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Contribution to the Epidemiology of Injuries in Elite Indoor Volleyball in Portugal

Beatriz Costa Basto

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AUTHOR	Beatriz Costa Basto
EMAIL	up201906762@up.pt
SUPERVISOR	António Pedro Pinto Cantista, MD, PhD
CO-SUPERVISOR	Helena Carvalho, PhD
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Statement of Scientific Integrity

This work has been authorised and is based at the Portuguese Volleyball Federation (FPV), with the collaboration of the Physical Medicine and Rehabilitation Service of the Local Health Unit of Santo António (ULSSA) at the Santo António University Hospital Centre (CHUdSA). I declare that I am the sole author of this work and that it has not been previously submitted for assessment in any course or curricular unit, whether at this or any other institution. References to other authors have been made in strict accordance with academic attribution standards and are properly cited within the text and in the reference list, following the appropriate referencing conventions. I am aware that plagiarism and self-plagiarism constitute academic misconduct.

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The Student:

Assinado por: **Beatriz Costa Basto**
Num. de Identificação: 15346357
Data: 2025.06.04 00:44:36+01'00'

Beatriz Costa Basto
Final-year Medical Student in the Integrated Master's in Medicine at Instituto de Ciências Biomédicas Abel Salazar – School of Medicine and Biomedical Sciences – of University of Porto.

The Supervisor:

Assinado por: **António Pedro Pinto Cantista**
Num. de Identificação: 03297348
Data: 2025.06.04 10:09:19+01'00'

António Pedro Pinto Cantista, MD, PhD
Senior Graduate Assistant and Director of the Physical and Rehabilitation Medicine Department at Santo António University Hospital Centre of Santo António Local Health Unit; Visiting Full Professor at Instituto de Ciências Biomédicas Abel Salazar (School of Medicine and Biomedical Sciences) of University of Porto.

The Co-Supervisor:

Assinado por: **Helena Maria Barroso Carvalho**
Num. de Identificação: 05424104
Data: 2025.06.04 00:32:03+01'00'

Helena Carvalho, PhD
Full Professor at Iscte – University Institute of Lisbon, and Integrated Researcher at the Centre for Research and Studies in Sociology (CIES-Iscte).

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Dedication / Dedicatória

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Preface

Given the widespread participation in volleyball in Portugal, injuries associated with the sport may hold particular relevance. Within this context, and as a medical student competing in the First Division of the Portuguese Championship, I recognise the scarcity of data on the epidemiology of volleyball injuries in Portugal. This study therefore seeks to make a meaningful contribution not only to the understanding of this sport but also to the broader fields of Health and Sports in our country.

As ICBAS School teaches its students, “The physician who knows only Medicine knows not even Medicine”. Following this principle, I believe that interdisciplinary knowledge between Sports and Medicine should be embraced by all specialists in these fields, not just those who work directly with professional or semi-professional athletes.

By consolidating, expanding, and disseminating this knowledge, we can more effectively enhance the prevention, diagnosis, treatment, and rehabilitation of sports injuries.

ABSTRACT

Background:
Volleyball is a globally popular sport with increasing participation in Portugal, yet national data on injury epidemiology at the elite level remain limited.

Objective:
To analyse sports injuries in elite volleyball in Portugal over the past five sporting seasons (2020/21 – 2024/25), focusing on the following parameters: injury risk; injury characteristics (including timing, onset, location, types); volleyball-specific injuries; severity, impact on performance and recurrence; potential risk factors; and associations among these parameters.

Methods:
A retrospective questionnaire was conducted among athletes from the Men's and Women's First Division Leagues in the 2024/2025 season. Data were collected on injury occurrence, type, severity, onset, anatomical location and potential risk factors.

Results:
The injury risk was 66.7%, corresponding to an estimate of 0.25 injuries per athlete per season. Injuries were predominantly traumatic and occurred more frequently during training, except in the case of ankle and knee injuries. The lower limb was the most affected region, particularly the ankle and knee. Ligament injuries were the most common, followed by muscle strains, tendinopathies and meniscal or cartilaginous knee injuries, and traumatic fractures. Outside hitters and middle blockers were at highest risk, with injuries often linked to jumping, landing, and defensive actions. Age was the only biological factor significantly associated with injury occurrence, whereas sex primarily reflected differences in the type, location, and occurrence of specific injuries. Knee injuries were the main cause of severe and season-ending injuries.

