
Original Article


Injuries and pathologies in beach volleyball players: A systematic review

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ABSTRACT

Jimenez-Olmedo, J.M., & Penichet-Tomas, A. (2015). Injuries and pathologies in beach volleyball players: A systematic review. *J. Hum. Sport Exerc.*, 10(4), pp.936-948. The aim of this paper is to review the available literature published on injuries and pathology in beach volleyball. The databases consulted were the Web of Science and Pubmed. After establishing the criteria for selection and filtering, a total of 32 articles were selected. All items found can be classified into four research lines. First are the studies focused on specific injuries such as shoulder, shoveling, knee and foot. The second line of research focuses on the study of the incidence, prevalence and frequency of injuries of beach volleyball players, whereas the third line deals on infections reported in the literature produced by nematodes or fungi. Finally, the last line of research includes articles addressing different objectives related to health such as the effects of training programs related to injuries, influence of weather conditions on the players, as well as publications for validation of assessment instruments or develop of guidelines and protocols for the evaluation and diagnosis of injuries. **Key words:** BEACH VOLEYBALL, HEALTH, INJURIES, REVIEW.

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INTRODUCTION

Beach volleyball is being studied for researchers and sports professionals from different fields of study. From the first published work on this sport (Wang, 1996), literature has experienced exponential growth over the last 20 years, when beach volleyball sport was incorporated to the Olympic program for the 1996 Atlanta.

It should be noted that throughout all this period, different areas of research have been of interest in the study of this sport. To date, high-impact 104 articles in beach volleyball have been published. These studies analyzed sport from different perspectives, fields of study or areas of interest, so that they can be encompassed in seven major blocks:

- Health: study of injuries, treatment and diagnosis. In addition, publications related to the field of health such as infections, evaluation guides or validation of health protocols in beach volleyball.
- Psychology: behavior-based studies, management of emotional or based on the decision states.
- Performance analysis: Publications related to the study of the actions and patterns of play and the players themselves, evaluated by different tests or test characteristics.
- Physiology: Publications focused on the physiological response of athletes and their physiological responses to the playing conditions
- Technology: Publications focused on the use of technology, its implementation in the sport of beach volleyball as well as the development of new tools for monitoring and evaluation.
- Biomechanics: motion analysis research and its relationship with sport and its specific characteristics.
- Sociological: development of sociological factors, involving the world of beach volleyball studies.

From the above blocks, special mention must be done for performance analysis and health. Performance analysis is the most prolific area, with the highest number of collected publications so far. The study and knowledge of an emerging sport, with professionalization of athletes and the consolidation of competitions have helped focus deeper into this sport and playing conditions. Therefore, the sport of beach volleyball is known at a professional level, with focus on the promotion of beginning categories. On the other hand, health's block has the second major number of publications. Studies focused on the knowledge of the prevalence of injuries have been conducted in different time periods with different samples. This has led to similar results obtained in some respects but differing in others. In addition, the health's block not only has focused on the description of the prevalence of injuries, both absolute values or related to playing or training hours, but also focused on the study and treatment of specific and own injuries.

Due to the interest shown on studies for the prevention, treatment and recovery from injuries to minimize recovery times and accelerate the return to activity of athletes, it is important to collect literature and analyse the studies up to the present.

This document provides a review of the scientific literature of beach volleyball sport, specifically in studies related to the health area, and more specifically to those related to injuries and pathologies that such type of athletes suffer.

MATERIAL AND METHODS

The search was performed on the Web of Science and PubMed databases. Inclusion criteria were published in one of the two databases, focusing to gather injury, illness, treatment and clinical interventions with players or beach volleyball players of any category. The terms used to search for information were "beach volleyball *" with a truncation. Besides, searches were filtered as articles only from 1996 to 2015.

RESULTS

The Web of Science search gave 104 articles and 52 articles in PubMed. Of all the items were filtered accordingly. After making the selection based on the criteria, 32 beach volleyball paper related with injuries and pathologies was selected.

The articles were categorized into 4 major lines of research, all related to the field of health in beach volleyball. Specifically, in the first line of research, there are publications dealing with the study of specific injuries (Table 1). This block contains description and treatment of specific injuries.

Table 1. Articles of specific injuries.

