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Sports - Related Concussion Injuries / Disabilities in Paralympics

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Abstract: ***The Paralympic Games are the pinnacle of the Paralympic athletic movement, which aims to provide inclusive sporting opportunities for people with disabilities. However, there is a high potential for injury or disease while engaging in sports. Paralympic competitors have disabilities such as cerebral palsy, spinal cord injury, blindness, intellectual disability, and a variety of other physical impairments that do not fit into the other classification groups, together referred to as les autre. Mild traumatic brain injuries (mTBIs), such as concussions, are also quite prevalent among Paralympics athletes. There are significant implications for risk management in a Paralympics athlete where risk factors are common, given the decreased physical fitness of athletes with impairments. In this review, we will discuss sports-related injuries (concussions) in the Paralympics as well as how concussions happened in different para-sports, for specific evaluation of para-athletes, their risk factor, and the prevention of injuries.***

Keywords: Concussion, Disabilities, Fractures, Paralympics, Physical Health

1. Introduction

Disability sports have gained popularity as people have become more aware of their options. The increasing participation of elite athletes in each Paralympics since 1952 reflects a growing spotlight on the event. Historically, Paralympic sports primarily centered on specific disabilities, but with rising popularity, individuals with diverse physical disabilities are now expressing interest in sports. The definition of six primary handicap kinds in Paralympic sports, including amputation or limb deficiency, cerebral palsy, spinal cord-related disability, vision impairment, and intellectual impairment [1]. Les Autres, the sixth category, provides accommodations for athletes with physical limitations not covered by the other categories. Sport for athletes with impairments has been practiced for over a century [2], with the Paralympic Games serving as the major event. The worldwide network "The Paralympic Movement" now offers sports possibilities for Paralympic competitors with physical, visual, or cerebral disabilities, from grassroots to elite level. The number of athletes participating in paralympic sports has increased significantly over the last several decades, as have their athletic prowess and access to technology, many of these athletes now compete on par with top competitors [3,4]. Physical exercise and involvement in sports are recognized to have a variety of beneficial impacts on one's health [5,6]. As people with chronic illnesses or disabilities have poorer physical fitness than those without such conditions, participation in athletics is crucial, particularly for those with impairments [7].

Figure 1: Different types of Paralympics

Several types of sports injuries have been shown to be avoidable in recent studies. Yet, thorough epidemiological information is necessary for the efficient implementation of injury prevention methods [8,9]. Keeping an eye on players is crucial in the preseason to prevent overtraining, injuries, and illnesses. Despite the IPC's (International Paralympic Committee) achievement in implementing an epidemiological monitoring system during the Paralympic Games, there is a dearth of longitudinal prospective data tracking Paralympic competitors over extended training seasons.

A recent analysis [10] found substantial disparities in injury rates amongst sports, highlighting the necessity for sport-specific research. Current studies within Paralympic sport have generally reported injuries linked to trauma, medical attention, or time loss, although their quality varies widely. Most research has been done in hindsight and has only recorded injuries that occurred during actual contests. There is also a wide variety of injury criteria that have been used, with the majority of research ignoring the relationship between disability and risk [11]. Thus, more longitudinal epidemiological studies are required to prospectively evaluate the incidence of sports-related injuries and diseases

among Paralympic athletes according to their level of risk. The majority of current injury monitoring systems [12] are only used in professional and commercial contexts for able-bodied top sports including soccer, tennis, and rugby. Moreover, many monitoring programs require that doctors fill out an injury report form [13]. Different sports need different attributes and circumstances. When medical staff is few, for instance, administering first aid might be challenging. Overuse injuries may be underreported, according to certain injury registration techniques [14].