Conclusion:
Despite a relatively low injury rate, elite volleyball in Portugal carries a considerable risk of major, severe, and sometimes season-ending injuries. Prospective studies using standardised injury definitions and classification criteria are needed to improve comparability across studies, guide prevention strategies, and enhance understanding of exposure-related risks.

Clinical Relevance:
These findings advance epidemiological knowledge related to volleyball and support the development of targeted injury prevention strategies for elite volleyball athletes.

Keywords:
Volleyball, Sports Injuries, Epidemiology, Injury Risk, Elite Athletes, Portugal

RESUMO (Portuguese)

Introdução:
O voleibol é um desporto com grande popularidade a nível mundial e com participação crescente em Portugal. No entanto, os dados nacionais sobre a epidemiologia das lesões ao nível de elite continuam escassos.

Objetivo:
Analisar as lesões desportivas no voleibol de elite em Portugal ao longo das últimas cinco épocas (2020/21 – 2024/25), com foco nos seguintes parâmetros: risco de lesão; características das lesões (incluindo momento e modo de instalação, localização, tipo de lesão); lesões específicas do voleibol; gravidade, impacto no desempenho e recorrência; potenciais fatores de risco; e associações entre estes parâmetros.

Métodos:
Foi realizado um questionário retrospetivo a atletas das Ligas da Primeira Divisão Masculina e Feminina na época 2024/2025. Recolheram-se dados sobre ocorrência de lesões, tipo de lesão, severidade, instalação (*onset)*, localização anatómica e potenciais fatores de risco.

Resultados:
O risco de lesão foi de 66,7%, correspondendo a uma estimativa de 0,25 lesões por atleta por época. As lesões foram predominantemente traumáticas e ocorreram com maior frequência durante os treinos, exceto no caso das lesões no tornozelo e no joelho. O membro inferior foi a região mais afetada, em particular o tornozelo e o joelho. As lesões ligamentares foram as mais comuns, seguidas de distensões musculares, tendinopatias e lesões do menisco ou cartilagem do joelho, e fraturas traumáticas. As posições mais afetadas foram os atacantes de entrada (ou zona 4) e os centrais. As lesões foram mais associadas ao salto, às aterragens e a ações defensivas. A idade foi o único fator biológico significativamente associado à ocorrência de lesão, ao passo que o sexo evidenciou sobretudo diferenças no tipo, localização e ocorrência de lesões específicas. As lesões do joelho foram a principal causa de lesões graves e de lesões que determinaram o término da época desportiva.

Conclusão:
Apesar de a taxa global de lesões ser relativamente baixa, o voleibol de elite em Portugal apresenta um risco considerável de lesões graves, algumas das quais podem terminar precocemente a época. São necessários estudos prospetivos que utilizem definições e critérios de classificação de lesões padronizados, de forma a permitir uma melhor comparação entre estudos, orientar estratégias de prevenção e compreender melhor os riscos associados à exposição.

Relevância Clínica:
Estes resultados contribuem para a investigação epidemiológica no voleibol e apoiam o desenvolvimento de estratégias de prevenção de lesões direcionadas para atletas de elite.

Palavras-chave:
Voleibol, Lesões Desportivas, Epidemiologia, Risco de Lesão, Atletas de Elite, Portugal

List of Abbreviations

ACL – Anterior Cruciate Ligament

BMI – Body Max Index

FIVB - Fédération Internationale de Volleyball

FPV – Federação Portuguesa de Voleibol

IOC – International Olympic Committee

ISS – Injury Surveillance System / ISP – Injury Surveillance Program

NCAA – National Collegiate Athletic Association

CONTENTS

List of Tables

List of Figures

INTRODUCTION

The Global Context of Volleyball and Epidemiological Research on Related Injuries

Volleyball is one of the world's five most popular sports, with over 800 million federated athletes across 222 national federations, according to 2022 data from the International Volleyball Federation (FIVB)[1]. In Portugal, the Portuguese Volleyball Federation (FPV) reports 59,202 federated athletes across 2,559 teams from 689 clubs, reflecting a significant rise in youth participation[2].