Author	Year	Aim	Sample	Result
Frey, Andersen & Feder	1996	Study of 12 cases of hyperplantaflexion in professional beach volley	12 cases	Players with this injury need 6 months of recovery. It mainly affects the loss of dorsiflexion. Treatment with anti-inflammatories, ice and rest, along with a strengthening program.
Reeser, Verhagen, Briner, Askeland & Bahr	2006	Establish strategies for preventing common injuries	-	Establish prevention and recovery strategies and risk factors for ankle sprains, patellar tendinitis and shoulder injuries by overuse.
Pfirschmann, Jost, Pirkl, Aitzetmuller, & Lajtai	2008	The purpose was to assess quadriceps and patellar tendinosis in professional beach volleyball players and to correlate ultrasound findings with clinical symptoms	202 total players. 100 male and 102 female	Quadriceps tendinosis was diagnosed in 13 (21%, dominant leg) / 21 (34%, non-dominant leg), patellar tendinosis in 13 (21%) / 18 (30%). Thickening and impaired quadriceps tendon structure is associated with anterior knee pain in beach volleyball players.
Lajtai et al.	2009	Clinical and imaging findings in the hitting shoulders of fully competitive professional beach volleyball players, as compared with their non hitting shoulders.	84 professional players, 54 male y 30 female	The prevalence of infraspinatus muscle atrophy in professional beach volleyball players is 30%. The typical, fully competitive player has subjectively unrecognized decreased strength of external rotation and frequent unspecific shoulder pain. Therefore, abnormal clinical and imaging findings in the beach volleyball player should be interpreted with care.

Vormittag, Calonje, & Briner	2009	Describe the different injuries practiced barefoot sports including beach volleyball.	-	Ankle sprains are less common in sand. Lacerations and abrasions in the skin are common foot injuries. It highlights the "sand toe" as self-injury to players who play sports in sand.
Frey	2010	Foot and ankle injuries in American beach volleyball players	-	Common foot and ankle injuries include ankle sprains, Achilles tendinosis, plantar fasciitis, sesamoiditis, arch strain, metatarsophalangeal (MTP) hyperextension, and MTP hyperflexion injuries. The use of prophylactic ankle braces is discussed and recommendations made.
Lajtai et al.	2012	Assessment with surface electromyography and nerve conduction velocity (NCV) to evaluate the infraspinatus muscle atrophy.	35 men professional player	Professional beach volleyball players have a high frequency of infraspinatus atrophy (34%) and significantly reduced shoulder strength of the hitting shoulder.
Seminati & Minetti	2013	This review discusses the prevalence of two of the most common overuse-related injuries in volleyball: shoulder and back/spine injuries		Different movements involved in the game (in particular spiking and serving) together with the anatomy of the volleyball players concur to the risk factors for overuse injuries of the shoulder and back/trunk. Shoulder overuse injuries in our analysis have a higher rate compared to the back/trunk injuries. However, high variability among the different studies suggests that overuse injuries prevalence could be underestimated.
Ottesen, Barfod, & Holck	2014	Description of a patella injury	44 years old man	Strong and acute pain with inability to extend the knee. I was diagnosed with the help of X-rays a traumatic separation type I.
Monteleone et al.	2014	The purpose of this study is to identify ultrasonographically the prevalence of myotendinous alterations in professional Italian beach volleyball players.	53 players, 31 female y 22 male	The abnormalities identified ultrasonographically were: 14 cases of calcific tendinopathy, 10 cases of impingement, 17 cases of inflammation of the cuff and 4 cases of rotator cuff degeneration.
Külling et al.	2014	Prevalence of disc degeneration and spondylolysis in the MRI of the lumbar spine of professional beach volleyball players	29 professional male beach volleyball players	Whereas 86% of players suffered from LBP during their career, the incidence of LBP (Low Back Pain) in the last 4 weeks was 35%. The most affected spinal levels were L4-5 in 14 (48%) and L5-S1 in 15 players (52%); both levels were involved in 5 players (17%). Six of 29 (21%) players showed a spondylolysis grade 4.