2. Types of Sports Injuries for disabled people

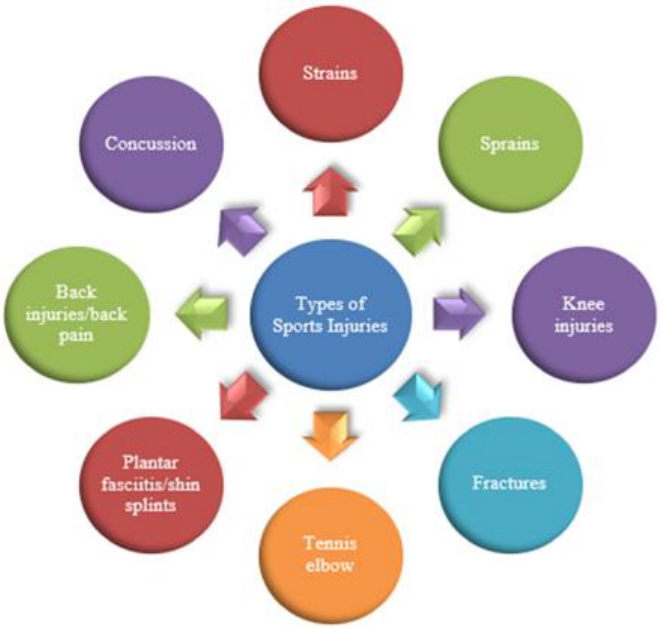

Figure 2: Different types of Sports Injuries

1) **Strains**
Due to the extensive usage of muscles and tendons during training and competition, strains are consistently the most prevalent sports injury. All these movable components are at risk of being ripped, injured, and in pain if they are forced to extend beyond their limits or move in ways they should not. [15].
2) **Sprains**
Ligament injuries, or sprains, are analogous to muscle injuries or strains. The connective tissues between skeletal elements are called ligaments. These ligaments are vulnerable to tearing if they twist in the incorrect direction [16].
3) **Knee injuries**
Since the knee is such a complex joint and takes a beating from the stresses of most sports, it has separated as a potential injury area on its own. Fractures, dislocations, and dislocations of the cartilage, as well as tears of the anterior cruciate ligament (ACL), occur often [17].
4) **Fractures**
Bone fractures (most often in the arms, legs, and feet) are common in high-impact and high-contact sports and may be excruciatingly painful, need weeks of immobilization, and in rare cases necessitate surgical intervention. Most intense and contact sports have the risk of fractures [18].
5) **Tennis elbow**
Tennis elbow may happen to anybody, regardless of whether or not they play tennis (golf is also a common culprit). Overuse and repeated motions may cause injuries, such as the common "tennis elbow," a strain of the elbow's ligaments. Pacing themself properly is the greatest defense. Relax, do other things, and always warm up and stretch before playing [19].
6) **Plantar fasciitis/shin splints**
Since both are caused by excessive use of the feet and legs without adequate support, they have been classified as overuse injuries. Inflammation of the plantar fascia, a tendon in the foot's arch, causes excruciating discomfort with every step [20].
7) **Back injuries/back pain**
Nearly every sport exerts pressure on the back and spinal column. Back pain, whether in the upper or lower back, is a common symptom of the cumulative effects of stress on the spine and the muscles that support it. Getting a severe back injury from a quick, jarring hit is possible [21].
8) **Concussion**
Concussions occur most often in contact sports like football when a player sustains a blow to the head, causing the brain to lurch within the skull, potentially injuring the tissues that keep the brain in place. Headache, dizziness, fatigue, and even momentary loss of consciousness are just some symptoms of a concussion, which may range from moderate to severe. If they know has suffered a blow to the head, they should always be checked out by a doctor specializing in the spine and brain. When given time to rest, most concussions recover from their effects within a week to several weeks. If they play contact sports like hockey or football, go bicycling or skating, etc., they should always wear properly fitting protective headgear to minimize the risk of concussion [22].

3. Epidemiology of sports-related injuries

Paralympic athlete, like other top athletes, faces the danger of sports-related injury in addition to their preexisting disability [23]. Sports have been shown to improve health in many ways, but injuries remain a major worry in the top sports world since they may cause short-term handicaps, permanent impairment, and even death [24,25]. Recent data shows a worldwide trend toward an ever-increasing yearly incidence of sports injuries requiring hospital treatment in industrialized nations, including the United States, where as many as 8.6 million are reported annually [26]. Concussions, ligament tears, joint deformities, and fractures are some traumatic sports injuries that may have long-lasting effects on an athlete's health.