Volleyball is played in two formats: indoor volleyball and beach volleyball, with the latter being a more recent and less widespread discipline. This study focuses on indoor volleyball, as it has the greatest impact in Portugal. It is considered a low-contact sport and consequently safer than other team sports such as football, handball and basketball[3–5], even at the highest levels of play[6]. However, it involves frequent jumps, falls, overhead upper limb actions and rapid and explosive movements, leading to both traumatic and overuse injuries[1]. As Uluöz suggests in his study on the Turkish Men's Volleyball League[7], the risk of injury in volleyball can be considered remarkable.

Epidemiological research on volleyball injuries varies in methodology, but common patterns emerge, as shown by Young et al.[1]. The level of competition may be one of the primary factors influencing injury rates and patterns. Unlike the National Collegiate Athletic Association (NCAA), which began conducting prospective studies in volleyball earlier[8–11], most research on professional and elite indoor volleyball has been retrospective[1,12–14], posing limitations. Bahr[15] highlights the advantages of season-long prospective data collection.

Before 2010, only two prospective studies had been conducted in Europe[16,17], but the Dutch study was limited to second- and third-division players, excluding the elite level. Additionally, even the retrospective studies on elite volleyball may not accurately represent today's elite players, given the sport's significant evolution and increasing professionalisation.

Recognizing the need for updated data, the FIVB launched its Injury Surveillance System (ISS) in 2010, modelled on IOC protocols, to track injuries in international competitions and guide prevention strategies[6,18]. Using the FIVB-ISS, Bere et al. later conducted the first detailed, multi-year study on world-class volleyball injuries[6].

In Portugal, a few studies on injury epidemiology have been conducted at the highest level of national volleyball. Aido[19], Massada[20], Magalhães[21] and Oliveira[22] were the first to study elite volleyball players, but their main limitation lies in the small sample sizes, which may not adequately represent the broader population of elite athletes in Portugal. As a result, Portugal is not an exception among countries with limited information on this field.

Existing studies in elite volleyball express injury incidence using various metrics, such as per player, per training hours, or per player hours. Data on injury incidence can be found in the Appendix on page 21.

Better understanding of Volleyball Injuries

Injury Environment: Game and Training Characteristics, Specific Actions and Players Functions

Volleyball has evolved significantly over the years. Played between two teams of six, the game is won by securing three out of five sets. Each set is played to 25 points, except for a fifth set, which is played to 15. Match duration varies based on the number of sets and points contested. The court is divided by a net, set at 2.24m for women and 2.43m for men.

Players perform various sport-specific skills, including serving, attacking, setting, blocking, defending, and passing. Serving and attacking are offensive, while blocking, defending, and passing are defensive, with setting acting as an intermediate role. These actions require additional non-volleyball-specific movements like jumping, landing, falling, and quick direction changes, all contributing to injury risk. Each position has a specific risk for certain injuries, as will be discussed.

Each team usually has 12 to 14 players assigned to five positions: setters, liberos, outside hitters, middle blockers, and opposites. Setters orchestrate offensive plays, while liberos lead the defensive strategy. Middle blockers focus on blocking the opponent's attacks, starting at the centre of the net and reaching the entire length of it. Opposites, positioned on the right side, primarily attack. Outside hitters perform both offensive and defensive tasks, although their main role is also to score points through attacking.

Jumping and landing, particularly in serving, attacking and blocking, generate high-impact forces, especially on the lower limbs and spine. Rapid direction changes following landings are also risky motions associated with many injuries. Repetitive overhead motions, especially those that generate significant force such as attacking and serving, elevate the likelihood of shoulder overuse injuries[1].

Blocking introduces player contact, either through hand/finger collisions at the net, or foot contact across the centreline, a frequent cause of ankle injuries. Approximately half of volleyball-related ankle sprains[§] result from blockers landing on attackers' feet, and one quarter from teammates landing on each other during multi-person blocking[16,25]. Traumas on hands and fingers are more frequently caused by collision of the ball and not by contact with another player.

Setting and defensive actions involve sudden direction changes, diving (with ground impacts), and frequent collisions with teammates or structures, challenging the perception of volleyball as a non-contact sport.

In light of the aforementioned, each volleyball-specific poses a risk of injury.