Pieber et al.	2014	The aim of the study was to examine the suprascapular nerve in Austrian high-performance beach volleyball players.	18 professionals male beach volleyball	No acute or chronic neurogenic changes in the infraspinatus muscle were seen in any player, although atrophy of the suprascapularis innervated muscles was present in five players.
Monteleone, Gismant, Stevanato, & Tiloca	2015	A report of two cases of grave atrophy of the deltoid muscle following painless axillary neuropathy	2 beach volleyball players, 1 male and 1 female	The presence of deltoid atrophy in two of 91 competitive level beach volleyball athletes, representing a prevalence of 2.2% occurring from presumed neuropathy of the axillary nerve. The cases were identified exclusively using physical examination of the shoulder and the athletes' medical history.

The second line of research of this review focuses on publications that address the description, prevalence and incidence of injuries (Table 2). In this major block, anatomic regions most prone to suffer injury are presented, together with the reasons that caused them and the relationship between the number of hours, either training or competition sport, with the number of injuries suffered by players of different categories and in different competitions.

Table 2. Injuries incidence, prevalence and frequency.

Author	Year	Aim	Sample	Result
Aagaard, Scavenius, & Jorgensen	1997	Comparison of the prevalence and incidence of injuries in indoor volleyball players and beach volleyball players	295 players of season 1993-1994.	Beach volleyball players had an incidence of 4.9 injuries every 1000h practiced against the 4.2 injuries every 1000h indoor players. In beach injuries occurred in defence and attack and the shoulder being the most affected area. The indoor injuries occurred more in block and spike actions. The most frequent injuries are on toes and ankle.
Paulseth, Martinovich, Scira, & Sherman	2002	Description between the association of the training methods used and the types and incidence of injuries in male players during a season	103 male players of AVP season 1998	They do not set different between ages, years of practice and incidence of injuries. The most severe injuries in terms of lost days were ankle, followed by the back and finally the knee. Recommendations included training techniques.
Bahr & Reeser	2003	Describe the incidence and prevalence of injuries to players and professional beach volleyball players	178 players at Final of Worldchampionship in 2011	The incidence of lost time injuries was established for acute injuries in 3.1 hours of competition in 1000 and 0.8 per 1000 hours of training. The incidence of acute injuries occurred in knee (30%), ankle (17%) and finger injuries (17%). Overuse injuries were back pain (19%), knee pain (12%) and problems with the shoulder (10%).
Kugler et al.	2006	The purpose of this study was to examine the prevalence of injury in Beach and indoor volleyball players	312 but only 178 players reported injuries	Register an incidence of 0.08 injuries per year. Most of the injuries were in knee (20%), ankle (17%), fingers (15%), shoulder (13.1%) and back pain (5.7%).

Gámez et al.	2006	The aim of this work is an epidemiological study focused on players of beach volleyball and beach soccer Spain	89 players, 54 beach volleyball players and 35 beach soccer players	The ligament and tendon injuries (36%) are most common in beach volleyball players. The foot and ankle are the regions that have higher injury rate, mainly skin character.
Zhang & Ge	2008	The aim is to investigate the incidence of injuries beach volleyball athletes participating in the 10th Chinese National Games	96 beach volleyball players	They have an injuries incidence of 47.7%. Acute and chronic injuries are higher than those suffered by athletes from other countries. Injuries Chinese athletes are mainly produced in blocking actions.
Junge et al.	2009	To analyse the frequency, characteristics, and causes of injuries incurred during the Summer Olympic Games 2008	96 players	Beach volleyball injuries were 8.3% of total injuries, being 50% of injuries during training and 50% for competition.
Eerkes,	2012	Review the specific injuries that are most common as a result of participating in the sport of volleyball and beach volleyball	-	Injuries can occur from frequent jumping as well as from hitting and blocking the ball. Injuries can be either acute or repetitive in nature. Injuries typically involve the ankles, knees, and shoulders.
Engebretsen et al.	2013	To analyse the injuries and illnesses that occurred during London in 2012.	96 beach volleyball players	12 injuries were recorded during the games. 54.5% of them in competition and 45.5% during workouts.

The next research line is related to infections in beach volleyball (Table 3). Several investigations have been focused on case studies as a result of infections and diseases caused by nematodes and fungi in the playing surface where the sport is practiced.

Table 3. Infections in beach volleyball.

Author	Year	Aim	Sample	Result
Aagaard et al.	1997	Case study of a nematode infection called braziliense <i>Ancylostoma</i> in a beach volleyball player	1 player	The case study only observed dermatological disorders. He was treated with albendazole 400 mg pills twice a day for five days. After 10 days no sign of infection was revealed.
Winokur & Dexter	2004	Describe fungal infections in beach volleyball players	-	Described fungal infections who tinea corporis, capitis, cruris, versicolor, and pedis, as well as onychomycosis. Personal hygiene, monitoring of the skin and avoid sharing clothing are the best preventive measures.