Despite the prevalence of sports injuries, no reliable prophylactic methods have been developed for use in Para sport or Paralympic sport [27]. The current body of knowledge indicates that injury rates are quite high, with a general tendency toward higher injuries in Paralympic competitors compared to non-disabled athletes [28]. Inconsistent incidence rates (IR) ranging from 0.12 injuries/competition to 33.3 injuries/athlete days have also been reported across different prospective studies, giving a

wide range of reported incidence proportions (IP) from 9% to 78%. Only one research so far has used real athletic participation to evaluate IR. Furthermore, three Paralympic athletes died in major tournaments in 2016, 2017, and 2019 in Brazil, Germany, and Ria de Janeiro respectively [29].

In addition, there is a shortage of research evaluating the risk factors and impairment-related processes of sports-related injuries. Some have theorized that Paralympic athletes' sports-related injuries may be distinct from non-disabled competitors because of their preexisting handicap and possibly accompanying health concerns. Athletes may be put in harm's way in different ways if they require external equipment like wheelchairs or prosthetics. It is well-known, for instance, that people who use wheelchairs often have shoulder pain. Even less is known about potential dangers, such as how much athletes train or behave. Overall, there is currently a severe shortage of evidence-based data on the epidemiology of sports-related injuries among Paralympic competitors. More so, the long-term effects of sports injuries among Paralympic athletes have been the subject of little research. One may speculate that a shoulder injury in a wheelchair athlete might have different effects than the same injury in a non-disabled competitor [30].

4. Concussion injuries in Paralympics

There has been much discussion and controversy about how to best avoid, recognize, analyze, and treat concussions in the world's most popular sports, including para-Sports. High head and facial injuries in football 5-a-side (blind football), Para Alpine Skiing, Para Ice Hockey, and Para Snowboarding, as shown by injury monitoring statistics from the most recent summer and winter paralympic games, illustrate the necessity for discussion over this injury [31,32]. Despite multiple incidents across multiple sports where athletes were seen to suffer a blow to the head, followed by unsteady gait and reports of significant injuries to the head and face, no concussions were reported by team physicians in the injury reporting survey at the Rio 2016 Summer Paralympic Games [33]. Research conducted on clinicians during the 2015 Cerebral Palsy (CP) Football World Championships found that although clinicians had a good grasp of concussions, their approaches to spotting and treating them varied widely. The athletes in this study are acutely aware of the need for specialized clinical assistance. Clinicians confront challenges when applying current concussion screening and treatment recommendations to para-athletes, which is on top of a greater requirement for concussion education [34,35].

While it is generally agreed that neurocognitive testing like the Sport Concussion Assessment Tool 5 (SCAT5) may be beneficial after a concussion, they have not been validated for use with the para-sport population and may not even be relevant in certain cases [36,37]. Disabled and able-bodied football players had vastly different SCAT3 scores at the outset. While it is generally agreed that neurocognitive testing like the Sport Concussion Assessment Tool 5 (SCAT5) may be beneficial after a concussion, they have not been validated for use with the para-sport population and may not even be relevant in certain cases. Disabled and able-bodied football players had vastly different SCAT3 scores at the outset [38,39].

Several studies have reported on the prevalence of concussions in different able-bodied sports. In contact sports, the rate of occurrence is higher than in non-contact ones. Incidence rates vary from 2.6% in women's gymnastics8 to 21.6% in women's hockey [40]. It's also well-established that many mild traumatic brain injuries (mTBIs) go unreported or unrecognised for a variety of reasons, such as a lack of knowledge of signs and symptoms or a tendency for athletes to mask symptoms so they won't be held out of competition. In one study, 105.27 percent of concussed athletes did not report their concussion [41].

Sixty-four percent of those who did not disclose the concussion did so because they didn't believe it was severe enough. Athletes risk fatal outcomes if they play through concussion symptoms and get a second head injury [42].