[§] The term *ankle sprain* is sometimes used broadly to describe all ligament injuries of the ankle; however, these are classified into three grades based on severity. Technically, *sprain* should refer only to grade 1 (mild) injuries, involving minor fibre rupture without laxity and typically a favourable prognosis. Grade 2 (moderate) injuries involve partial disruption of ligament fibres, with detectable laxity and a variable prognosis depending on the ligament affected. Grade 3 (severe) injuries are characterised by gross laxity and instability due to complete fibre rupture; these also have a ligament-specific prognosis and often require stabilisation[23,24].

Action- and Position-Related Injury Risk

Evidence consistently shows that blocking and spiking are the volleyball skills most associated with injuries, with following at a distance. Serving, passing, and setting have the lowest injury rates[26]. Considering this, players have an increased risk for injury when they are at the front-row positions. Therefore, middle blockers, opposites, and outside hitters face a higher risk, as they execute more attacks and blocks[7,25].

Detailed findings regarding action- and position- related risks are provided in the Appendix on pages 21 and 22.

Timing of Injury Occurrence: Match versus Training and Seasonal Phase

Some research suggests that injury incidence is generally higher during competition than training, primarily due to increased risk-taking behaviours during matches[25]. However, the literature is not consistent, as several studies report a higher frequency during training. Detailed findings are provided in the Appendix on page 22.

Regarding the timing within the season, although some studies[27,28] suggest that injuries peak during the in-season period, data on specific phases (pre-season, regular season, playoffs, off-season) remain limited.

Injury Onset

Injuries occur when a tissue's capacity to withstand stress or deformation is surpassed, either from acute trauma or chronic overuse. Studies on volleyball injuries trends have shown mixed results: research before 2010[26] suggested overuse injuries were more common, while newer studies indicate traumatic injuries are more frequent. However, some authors[29] argue that high-quality data is still lacking and varying definitions affect injury statistics. If an injury is defined as "any complaint from playing volleyball practice" overuse injuries appear more frequent, but if "time lost" definition is used, overuse injuries are underreported, as athletes continue playing despite discomfort.

The definition, characterisation, and distinction between traumatic and overuse injuries, as well as study findings are detailed in the Appendix on page 23.

Risk Factors for Volleyball Injuries

Risk factors for musculoskeletal injuries in volleyball, as evidenced in the literature [1,14,29–33], can be intrinsic or extrinsic[34]. Intrinsic factors include sex, age, BMI, strength and conditioning, biomechanical and anatomical factors, techniques and movement patterns and previous injury history. Extrinsic factors involve activity type (matches vs. training), player position, competition level, exposure time (volume of hours training and competing), recovery (nutrition, sleep, etc), playing surface and equipment.

Some factors, like sex and biomechanics, may pose specific risks for certain injuries (e.g.: women may be more prone to ACL injuries due to knee *recurvatum*[35]; and shoulder injuries may be influenced by glenohumeral internal rotation deficits and scapular dyskinesis[36]). These factors often interact (e.g. sex may influence biomechanical characteristics, as structural and biological differences between men and women exist[33]) and can indirectly contribute to injury occurrence.

Modifiable factors, such as exposure time, may be the primary targets for injury prevention[31].

Common Volleyball Injuries: Location and Injury Types

Repetitive jumping and landing can cause lower limb overuse injuries, influenced by technique and playing surface. One-footed landings produce greater ground reaction forces and muscle activity than two-footed ones. Common injuries include patellar and quadriceps tendinopathy, patellofemoral pain syndrome, knee sprains, ACL or other knee ligament, meniscal tears, stress fractures, ankle sprains and ligament tears, sometimes with associated fractures[1].

In turn, the repetitive overhead motion involved in attacking and serving predisposes volleyball players, especially attackers, to shoulder overuse injuries, such as rotator cuff tendinopathy or tears, biceps tendonitis or tears, labral tears, instability, impingement, scapular dysfunction, and suprascapular neuropathy. Common upper limb injuries also affect the hand, fingers, and wrist, including sprains, tendonitis, fractures, and dislocations[1].

Volleyball athletes may also sustain head injuries, such as concussions, and spinal injuries, including back muscle strains, intervertebral disc injury, spondylolysis, and potentially spondylolisthesis[1].

In terms of frequence, the lower limb is the most commonly affected region, accounting for 50–60% of all injuries, while upper limb injuries represent 20–30% across all levels and styles of play[1].

