



Epidemiology of Common Injuries in the Volleyball Athlete

Warren K. Young¹ · William Briner¹ · David M. Dines¹

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Abstract

Purpose of Review To review the recent literature regarding the epidemiology of injuries in the volleyball athlete across all levels of play and to discuss areas where further studies are needed.

Recent Findings Injury epidemiology for volleyball at the collegiate and high school level has been supported by a longitudinal injury surveillance program through the NCAA Injury Surveillance System (NCAA ISS) and High School Reporting Information Online (HS RIO) for the past 30 years. The creation of the FIVB Injury Surveillance System (FIVB ISS) in 2010 shows promise in advancing the literature on the injury at the professional level, and further studies on beach volleyball injuries are needed. Overall, injury patterns in volleyball in the past decade showed similar distribution to prior studies, but the rate of injury may be decreasing. Common injuries in volleyball include ankle sprains, patellar tendinopathy, finger and thumb sprains, overuse injuries of the shoulder, and concussions.

Summary Injury surveillance from the NCAA has demonstrated injury trends at the collegiate level, but further longitudinal studies are needed to evaluate injury at the professional level and for beach volleyball to help develop injury prevention strategy.

Keywords Volleyball · Injury · Epidemiology · Professional · Collegiate · Beach · FIVB · Concussion

Introduction

Volleyball is one of the top 5 most popular sports in the world. In 2022, the International Volleyball Federation (FIVB) will have 222 affiliated national federations with over 800 million participants worldwide. There are two main disciplines of volleyball: indoor volleyball and beach volleyball. The skillset for both types is similar, with the obvious differences between the two disciplines being the court size, playing surface, and number of players on the court. Beach volleyball was invented in 1920 but is relatively young in worldwide popularity. It was officially recognized by the FIVB as a discipline in 1986 and made its Olympic debut in 1996.

Volleyball is a limited-contact sport and is considered a safe sport with low incidence of injury. It is fast-paced and requires repetitive overhead and jumping motions, which can lead to both acute and overuse injuries of the upper and

lower extremity. Acute injuries can occur especially at the net zone, where teammates and opposing players jump to attack and defend in close quarters, making injuries of the head, face, hands, and ankles common (Table 1).

The overhead motions of serving and spiking of the volleyball can generate significant force. There are three common types of spikes: straight-ahead, cross-body, and roll shot, which is an off-speed spike. The two most common types of serves are the jump serve and the float serve. The spike and the jump serve have similar force and torque. They share a common motor pattern that can be divided into five phases: approach, takeoff, arm cocking, arm acceleration, and follow-through [1]. Between the arm cocking and acceleration phase, the dominant shoulder is maximally externally rotated and then quickly recoiled at the apex of the swing during the acceleration phase to generate maximum force on a 9- to 10-oz volleyball. The spike can generate ball speeds of almost 28 m/s [1], reaching the baseline receiver as fast as 0.3 s. For a specialized attacker, the many repetitions of such a forceful overhead motion can lead to similar overuse injuries as seen in other overhead sports such as baseball and tennis. These injuries include rotator cuff tendinopathy and tear, proximal biceps tendonitis and tear, glenoid labrum

✉ Warren K. Young
youngw@hss.edu

¹ Primary Sports Medicine, Hospital for Special Surgery, 535
E 70th St, NY 10021 New York, USA

Table 1 Common volleyball injuries

Common volleyball injuries
Upper extremity
- Rotator cuff tendinopathy
- Shoulder sprain
- Shoulder impingement
- Glenohumeral dislocation/subluxation
- Shoulder instability
- Glenoid labrum tear
- Suprascapular nerve neuropathy
- Wrist sprain
- Wrist tendonitis
- Wrist fracture
- Finger sprains
- Finger fracture and dislocation
Lower Extremity
- Ankle sprain
- Ankle ligament tears
- Ankle fracture
- Patellofemoral pain syndrome
- Patellar tendinopathy
- Knee sprain
- Knee ligament tear
- Stress fractures of the lower extremity
Head/Neck and Spine
- Concussion
- Muscle strains of the back
- Intervertebral disc injury
- Spondylolysis

tear, shoulder instability, impingement syndrome, scapular dysfunction, and nerve injury.

The forces from the repetitive actions of jumping and landing can lead to lower extremity overuse injuries. The amount of stress can be affected by jumping and landing techniques and the playing surface. The maximum ground reaction forces on sand during the take-off phase of squat jumps are decreased by 8% compared to a rigid surface [2]. One-footed landings have been reported to have higher ground reaction forces and muscle activity than two-footed landings [3]. Different landing techniques have been observed between gender, court position, and type of spike and serve [3]. It may also be affected by different tactical styles between beach and indoor volleyball and situationally in attacking and blocking [3]. Lower extremity injuries seen in volleyball include patellar tendon tendinopathy, ACL tears, meniscus tears, stress fractures, and ankle sprains.