Veraldi, Persico, & Valsecchi	2011	Descriptive case study of Tungiasis infection	1 Italian beach volleyball player	Case of tungiasis in an Italian beach volleyball player acquired the infestation in Brazil.
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Finally, the last line of research shows publications of different topics that can not be encompassed in any of the above (Table 4). These publications aimed at different objectives with beach volleyball players. The subject of these publications is from research on the validation of protocols to studies on the environmental conditions.

Table 4. Other articles related with health in beach volleyball.

Author	Year	Aim	Sample	Result
Martin	1999	Study on environmental conditions in the play area at Atlanta 96.	-	Temperatures were measured in the different areas of play, including beach volleyball stadium. Also they were recorded the incidences related to heat stroke and the influence of environmental conditions on the players
Dickinson & Hanrahan	2009	This study investigated the properties of the Athens Insomnia Scale the Fatigue Severity Scale, and subscales of the SLEEP-50 in elite Australian athletes, to determine their appropriateness for this population.	Rowing ($n=8$), netball ($n=8$), basketball ($n=19$), beach volleyball ($n=8$), and sailing ($n=16$) squads.	All scales and subscales showed high internal consistency. All measurements were significantly correlated, demonstrating convergent validity.
Panhuyzen-Goedkoop & Smeets	2009	Description of a case of Palpitations and Presyncope on Effort	1 female player	The ECG demonstrated a saddle back type ST _{segment} elevation in right precordial leads V1-V2, potentially compatible with type II Brugada syndrome. Moreover, SCN5A gene analysis was eventually performed and was negative form mutations compatible with Brugada syndrome.
Bahr	2009	The aim of this paper was to provide recommendations on how standardised methodology can be developed to quantify overuse injuries in surveillance studies using beach volleyball data	No sample	Four recommendations: The studies should be prospective, with continuous or serial measurements of symptoms; valid and sensitive scoring instruments need to be developed to measure pain and other relevant symptoms; prevalence and not incidence should be used to report injury risk; severity should be measured based on functional level and not time loss from sports.

(Roald Bahr & Reeser, 2012)	2012	To monitor heat stress and record cases of heat-related medical forfeits on the Swatch FIVB Beach Volleyball World Tour	48 of 51 events	The incidence of significant heat illness among athletes competing on the FIVB Beach Volleyball World Tour appears to be quite low, even though weather conditions frequently result in a wet bulb globe temperature (WBGT) index >32 °C. Currently available guidelines appear to be inadequate to fully assess the risk of heat stress and too conservative to inform safety decisions in professional beach volleyball.
Ruiz et al.	2012	The aim of this investigation is to obtain information about muscle stiffness, the mechanic and contractile properties of the muscles using the TMG with high level beach volleyball players as well as to demonstrate the usefulness of this method to evaluate the muscles in charge of the knee flexion and extension	14 male players and 10 female players in 2009	The data obtained of the subjects in our sample let us confirm that TMG is a highly useful technique for the evaluation of structures of muscular stiffness and muscular balance of athletes. However, we should remember that the validity and reproducibility of the results are conditioned to strict evaluation protocols.
Bele, Östenberg, Sjöström, & Alricsson	2015	The purpose of this study was to examine beach volleyball player's experience regarding shoulder injury and how it affects their return to play.	5 elite beach volleyball players, 4 male and 1 female	The findings of this study indicate that three different factors that increase the chances of getting back to beach volleyball after shoulder injury, including the player's self-motivation, support from community, family, teammate and coach.

DISCUSSION

As presented in the results section, the literature published to date related to the field of health in beach volleyball as inclusion criteria set out in this document includes four research lines that will be discussed below:

Specific injuries

The research line in specific injuries collects publications on the study of injuries that have been published on diseases, injuries or ailments in narrow parts of the body. Literature has focused on those injuries that caused more problems or have shown higher prevalence so different publications on the same anatomical region have arisen: shoulder, knee, foot and back have been specifically studied.