Regarding the specific body part affected by injuries, evidence indicates that ankle, knee and shoulder injuries are most common in volleyball[1,29]. At the professional and elite level, the 2015 FIVB-ISS study[6] reported that the ankle accounted for 25.9% of all injuries, followed by the knee (15.2%), fingers (10.7%), and lower back (8.9%). Joint sprains represented 32.5% of injuries, mainly affecting the ankle, fingers, and knee. Muscle strains accounted for 14.1%, primarily in the lower back and thigh, while contusions were also frequent (12.7%). Ankle sprains were the most common diagnosis, comprising 19.8% of all injuries.

A Spanish study[27] found that sprains, tendinopathies, and strains were the most common injuries, while Magalhães' study[21] identified tendinopathies, myalgia, and sprains as the most prevalent.

OBJECTIVE

The primary aim of this study is to analyse sports injuries in elite volleyball in Portugal over the past five sporting seasons, from 2020/21 to 2024/25. Accordingly, the study assessed the following:

- injury risk;
- injury characteristics (including timing, onset, location, types);
- specific volleyball injuries;
- severity, impact on performance and recurrence;
- potential risk factors;
- associations between these parameters.

METHOD

Sample

The present study is a retrospective observational study based on a questionnaire administered to all senior-level athletes enrolled in the 2024/2025 season of the Men's and Women's Portuguese First Division Volleyball Leagues, regardless of age. Teams and athletes from other senior divisions were excluded. However, it is worth noting that some eligible athletes may also participate in junior-level competitions.

Both the Women's and Men's First Division Leagues comprise 12 teams each. With an average of approximately 14 athletes per team, the total population includes 341 registered athletes[37,38]. In the end, 171 athletes completed the questionnaire, resulting in a response rate of 50.1%.

Instrument

The questionnaire was developed specifically for this research, drawing on existing related studies[6,13,15–18,21,24,30,39–41]. Due to time constraints and logistical considerations, a retrospective design was chosen over the recommended prospective approach for sports injury epidemiology studies [15].

To study injury frequency, it was first essential to define what constitutes an injury and how injuries could be characterised. These decisions were based on previous definitions[15,42], which are explained in greater detail in the Appendix (page 24).

This study excluded injuries classified as "any physical complaint". Instead, it focused on the most impactful injuries, using the criteria of either "medical attention" or "time loss". An injury was included if it: (1) required medical intervention or treatment, or (2) resulted in at least one week of absence from training or competition, even without medical attention.

Injury severity was categorised according to the duration of time lost before returning to play, following the approach used in previous studies[17]. Injuries were classified into the following severity classes: minor (up to 2 weeks), moderate (2 weeks to 1 month), major (1 to 3 months), severe (more than 3 months), and season-ending (no return to competition during the season). For season-ending injuries, absence duration was recorded until the athlete fully resumed volleyball-specific training.

While prospective designs are ideal for analysing risk factors, this study aimed to explore their prevalence among injured athletes. The questionnaire gathered basic epidemiological data from all participants, including sex, age, height, weight, professional status, and weekly training volume, which were considered potential risk factors.

Exposure data were collected for all participants by recording the number of training sessions during the current season. For injured athletes, additional exposure information was collected, including weekly hours of ball training and physical conditioning, as well as competition exposure during the season of injury. Competition exposure was recorded as the number of matches per week, rather than total hours, due to the variable duration of volleyball matches.

Injury classification was based on location (body part), injury type and onset, based on the FIVB *Volleyball Injury Report Form M-10* 2024 version[41] and *Translations between (to and from) SMDCS 2 and OSIICS 13*[43], resulting in a modified categorisation.

To identify the type and location of each injury, athletes answered an open-ended question. Injuries were further classified as traumatic or overuse using a set of questions adapted from Bahr's *Survey of pain problems*[15], aiming to better capture overuse injuries, which are often underreported. Injured athletes also provided contextual details including activity type (match, training, etc.), playing position, and exposure variables (e.g., training hours, matches per week).

The injury onset categorisation was revised to include non-assessed variables and variables evaluated separately in other questions. Injuries were classified as *acute/traumatic*, *overuse injury exacerbation*, or *subacute overuse (sudden onset).* Subacute overuse injuries were distinguished by their abrupt onset, which may conflate them with traumatic injuries (e.g., stress fractures).