At higher levels of competition, there are five types of positional specialization: outside hitters, middle hitters, setters, and defensive specialists (libero). These specialized roles have different types of training and skill sets, which

can see different patterns of injury. There may also be differences in injury rates and patterns between levels of competition and between indoor and beach volleyball.

Professional and Elite Indoor Volleyball

Epidemiologic studies of injuries in professional and elite-level indoor volleyball players over the past three decades have been mostly performed retrospectively within one national team over the course of one season. In 1992, Watkins and Green et al. reported on injuries in male players within the Scottish National League during the 1989–1990 season. In the survey of 86 players, they found 46 injuries, representing an incidence of 0.53 injuries per player [4]. The most common location of injury was the knee (30%), followed by the ankle (26%), fingers (22%), and back (17%). A similar study of Swedish elite male and female players during the 2002–2003 season found an overall incidence of 0.77 injuries per player [5], whereas a study of an elite Spanish volleyball league over one season of 490 players found an injury incidence per player of 0.94 [6]. Both studies found that the ankle and the knee were the most common locations for injury [5, 6].

In 2003, a prospective study of the Dutch men's and women's national volleyball teams with 44 teams and a total of 419 players found a total injury incidence of 2.6 per 1000 h of play [7]. Men had a slightly higher injury incidence of 3.0 compared to women's 2.4 per 1000 h. Overall match play had a higher total injury incidence of 4.1 compared to 1.8 during training. Most injuries were acute with a reported injury incidence of 2.0 per 1000 h compared to 0.6 per 1000 h for overuse injuries.

In 2010, the FIVB Injury Surveillance System (FIVB ISS) was established by the International Volleyball Federation and modeled on the International Olympic Committee surveillance program to collect data about the rate and pattern of injuries in FIVB competitions [8••]. In 2015, Bere et al. published a multiyear study on professional players with data from the FIVB ISS. The study of senior and junior international professional and elite volleyball players over a 4-year period from September 2010 to November 2014 included 32 events with prospective registration of injuries during all major FIVB tournaments. The total incidence of injury was 10.7 per 1000 player hours. Seniors had a statistically significantly higher injury incidence of 11.9 per 1000 player hours compared to the juniors with 9.0 per 1000 player hours. There was no significant difference between males and females. Injuries resulting in time-loss was 3.8 per 1000 player hours. Seniors had a two-times greater risk of time-loss injuries than juniors. Overall, severe injuries leading to greater than 4 weeks of time loss had a very low incidence of 0.3 per 1000 player hours. The study showed

that most injuries occurred during match play (62.5%) as compared to 37.5% during training. Injuries were also more frequent in center players [8••].

Collegiate, Youth, and Recreational Indoor Volleyball

In collegiate volleyball, the studies on injury epidemiology for women exceeds that of men. This may be because there are significantly more NCAA women's volleyball teams than men's teams. Currently In 2022, there are 26 Division I men's volleyball teams compared to 340 Division I women's teams.

Three studies analyzed and reported on injury data collected from the NCAA Injury Surveillance System (NCAA ISS) between 1988 and 2019 for collegiate women's volleyball [9, 10••, 11]. In 2007, Agel et al. reported data from 16 seasons between 1988 and 2004. The study found an overall injury rate of 4.58 per 1000 athlete exposures (AEs) during games and 4.1 injuries per 1000 AEs during practice [9]. While not statistically significant, injury rates during games on average decreased by 1.1% annually. During practice, rates decreased by 0.8% annually. During the 2004–2014 seasons, Kerr et al. reported a total injury incidence rate of 3.81 per 1000 AEs, with 3.83 per 1000 AEs during competition and 3.8 per 1000 AEs during practice [10••]. Over the course of those 10 seasons, there was a significant decrease in injury incidence during practice and competition, with an annual average change of -0.53 per 1000 AEs and -0.51 per 1000 AEs from 2004 to 2009. Most recently, Chandran et al. in 2021 reported an overall injury incidence of 6.73 per 1000 AEs during 4 seasons from 2014 to 2019. There was no significant difference between competition and practice, and no significant difference between Division I and III levels of competition [11].

