, no. 1, Dec. 2022, doi: https://doi.org/10.1186/S13102-022-00536-9/FULLTEXT.HTML.
27. K. Hollander, S. Kluge, F. Glöer, H. Riepenhof, A. Zech, and A. Junge, "Epidemiology of injuries during the Wheelchair Basketball World Championships 2018: A prospective cohort study," *Scand. J. Med. Sci. Sport.*, vol. 30, no. 1, pp. 199–207, 2020, doi: https://doi.org/10.1111/sms.13558.
28. A. S. Tenforde *et al.*, "Prevalence and Anatomical Distribution of Bone Stress Injuries in the Elite Para Athlete," *Am. J. Phys. Med. Rehabil.*, vol. 98, no. 11, pp. 1036–1040, 2019, doi: https://doi.org/10.1097/PHM.0000000000001287.
29. W. Derman *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.*, vol. 47, no. 7, pp. 420–425, 2013, doi: https://doi.org/10.1136/bjsports-2013-092375.
30. N. Webborn and C. Emery, "Descriptive epidemiology of paralympic sports injuries," *PM R*, vol. 6, no. 8 SUPPL., pp. S18–S22, 2014, doi: https://doi.org/10.1016/j.pmrj.2014.06.003.
31. L. Engebretsen *et al.*, "Sports injuries and illnesses during the London Summer Olympic Games 2012.," *Br. J. Sports Med.*, vol. 47, no. 7, pp. 407–414, 2013, doi: https://doi.org/10.1136/bjsports-2013-092380.
32. N. R. Heneghan, L. Heathcote, P. Martin, S. Spencer, and A. Rushton, "Injury surveillance in elite Paralympic athletes with limb deficiency: A retrospective analysis of upper quadrant injuries," *BMC Sports Sci. Med. Rehabil.*, vol. 12, no. 1, Jun. 2020, doi: https://doi.org/10.1186/S13102-020-00183-Y/FULLTEXT.HTML.
33. L. Rudolph and S. E. Willick, "Review of Injury Epidemiology in Paralympic Sports," *Adapt. Sport. Med.*, pp. 51–58, 2018, doi: https://doi.org/10.1007/978-3-319-56568-2_4
34. C. Slocum, C. A. Blauwet, and J. B. Anne Allen, "Sports Medicine Considerations for the Paralympic Athlete," *Curr. Phys. Med. Rehabil. Reports*, vol. 3, no. 1, pp. 25–35, Mar. 2015, doi:https://doi.org/10.1007/s40141-014-0074-x
35. Z. Kasińska, P. K. Urbański, and T. Tasiemski, "Sports Injuries among Players of the Polish National Team in Amputee Football in the Annual Training Cycle," *J. Hum. Kinet.*, vol. 81, no. 1, pp. 211–219, 2022, doi: https://doi.org/10.2478/HUKIN-2022-0021.

36. A. Hirschmüller, K. Fassbender, J. Kubosch, R. Leonhart, and K. Steffen, "Injury and Illness Surveillance in Elite Para Athletes: An Urgent Need for Suitable Illness Prevention Strategies," *Am. J. Phys. Med. Rehabil.*, vol. 100, no. 2, pp. 173–180, 2021, doi: https://doi.org/10.1097/PHM.0000000000001501.
37. G. Probleme and P. Spiele, "Health Problems in German Paralympic Athletes Preparing for the 2020 Tokyo Paralympic Games," no. May, pp. 212–217, 2021, doi: https://doi.org/10.5960/dzsm.2021.487.
38. M. Jarraya *et al.*, "Sports injuries at the Rio de Janeiro 2016 Summer Paralympic Games: use of diagnostic imaging services," *Eur. Radiol.*, vol. 31, no. 9, pp. 6768–6779, Sep. 2021, doi: https://doi.org/10.1007/s00330-021-07802-3.
39. J. Bauerfeind, M. Koper, J. Wieczorek, P. Urbanski, and T. Tasiemski, "Sports Injuries in Wheelchair Rugby-A Pilot Study," *J. Hum. Kinet.*, vol. 48, no. 1, pp. 123–132, 2015, doi: https://doi.org/10.1515/hukin-2015-0098.