Procedures

Initial contact was made by phone with a team representative — preferably the team director — to explain the study objectives and request the team's participation. Once authorisation was granted, a link to the online questionnaire was sent to the team representative, who then distributed it to the athletes.

To promote response, teams were advised to encourage athletes to use team meetings to fill in the questionnaire. It included a briefing information note and an informed consent. The questionnaire was available online in Portuguese and English (see Appendix, pages 46 and 50). It remained open for five weeks, between 11th November and 18th December 2024. All responses were anonymised and automatically recorded.

Variables treatment and data analysis

This section outlines the transformation of certain study variables and explains some decisions made during data processing. Variables treatment and statistical analysis were performed using Excel and the Statistical Package for the Social Sciences (SPSS, version 29.2)[44].

For cross-tabulation, Body Part categories were consolidated into nine groups. Additionally, some of these categories, along with categories from Injury Type, were combined to better assess specific volleyball-related injury risks.

Participants were also divided into two age groups: < 19 years and ≥ 19 years. This partition was based on the consideration that athletes currently under 19 were under 15 during the first season (2020/21). As a result, they potentially differ in exposure and injury risk, as they may not have participated in Senior Division Leagues throughout all the seasons of the assessment period. This categorisation helped compare injury risk and exposure time between the two groups.

Considering that many student-athletes or athletes with other jobs may attend all their team's training sessions, athletes were categorised not only based on their athlete context but also on their training attendance. Athletes from categories other than *Professional* who attended all training sessions were classified as *Professional-Like*. Any athlete who did not participate in all training sessions with their team was categorised as *Non-Professional*. *Professional* athletes who attended all sessions (as expected) retained their classification.

Descriptive analyses were conducted using percentages for categorical variables and minimum, maximum, mean, and standard deviation for quantitative variables. Bivariate analyses were also performed to explore associations between variables. Specifically, Spearman's rho correlation was used for ordinal variables, and Pearson's correlation was applied for quantitative variables. Chi-square tests were employed to examine relationships between categorical variables. For comparisons involving a quantitative dependent variable, independent samples t-test was used when comparing two groups, and one-way analysis of variance (ANOVA) (F-test) was applied when comparing more than two groups. A significance level of 5% ($p < 0.05$) was adopted for all statistical tests.

RESULTS

Participants

Biological Characteristics

The biological characteristics are presented in Table I. The 171 participants ranged in age from 15 to 40 years, with an average of 24.6 years (*DP* = 5.5 years), and the majority were female athletes (n = 101, 59.1%). Body Mass Index (BMI) was calculated, and athletes were divided based in World Health Organization (WHO) classification, with additional subcategories (Table II). No participants were underweight or obese. However, 16.4% of volleyball athletes had a BMI between 25.0 and 27.5, which is considered overweight. The majority (83.6%) had normal weight[45].

Current Athletes' Context and Training Frequency

Among all athletes, 45.0% were professional players, meaning they exclusively dedicate to volleyball. The remaining 55.0% reported having additional functions apart from volleyball, with student-athletes comprising 33.3% and those engaged in other professions accounting for 21.1% (Table III).

Table IV presents the results for athletes who have attended all training sessions with their respective teams during the current season. A large majority of athletes (90.0%) attended every training session. While half of these belong to the Professional group (Table III), the remaining 45.0% consists of athletes who, despite having additional occupations outside volleyball, maintain a *Professional-Like* level of attendance. Only 17 athletes reported not attending all training sessions (*Non-Professional*).

Most athletes (70.2%) attended between 6 and 10 training sessions per week during the current season, and 24.0% trained 4 to 5 times per week. Only 9 athletes reported more than 10 training sessions per week (Table V).

Injury Risk

More than half of the athletes reported at least one injury (n = 114 out of 171, Table VI), indicating an injury occurrence of 66.7%. About one third (33.9%) experienced a single injury, while 23.4% sustained two injuries during the period under study. A total of 193 injuries were recorded, averaging 1.13 injuries per athlete. Considering the questionnaire covered an estimated period of 4.5 seasons, this corresponded to an average injury incidence of 42.9 injuries per season.

Injuries

Injury characteristics

Although a total of 193 injuries were reported, participants completed the second part of the questionnaire (injury characterisation) for only 174 of them. Additionally, injuries sustained during the beach volleyball season (n = 3) were excluded, thus, the following information refers exclusively to the assessed injuries (n = 171, Table VII and subsequent tables).