While studies on NCAA men's volleyball are scarce, Baugh et al. in 2017 reported on two seasons of NCAA men's volleyball from 2013 to 2015. It showed an injury rate of 4.69 per 1000 AEs [12]. NCAA women's volleyball was compared in the same study, and women had a higher rate of injury in practices but not during competition. Women also had a higher rate of non-time-loss overuse injury. Men had a higher rate of time loss injury related to ball contact [12].

At the high school level, volleyball is the most popular girls' sport in the US, with seven times more girls playing volleyball than boys. In addition to NCAA women's volleyball, Kerr et al. in 2018 also reported on high school girls' volleyball injury epidemiology from 2004 to 2014 using the High School Reporting Information Online (HS RIO) injury surveillance system. Girls' high school volleyball had a lower rate of injury in both competition and practice, with a total injury rate of 1.11 per 1000 AEs. The injury rate was

less than one-third of NCAA women's volleyball during the same time period [10••, 13].

McGuine et al. in 2020 reported on high school girls' volleyball during the 2018 season and included 2072 players with 549 injuries. The overall injury rate was 5.3 per 1000 AEs, with 71.6% being time-lost injuries. A total of 7.1% of injuries required immediate referral to the ED for evaluation. Acute injuries were more common than overuse injuries (69.5% vs. 30.5%), and were greater during competition than practice. The study noted overall injuries were more common in outside hitters, followed by middle blockers and setters [14].

Beach Volleyball

There are limited studies on the injury patterns of beach volleyball, especially at the professional level. In 2003, a retrospective study of beach volleyball injuries included 178 professional men and women over a 7.5-week summer season with fifty-four injuries [15]. The rate of acute injuries was 3.1 per 1000 competition hours and 0.8 per 1000 training hours. Overuse injuries were treated in over one-third of the players. The most common were low back, knee, and shoulder issues (19%, 12%, and 10%, respectively) [15].

Beach volleyball became an NCAA Division I sport in 2015. Juhan et al. compared rates of injury between indoor volleyball versus beach volleyball using a single institutional database for their NCAA Division I teams in indoor and beach volleyball from 2003 to 2020. The total injury rate was significantly lower for beach volleyball with 1.8 injuries per 1000 h compared to indoor volleyball at 5.3/1000 h [16]. There were significantly more concussion, knee, and leg injuries in indoor volleyball and significantly more abdominal and wrist injuries in beach volleyball. The rate of injury was higher in practice than in games in both sports. Despite the rate of knee injury being higher in indoor players, the time lost from a knee injury in beach players was longer and statistically significant, as were time lost from low back injuries [16].

Lower Extremity Injuries

The lower extremity was the most common location for injuries in all levels of play, accounting for 50–60% of all injuries [4, 5, 7, 8••, 9, 10••, 11]. At the professional and elite level, the ankle was the most injured lower extremity location, accounting for 25.9% of all injuries [8••]. Ankle injuries were also the most common despite age and gender, and they were the most common injury in all positions except for the libero [8••]. A total of 47.4% of ankle injuries were caused by contact with another player, and 25.4% were

reported as non-contact trauma. Only 4.4% were due to overuse. The knee was the second most common lower extremity location, accounting for 15.2% of all injuries [8••]. It was the second-most common location for all positions except for setters and was the most common overuse injury overall [8••].

In professional beach volleyball, one study found that the knee was the most common location of injury, accounting for 30%, with the ankle second-most at 17% of all injuries [15]. The knee only accounted for 12% of all overuse injuries [15]. In NCAA Division I beach volleyball, foot, knee, and ankle injuries accounted for 14%, 13%, and 12% of all injuries, respectively [16].

In collegiate indoor volleyball, the ankle had the highest injury rates during competition in all three studies [9, 10••, 11]. The ankle had the highest injury rates in practice between 1988 and 2014 [9, 10••]. It was also the most injured body part that resulted in lost time, accounting for 25.8% of injuries [12]. The knee was the most injured for non-time loss at 25.5% [12].

Similarly for high school girls' volleyball, ankle injuries were the most reported injury and made up 25 to 36.6% of all injuries [10••, 14]. The knee was the second-most common location, accounting for 10.9 to 14% of all injuries reported [10••, 14].

For ankle injuries, a lateral ankle sprain was the most common injury in all levels of competition and occurred with highest incidence during matches. In NCAA women's volleyball from 1998 to 2004, lateral ankle sprains and knee internal derangement, which include ligament and meniscal injuries, made up over 50% of severe injuries during competition requiring more than 10 days of time loss. Lateral ankle ligament tears and sprain were the most common diagnosis from 2014 to 2019, accounting for 11.1% of all diagnoses. Lateral ankle sprains were also the most common diagnosis in high school girls [10••]. Patellar tendinosis was the most common cause of overuse knee injuries in female high school and college players [10••, 13].