One of the topics of interest has been the study of ankle and foot. The first publication on this distal area appeared in 1996 (Frey, Andersen, & Feder, 1996) where a study of treatment and diagnostic of "sand toe" or hyperplantarflexion was developed to 12 athletes. The right treatment for this specific foot injury was ice,

anti-inflammatories and rest along with a program to strengthen. Interest in the study of the foot has led to the study on specific foot injuries suffered by players, both volleyball and beach volleyball (Frey, 2010). The most common injuries were ankle sprains, achilles tendonitis, plantar fasciitis, sesamoiditis, arch strain, metatarsophalangeal (MTP) hyperextension and MTP hyperflexion. In addition, a study focused on sports practiced without shoes is published (Vormittag, Calonje & Briner, 2009), among which is the beach volleyball. In this work, ankle injuries are less common than indoor, but on the other hand, lacerations in skin by abrasions is a common injury, while stressing "sand toe" as a specific injury of athletes who practice sand sports.

Following the specific injuries, another group of studies have focused on the shoulder joint and adjacent structures. The first specific study on the shoulder was published in 2009 (Lajtai et al., 2009), where prevalence of infraspinatus muscle atrophy in professional beach volleyball is of 30% of players. Years later, infraspinatus muscle atrophy is study more deeply (Lajtai et al., 2012), where a prevalence of 34% was established as a consequence of a repetitive traction injury of the suprascapular nerve. Other studies focused on shoulder have been studied with specific techniques for shoulders injuries (Monteleone et al., 2014), detecting cases of calcific tendinopathy, impingement, inflammation of the cuff and rotator cuff degeneration in Italian athletes in beach volleyball. Also a study of the suprascapular nerve (Pieber et al., 2014) and its prevalence in athletes showed a detection of 5 of the 18 athletes tested. Finally, a report of two cases of severe atrophy of the deltoid muscle with a prevalence of 2.2% along with a review of injuries both back and shoulder (Monteleone, Gismant, Stevanato & Tiloca, 2015) complete the publications over shoulder. In the latter publication, the reason for shoulder injuries exposed to high values of torque and range of motion in a very short time is stated.

On the other hand, despite not having as many publications as the foot or shoulder, back and knee studies have also been of interest in specific literature. As for the knee, the first article appears in 2008 (Pfirrmann et al., 2008) where quadriceps and patellar tendinosis was diagnosticated to 34 and 13 athletes out of 202 of the sample. The knee quadriceps tendon thickening was also establishing as the cause of previous pain symptoms. The next knee publication focuses on the description of a case study in a man of 44 years suffered a traumatic separation of a type I patella bipartite (Ottesen, Barfod & Holck, 2014).

Two publications deals with the study of the back. The first one studied back injuries along with shoulder injuries as common pathologies in beach volleyball players (Seminati & Minetti, 2013). A year later, a study on the prevalence of disc degeneration prevalence and spondylolysis (Kulling et al., 2014) established that the most affected spinal levels were L4-5 in 14 (48%) and L5-S1 in 15 players (52%).

Finally, a research on the most common injures is published in 2006 (Reeser et al., 2006), where prevention strategies are set for ankle sprains, patellar tendinitis and shoulder injuries.

Injuries incidence, prevalence and frequency

The publications until today deal with the description of the type of more frequent injuries and their impact. The first study aimed to determine the incidence of injury in beach volleyball by making a comparison with indoor volleyball (Aagaard, Scavenius & Jorgensen, 1997). In this article, a differentiation between incidences of injury of beach volleyball players and indoor players is stated, with 4.9 and 4.2 injuries every 1000 hours of practice, respectively. It also establishes athletes are more injured in attack and defence actions on the beach, with shoulder as the most common injury, while blocking actions and attack produced more injuries in indoor volleyball, with finger and ankle injury as the most frequent injury. In this line, some studies have studied in pattern of injuries in indoor players and beach volleyball (Kugler et al., 2006) setting

0.8 injuries per year being the knee injury (20%), ankle (17%), fingers (15%), shoulder (13.1%) and back pain (5.7%) the most common. Also, a review of the most common injuries in volleyball and beach volleyball is published in 2012 (Eerkes, 2012). In this paper, ankle injuries, knee and shoulder were established as the most common injuries.