Injury Timing

Injury incidence was higher during the 2023/24 season and lower in the current season, which was only assessed up to its midpoint (Table VII). Regarding the timing within the sporting calendar (Table VIII), most injuries occurred during the regular season (62.0%), followed by the pre-season. Off-season injuries were primarily linked to National Team training or competition, while the remaining three injuries occurred during off-season training not aimed at competitive preparation.

When asked about the activity they were performing at the time of injury (Table IX), 26.3% reported injuries during a game, and 43.3% during ball training. The lowest injury rates occurred during gym or physical conditioning sessions and warm-ups for ball related activities. Missing responses accounted for 26.3%. Of the 45 injuries that occurred during a match, 27 (60.0%) took place in the second or third set (1 missing response, 13 in the first set and 4 in the fourth or fifth set).

Injury Onset, Location and Types

Regarding the onset of the injuries, 72.5% (n = 124) were classified as acute/traumatic, 19.9% (n = 34) as exacerbations of overuse injuries, and 13 were classified as overuse injuries with a sudden onset, also referred to as subacute overuse.

When analysing the major regions of the body, the lower limb was by far the most affected, accounting for 66.1% of all injuries. The upper limb and trunk each accounted for 14.0%, while the least affected region was the head, face, and neck (Table X). In terms of specific body parts (Table XI), the ankle (27.5%) and knee (24.5%) were the most commonly injured, followed by the hip, groin, and thigh (n = 12), abdomen, lumbosacral region and hand and fingers (n = 11 each).

Regarding injury types (injured tissues and their respective damage), ligament injuries were the most common (n = 64; 37.4%, Table XII), followed by muscle strains (n = 28, 16.4%), lesions of the meniscus, labrum, or cartilage (n = 19, 11.1%), tendinopathy (n = 16), and traumatic fractures (n = 12).

Injury Associations with Actions and Playing Positions

Regarding specific volleyball actions (Table XIII), the action most frequently associated with injury was jumping for a block or attack (25.7%), followed by defence and reception (15.2%) and landing from a block or attack (14.6%). From all injuries, the most injured players (Table XIV), performed functions exclusively as outside hitters (29.2%) and middle blockers (26.3%), followed by opposite hitters (18.7%). Setters and liberos were the least frequently injured. Some athletes (n = 9), as detailed in Table XV, played for more than one position during the season in which the injury occurred.

Severity / Absence Time

Among the reported injuries, 74.9% prevented athletes from participating in at least one official game (Table XVI). Major and severe injuries accounted for 25.1% (n = 43), while season-ending injuries comprised 11.7% (n = 20). The mean absence time for season-ending injuries was 8.6 months, ranging from 3.5 to 24 months.

Treatment, Pre-Return Management, and Recurrence

Of the 171 reported injuries, 16.4% (n = 28) required surgical intervention, regardless of whether conservative methods were also used. Most injuries (82.5%) were managed exclusively with conservative treatment, while two cases were addressed with rest alone. More than half of the injuries were treated solely with non-pharmacological methods. A combination of non-pharmacological and pharmacological treatments was used in 21.6% of cases, and pharmacological treatment alone was employed in 14 cases.

Prior to returning to competition, 33.9% (n = 58) of all injured athletes participated exclusively in conditioned gym training, while 29.2% (n = 50) combined it with conditioned ball training (Table XVII). Thirteen players did not take part in any form of training during their recovery.

The recurrence rate was 27.5% (47 out of 171 injuries).

Exposure and Other Variables in Injured Players

Weekly exposure to ball training and gym (physical conditioning) training is summarised in Table XVIII and Table XIX, respectively. Most players engaged in ten or more hours of ball training per week, with nearly 40% training between 10 and 13 hours, and a similar proportion training over 13 hours. Regarding physical conditioning, most players spent three or more hours per week in the gym during the season in which their injury occurred.

Most injured players (77.8%) participated in either one match (31.6%) or, occasionally, two matches (46.2%) per week during the season they were injured. Additionally, 20.5% played two matches regularly, while only three injured athletes reported occasionally playing three matches per week. Of the total injuries, some of which occurred in the same athlete but across different seasons, 67.8% affected players who participated in at least 80% of the match time, during that season (Table XX).