Upper Extremity Injuries

Upper extremity injuries accounted for 20–30% of all injuries reported at all levels and styles of play [4, 7, 8••, 9, 10••, 11]. In profession and elite indoor volleyball players, Bere et al. found that finger and thumb injuries were the most common upper extremity injury, accounting for 10.7% of all injuries [8••]. The shoulder was the second most common making up 5% of all injuries [8••]. At the collegiate level, the shoulder, and hand and wrist injuries both made up about 9% of all injuries [10••, 11]. Hand and wrist injuries were more common than shoulders in the high school girls' volleyball population [10••, 13]. Shoulder injuries are the

third most common cause of time-loss injury in collegiate women's volleyball [9]. In beach volleyball, shoulder injuries were reported slightly more often than hand/wrist injuries [16]. By position, shoulder injuries are more common in outside hitters and middle blockers [4, 8••], while finger and thumb injuries were most common in liberos [8••].

Common overuse injuries to the shoulder include rotator cuff tendinopathy, glenohumeral instability, glenoid labrum tear, acromioclavicular joint pathology, and nerve injury [17]. While usually rare, suprascapular nerve neuropathy leading to infraspinatus muscle atrophy has been reported in volleyball players with an incidence between 12.5 and 34% [18•, 19•] and maybe a unique injury to volleyball players. The mechanism of injury is hypothesized to be a stretch neuropathy from the repetitive hitting motion [19•, 20], but it may also be due to compression by a ganglion or paralabral cyst, abnormal superior transverse scapular ligament, or a hypertrophied spinoglenoid ligament. It is also theorized that the biomechanics of the float serve achieved by arresting external rotation in mid-follow-through results in a maximal eccentric contraction of the external rotators, leading to traction at the nerve endings in the infraspinatus [20]. Despite having objective weakness and abnormal EMG muscle activity compared to the non-hitting shoulder, most players with infraspinatus atrophy do not report subjective restrictions [19•].

Concussions

Despite being a limited-contact sport, concussions made up a larger than anticipated percentage of injuries throughout all levels of play in indoor volleyball. In female players, the concussion rate in the NCAA has been reported as 4.93 per 10,000 AEs, with 6.05 during competition and 4.43 during practices [21]. This is the highest amongst limited-contact sports including softball, swimming/diving, and baseball. It is even higher in rate than men's basketball, which is categorized as a high-contact sport [21]. Concussions were the second most common specific diagnosis in NCAA women's volleyball from 2014 to 2019. It was notable for 7.3% of injuries, with rates increasing from 2015 to 2019 while other injury rates decreased [11]. In men's and women's NCAA volleyball, concussions accounted for almost 20% of time-loss injury, with blocking and digging the most common mechanism [12].

A cross-sectional survey of youth volleyball players in Canada showed an incidence of concussion of 7.1 per 100 athletes in males and 7.5 per 100 athletes in females. The authors observed that 57% of concussions involved ball-to-head contact, 61.6% occurred during practice or warm-ups, and 38.4% during gameplay [22].

Conclusions

Volleyball overall has a low incidence of injury, especially for severe injuries. Epidemiologic injury studies can be difficult to compare due to the differences in study methodology, including study design, injury definition, player population, and exposure calculation, but injury patterns and trends can be seen in these studies.

The literature over the past decade is consistent with prior research and shows that ankle sprains continue to be the most common injury, especially during competition. Knee injuries continue to be the most common cause of overuse injury, and finger injuries, especially occurring during blocking, remained high. Overall, data from the NCAA ISS suggests that injury rates are on a downward trend. This may be due to injury prevention research in volleyball. Specifically, injury prevention programs have shown benefits in preventing ankle injuries. The use of an ankle brace may decrease risk in players without a history of an ankle injury but may not be effective in preventing recurrent ankle sprains [23–26]. A shoulder injury prevention program focused on rotator cuff and scapular strength and stabilization may be effective in prevention of upper extremity injuries for volleyball players [27].

While there has been a fair amount reported at the collegiate level, injury rates at the professional level have not been as robust and have not had the same high-quality continuity. The only multi-year study on professional athletes lacked data outside of tournament play and did not report on the incidence of concussions [8••]. Additional research is recommended in order to further our understanding of volleyball injuries at all levels of competitions and to develop prevention strategies and programs.

Declarations

Conflict of Interest Warren Young and William Briner declare that they have no conflict of interest. David M. Dines reports personal fees from Zimmer Biomet Incorporated and Thieme Publishers.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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