40. H. PARK and J. (Sung) H. You, "Sports Injury and Physiotherapy Services in the 2018 PyeongChang Winter Paralympic Games: Considerations and Potential Recommendations for Future Paralympics," *Arch. Phys. Med. Rehabil.*, vol. 103, no. 3, p. e32, Mar. 2022, doi: https://doi.org/10.1016/j.apmr.2022.01.088.
41. S. E. Willick *et al.*, "The epidemiology of injuries at the London 2012 Paralympic Games," *Br. J. Sports Med.*, vol. 47, no. 7, pp. 426–432, 2013, doi: https://doi.org/10.1136/bjsports-2013-092374.
42. N. Webborn, S. Willick, C. E.-C. journal of sport, and undefined 2012, "The injury experience at the 2010 winter paralympic games," *journals.lww.com*, Accessed: Oct. 16, 2022. [Online]. Available: https://journals.lww.com/cjsportsmed/Fulltext/2012/01000/The_Injury_Experience_at_the_2010_Winter.2.aspx
43. W. Derman *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.*, vol. 52, no. 1, pp. 24–31, 2018, doi: https://doi.org/10.1136/bjsports-2017-098039.
44. C. Silva *et al.*, "Injuries in wheelchair basketball players: a systematic review," *mdpi.com*, 2022, doi: https://doi.org/10.3390/ijerph19105869.
45. W. Derman, C. Blauwet, N. Webborn, M. Schwellnus, P. Van De Vliet, and D. Lazarovski, "Mitigating risk of injury in alpine skiing in the Pyeongchang 2018 Paralympic Winter Games: The time is now!," *Br. J. Sports Med.*, vol. 52, no. 7, pp. 419–420, 2018, doi: https://doi.org/10.1136/bjsports-2017-098864.
46. L. L. Ma, Y. Y. Wang, Z. H. Yang, D. Huang, H. Weng, and X. T. Zeng, "Methodological quality (risk of bias) assessment tools for primary and secondary medical studies: What are they and which is better?," *Mil. Med. Res.*, vol. 7, no. 1, pp. 1–11, Feb. 2020, doi: https://doi.org/10.1186/S40779-020-00238-8/TABLES/1.
47. N. Webborn, S. Willick, and C. A. Emery, "The injury experience at the 2010 winter paralympic games," *Clin. J. Sport Med.*, vol. 22, no. 1, pp. 3–9, 2012, doi: https://doi.org/10.1097/JSM.0b013e318243309f.
48. H. Mardiyanto, S. Saputra Perdana, and I. Norazmi, "Perbandingan Agility Pada Pemain Sepak Bola Paska Rehabilitasi Rekonstruksi Anterior Cruciate Ligament Dengan Pemain Sepak Bola Sehat," *FISIO MU Physiother. Evidences*, vol. 2, no. 1, pp. 36–38, Jan. 2021, doi: https://doi.org/10.23917/fisiomu.v2i1.12931.
49. N. Webborn *et al.*, "The Epidemiology of Injuries in Football at the London 2012 Paralympic Games," *PM R*, vol. 8, no. 6, pp. 545–552, 2016, doi: https://doi.org/10.1016/J.PMRJ.2015.09.025.
50. M. Bragaru, R. Dekker, J. H. B. Geertzen, and P. U. Dijkstra, "Amputees and sports: a systematic review," *Sport. Med.*, vol. 41, no. 9, pp. 721–740, 2011, doi: https://doi.org/10.2165/11590420-000000000-00000.

51. K. Fagher, O. Hassan Ahmed, N. Pernheim, and E. Varkey, "Prevalence of sports-related injuries in paralympic judo: An exploratory study," *J. Sci. Med. Sport*, vol. 22, no. 8, pp. 902–906, Aug. 2019, doi: https://doi.org/10.1016/j.jsams.2019.03.005.
52. H. Oh, W. Johnson, and I. P. Syrop, "Winter adaptive sports participation, injuries, and equipment," *Sports Med. Arthrosc.*, vol. 27, no. 2, pp. 56–59, 2019, doi: https://doi.org/10.1097/JSA.0000000000000236.
53. W. Gawroński, J. Sobiecka, and J. Malesza, "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.*, vol. 47, no. 13, pp. 844–849, 2013, doi: https://doi.org/10.1136/bjsports-2013-092298.