Figure 3: Reasons for concussion in Paralympic

5. Concussion in different Para Sports

5.1. Wheelchair Basketball

Competitive wheelchair basketball is played at the high school, college, club, and international levels [43]. Participation in wheelchair sports is predicted to rise in the future years as more and more veterans with impairments return from the current conflicts. The rising popularity of adapted sports necessitates a broader understanding of the topic of disability in athletics [44,45]. Despite growing interest, studies assessing the frequency with which handicapped athletes sustain injuries remain few. Few studies have been undertaken, and those that have were limited to professional athletes and noncontact activities (e.g., wheelchair track and swimming). Although these studies have limitations, they nonetheless show that handicap sports have injury rates comparable to those of able-bodied sports [46,47].

More medical professionals with a knowledge of physical disabilities are needed to provide coverage for adapted athletics. In the United States alone, 1.6 to 3.8 million traumatic brain injuries (TBIs) occur annually during able-bodied sports and leisure activities [48].

5.2. Football 5-a-side and Football 7-a-side

Football 5-a-side refers to football (soccer) for players with vision impairment. Goalkeepers are seeing and call out a defensive plan to 4 players who wear eyeshades to guarantee all have no vision [49]. In addition to having, which lowers their ability to brace for or block a hit to the head, players tend to play in more of an upright stance than non-VI players, thereby exposing them to a higher danger of head-to-head contact. A significant prevalence of head and facial injuries in this sport was identified during the 2012 London Paralympic Games (13.6% of all injuries), however this was in only 22 total injuries [50].

As it was previously said, just 2.2% of the whole Games population had an injury. Cerebral palsy (CP) football, often known as Football 7-a-side, is the other version of football contested at the Paralympics. The reduced danger of head injury is a result of players' unimpeded field of vision and the prohibition of heading the ball. As before, the overall number of injuries was small, but only one of the 17 injuries (7.1%) involved the head or face. Five of the seventeen (or 29%) injuries sustained in the tournament were to the head or face, and Football 5-a-side continued to have the highest injury rate of any sport at the Games. According to a study conducted over a four-year period by Magno e Silva and coworkers11, 8.6% of the injuries sustained by VI Brazilian players played at an international level were to the head (5 competitions) [51].

5.3. Para ice hockey

Para ice hockey, like its upright cousin, is a quick game played on an ice rink with rigid boards. It's fairly uncommon for players to collide with one another, either on purpose or by accident, since physical contact is an integral component of the game. Therefore, the potential for concussion seems high. However, there are no published research on concussion in this sport; the only applicable data come from the Paralympics surveillance studies. Notable members of the top-performing Para ice hockey teams in the 2010 Vancouver Paralympic Games included the team's doctor, therapist, coach, and manager. The risk of concussions was high, and it was generally accepted that body checking was the primary cause of damage. Even though this was small anecdotal research, the fact that no concussions were documented in the 2010 Games survey suggests that this is a more significant problem than previous surveillance studies have suggested [52]. Various studies on concussion in paralympic were depicted in table 1.

Table 1: Overview of studies on Concussion in Paralympics

Author	Aim	Conclusion
Sá K et al., 2022 [53]	To collect data on the prevalence of injuries, types of injuries, and affected areas among wheelchair basketball players.	A wide variety of injuries are experienced by wheelchair basketball players, most of which are associated with biomechanics and athletic activity.
Weiler et al., 2021 [54]	This study aims to determine the prevalence and rate of sports-related concussion (SRC) among top Para athletes over a 52-week period and to investigate the causes of these head injuries.	Concussions are as common among top-tier Paralympic athletes as in able-bodied sports. The most prevalent mechanism of SRC injury was collisions, and the rates of SRC were considerably higher among visually impaired athletes and female athletes.
Song et al., 2020 [55]	With the goal of the major features that may be utilized to establish viable preventative measures for future Winter Paralympic Games by analyzing and summarizing existing research relating to the characteristics, and incidence of injuries of various winter Paralympic sports events.	Impaired athletes have a higher-than-average incidence of injuries, which may be on par with their able-bodied competitors. Since there haven't been much research done on injury patterns and ways to avoid them, it's hard to have a better grasp on what causes injuries and what measures may be taken to reduce their prevalence. More research that focuses on disabilities and follows participants over time is essential.
Derman wt al., 2018 [56]	Aiming to detail the injury rate throughout Rio 2016 Summer Paralympic Games preparations and competitions.	The results of this study show that injury rates (IRs) were lower than those reported for the London 2012 Summer Paralympic Games, football 5-a-side, judo, and football 7-a-side were independent risk factors for injury, precomputation injuries had a higher IR than competition period injuries, and shoulder injuries were the most frequent. Their findings would enable comparable information to be gathered at future Games and might be used to guide injury prevention programs.