In 2003, Bahr and Reeser (2003), specifically address beach volleyball injuries during world championship beach volleyball. In this publication, incidences of 3.1 injuries per 1000 hours of competition and of 0.8 injuries per 1000 hours of training are established. The most common acute injuries are knee (30%), ankle (17%) and fingers (17%). They have also set back pain (19%), knee pain (12%) and problems with the shoulder (10%) as overuse injuries.

In this same line, a series of studies were published on injuries in sports events, among which are also beach volleyball. In 2008, (Zhang & Ge, 2008) conducted a study of injuries in the 10th National Games of China, establishing a harmful effect of 47%, where blocking actions were the cause of injury. Also in the last two editions of the Olympic Games, in Beijing 2008 (Junge et al., 2009) and London 2012 (Engebretsen et al., 2013), beach volleyball injuries were also registered. In Beijing and London, injuries of these athletes during the games accounted for 8.3% and 12.5% of all recorded injuries, respectively.

Finally, two studies comparing injuries in beach volleyball players with other variables or sports were published. In the first one, a comparison between the training methods and the injury incidence is conducted (Paulseth, Martinovich, Scira & Sherman, 2002), establishing that the most common injuries are ankle sprains, back injuries and knee injuries. In the other study of 2006 carried out a comparison of injuries for two sand sports, comparing thus beach volleyball players with beach soccer players (Gamez et al., 2006). It was establishing that the most common injury is in tendon and ligament (36%), followed by foot and ankle injuries, with skin lesions as the most frequent ones.

Infections in beach volleyball

In the third research line of health, three studies focused on nematode and fungal infection in beach volleyball athletes. The first appears in 1997 (Biolcati & Alabiso, 1997), as the case of a beach volleyball player infested by a nematode called *Brasiliense Ancylostoma*, where followed treatment was described. The second article contains description of the fungal infection for beach volley players (Winokur & Dexter, 2004) where different fungal infections caused by fungi type of *tinea corporis*, *capitis*, *cruris*, *versicolor*, *onychomycosis* are described. They found that the best preventive measures were personal hygiene, surveillance and not sharing bathroom fixtures. Finally in 2011, a case of *Tungiasis* infection (Veraldi et al., 2011) is documented in an Italian beach volleyball player, where treatment and clinical picture presented by the athlete is again indicated.

General

This fourth and final research line of publications include all health-related studies that cannot be included within the above three groups, so publications on different subjects are collected but related to the field of health Beach volleyball.

The first two publications focused on the study of the relationship between temperature and beach volleyball. The first one collects climate data in beach volleyball during the 1996 Summer Olympics (Martin, 1999) and its influence on the players. In the same way, some recommendations are published to prevent the effects of heat on beach volleyball players during FIVB tournaments (Bahr & Reeser, 2012).

Other studies have focused on the validation of scale test using beach volleyball players as sample, among others (Dickinson & Hanrahan, 2009) and the development of protocols and procedures for data collection for the study of injuries using beach volleyball players data (Bahr, 2009).

The literature also includes a description of a case study of 21-year beach volleyball players that presents a picture of pre palpitations and syncope on effort, performing a descriptive study in depth and ECG diagnosis (Pahunyzen-Goedkoop & Smeets, 2009).

Another of published papers on health within this block is the study of muscle stiffness through TMG electromyography (Ruiz et al., 2012), establishing as a method and proper technique to assess both stability and muscle stiffness in beach volleyball athletes.

Finally, the last work published to date is a study of recovery and return to competition of athletes after suffering a shoulder injury (Bele et al., 2015), with factors such as coach, family, personal motivation and reasons that led to the training and competition.

CONCLUSIONS

According to the literature reviewed in this paper, the field differences between volleyball and beach volleyball plays a role on different types of injuries suffered by players. Indeed, the playing surface and the total number of players per team become the major factor to explain such contrast. The number of players, a couple, and the number of repetitions of different technical actions force volleyball beach players to perform a greater number of actions throughout a game.

For beach volleyball players in studies published to date, it was establish an injury incidence between 3.9 and 4.9 injuries per 1000 hours, with injuries both in competition and in training. In addition, the majority of injuries are caused in defensive and attack actions. Besides, the body parts that suffer most acute damage are knees, ankle and fingers, while for overuse, back, knee and shoulder. Finally, the main reason for injuries is the high degree of repetition of explosive actions, where athletes undergo joints to great stress and speed in execution techniques required for game development.

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