6. Para-athlete customized assessment tools

All questions from SCAT5's "immediate or on-field assessment" and "office or off-field assessment" parts were used to compile the appendices for each sport-specific impairment category (online supplemental files). Using a traffic light approach, they identified which items from the SCAT5 should not be utilized for para-athletes in green, which things should need extra considerations for certain para-athletes (depending on the extent or form of athlete disability), and which items remained unchanged. The appendices include precise instructions for using each SCAT5 question in on-field, office, or off-field evaluations of para-athletes with suspected concussions are (Bilateral) upper limb deficiency, (Single) lower limb deficiency, (Bilateral) lower limb deficiency, (Single) upper limb deficiency, (Single) upper limb deficiency, Globe absents, Impaired vision, Spinal cord injury (SCI) with quadriplegia, SCI with paraplegia, CP with spastic diplegia, CP with spastic quadriplegia, CP with spastic hemiplegia, Absent vision, Mixed CP, Ataxic CP, Dyskinetic CP, Spina bifida, Intellectual impairment. Arthrogryposis, Muscular dystrophy, Multiple sclerosis, Polio, and Achondroplasia [57].

7. Risk factors and prevention of injuries

Injury monitoring is the first phase in the concept of preventing sports injuries. Injury mechanisms and risk factors might then be identified, allowing for the development of preventative measures. Sports injuries may be caused by either internal or external reasons. The athlete's own characteristics and behaviors are considered intrinsic risk factors, whereas environmental influences are considered extrinsic risk factors. It is possible that the presence of a disability is itself a risk factor in disabled athletes. For instance, in the 1988 Paralympic Games, blind athletes accounted for 78% of all recorded lower extremity injuries in the Canadian squad, and in the 2010 Paralympic Games, Nordic skiers were more likely to sustain injuries from falls. It has been assumed by Athanasopoulos et al., (2009) that the high rate of ankle injuries in athletes is attributable to a lack of proprioception, and it has been claimed that visual impairments might influence postural stability [58].

Preventative measures have recently attracted more attention in the field of sports medicine research [59]. Results from a preventive training program for female soccer players indicated a 64% decrease in ACL injuries [60]. However, Van Beijsterveldt et al., (2013) found contradictory data on the efficacy of exercise-based programs in preventing soccer injuries, and they urged the conduct of high-quality research to determine the appropriate kind and intensity of workouts [61]. The need for warm-up tactics, stretching and strengthening to be included into preventative programs for impaired athletes. In order to lower the injury rate among impaired skiers, it was recommended to concentrate on leg strength, cardiovascular fitness, and proper equipment. Due to the link between high training volumes and disability-related muscular discomfort in athletes, Bernardi et al., (2003) recommended keeping tabs on how often an athlete trains as a means of preventing injuries [62]. Injury prevention programs should focus first on high-risk sports, according to the authors of research that monitored injuries during the 2012 Paralympic Games [63].

People with CP may also have foot and knee abnormalities due to their condition [64]. Discoordination, spasticity, and constricted range of motion may put extra strain on muscles, joints, and tendons, as revealed by research by Patatoukas et al., (2011), found that as compared with other athletes, cerebral palsy athletes had a higher percentage of injuries to soft tissues [65]. Athanasopoulos et al. (2009) hypothesized that higher tensile pressures in the lower limb due to spasticity and abnormalities would explain why CP athletes are more likely to sustain lower extremity injuries [58]. It has been hypothesized that the increased frequency of injuries may be due to altered biomechanics in the lower limb. Amputee athletes appeared to have a significant incidence of discomfort and injury [66]. Running with asymmetrically elevated strains might cause damage in the intact lower limb for athletes who have had a unilateral amputation [67-69].

Low bone mineral density may be an innate risk factor for injury in wheelchair athletes. Lower extremity fractures are more common in people with SCI, and osteoporosis is a major contributor [70]. A study by Patatoukas et al., (2011) found that the rate of fractures among athletes with spinal cord injuries was substantially greater than among athletes without SCI [65]. During the 2002 Winter Paralympics, four ice sledge hockey players suffered fractures. Only one fracture was recorded in 2010, therefore the new regulations on protective gear and sledge height seem to have been effective [71]. Furthermore, wheelchair athletes reported a high prevalence of upper extremity injuries, and these athletes typically depend on their upper extremities in both their sports and everyday life, that might produce extreme stress on tissues.

Sitting posture, weaker upper-extremity muscles, denervated muscles, flaccidity, muscle spasms, and spasticity are all variables that caregivers must take into account while assessing a person with a disability. Shoulder impingement may develop in these athletes due to a lack of strength in the external rotators and the shoulder adductor muscles. Because of the internal rotation of the humerus and scapular protraction that characterizes the sitting position in a wheelchair, this issue is often made worse. Injuries to the upper extremities were also the most commonly reported during the 2012 Summer Paralympics. Hence it has been advised that future studies focus on identifying the causes of and developing effective techniques for preventing injuries to this area of the body [72].

8. Discussion

In addition, the authors of the Olympic Games 2012 injury monitoring report calls for developing additional prevention measures unique to each sport. The examined literature has hardly touched upon internal and external risk factors. All athletes should get a physical examination to check for weaknesses in their flexibility, strength, and cardiovascular function that might put them at risk for injury. The prevention of medical complications by injury assessment before an event [73].

Previous research has demonstrated that sports-related injuries and diseases are a big problem even within Paralympic sport [74]. Further, there has been a dearth of research on the causes of impairment and the dangers posed by different activities. Injuries and illnesses will be tracked over time and compared across sports and demographics using the proposed research design.

Information on the causes of injuries and illnesses in athletes over time will allow researchers to track shifts, identify causal relationships, and zero in on high-risk activities.

One potential drawback is the lack of baseline data on clinical evaluations. However, it has been shown that self-report systems may be used to record sports-related occurrences in a valid and reliable manner and to track the development of athletes' mental health.

This multi-year study investigates a difficult and little-explored topic. Advancement calls for both fundamental and practical study. Considering that injuries and illnesses may be sport- and disability-specific, it is crucial to conduct long-term assessments of putative cause-relationships of sports-related injuries and illnesses by athlete categorization and

specific impairment type [75]. Longitudinal self-report studies may also deal with issues including participant attrition, poor response rates, and misunderstandings or misinterpretations of the questions. Given that this is the first research of its kind including Paralympic competitors with varying degrees of physical, visual, and intellectual impairments, it is crucial that the suggested approach be applicable to all of these conditions.

9. Conclusion

In many sports, especially para-sport, concussions are a prevalent injury. Clinicians have challenges applying concussion evaluation and treatment recommendations to para-athletes, and the need for concussion education is greater than ever. Para athletes suffer from a wide variety of injuries with varying causes. It is recommended that existing procedures be used when treating a concussion in a para-athlete. Regarding an assessment or the return to play procedure, the doctor should err on caution. Future research should study the usage and performance of standard evaluation instruments in the para-athlete community to better direct their clinical use and inform prospective adjustments. To lessen the frequency of concussions in para-athletes, it's important to think about both general techniques to avoid head trauma and adjust the rules of the sports.

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