Regarding supervision during gym training (physical and strength conditioning) in the season of the injury, 76.0% of athletes completed more than half of their sessions under the supervision of a physical trainer (72.5% with the team's physical trainer and 6 cases with an external trainer). The remaining were supervised in half or fewer of their gym sessions (n = 33; 19.3%).

When comparing weight at the time of injury to the current weight, 74.9% of athletes (n = 128) reported no change. A small number of athletes (n = 7) weighed more at the time of injury, with one case showing a difference of +16 kg, and the others no more than +4 kg. Conversely, 19.9% of athletes (n = 34) weighed less at the time of the injury compared to the time of response, with 20 cases showing a difference of up to -5 kg, 11 cases up to -10 kg, and two cases up to -15 kg.

Concerning sleep duration at the time of the injury, 19.9% indicated sleeping eight or more hours per night, 46.8% mentioned seven to eight hours, 25.1% reported six to seven hours and only 14 athletes stated less than six hours.

Associations with Injury Risk and Number of Injuries

No significant association was found between sex and injury occurrence (p = 0.510). Nor did the average number of injuries among injured female and male athletes differ significantly (M_{Female} = 1.65 and M_{Male} = 1.76, p = 0.256). Neither the association between BMI and injury occurrence (p = 0.116), nor the correlation between BMI and the total number of injuries (r = 0.090, p = 0.170) was significant.

The age difference between injured and non-injured athletes was marginally significant, with injured athletes being slightly older on average than their non-injured counterparts ($M_{Injured}$ = 25.1 and $M_{Non\text{-}injured}$ = 23.6, t (169) = -1.67, p = 0.048). However, no significant correlation was found between age and the total number of injuries (r = 0.050, p = 0.300).

Among the injured athletes, no significant association was found between player position and the total number of injuries (p = 0.237).

Associations with Injury Characteristics

Female athletes were more affected in the hip, groin and thigh; head, neck, and upper trunk; knee; and lumbosacral region (Figure 1). In contrast, male athletes were more likely to sustain injuries to the upper limb. Concerning Figure 2, the relatively flat trends for both BMI and age suggest that neither variable is markedly associated with injury localisation.

No significant association was found between sex and injury onset (p = 0.842). Figure 3 shows that athletes with overuse injuries had a higher mean age than those with traumatic or subacute overuse injuries. However, the association between age and injury onset was not significant (p = 0.159). Similarly, BMI did not vary significantly across injuries with different onsets (p = 0.787).

Figure 4 presents the distribution of player positions across injured body parts. Despite being the least injured players overall, liberos ranked first for injuries in the hip, groin, and thigh (33.3%) and showed a notable incidence of injuries in the hand/fingers, wrist, and forearm (21.4%). Middle blockers stood out for shoulder and elbow injuries (50.0%), as well as knee injuries (33.3%), and were second in abdomen injuries (27.3%). Opposite hitters were most affected in the lumbosacral region (36.4%) and followed middle blockers in shoulder and elbow injuries (30.0% of proximal upper limb injuries). Outside hitters exhibited a more even distribution of injuries, ranking first in the ankle (34.0%) and abdomen (36.4%). Setters shared the same proportion of injuries to the head, neck, and upper trunk as middle blockers and outside hitters, each accounting for one-third of the injuries in those regions. Figure 5 shows a similar distribution of injuries by playing position across the different injury onsets, indicating no significant association (p = 0.925).

Figure 6 displays the distribution of injuries by volleyball activity across injured body parts. Only ball training and competition injuries were included, as other volleyball-related categories had insufficient frequencies. Most injuries occurred during training, except those to the ankle and knee, which were more common in competition. No abdominal, shoulder, or elbow injuries were reported during official matches.

Figure 7 shows that specific volleyball actions were closely associated with injuries to particular body regions. Attacking was strongly linked to injuries in the abdomen (87.5%) and the shoulder–elbow region (50.0%). Blocking was associated with injuries affecting areas such as head and face

hand and fingers, shoulder and elbow. Collisions accounted for 50.0% of injuries to the head-neck-upper trunk, and 42.9% of injuries to the hand, fingers, wrist, and forearm. Defensive actions (defence and reception) were the leading cause of injuries to the hip, groin, and thigh (75.0%). Jumping was associated with injuries to the lower leg (50.0% of those), knee (48.5%), ankle (39.1%) and lumbosacral region (33.3%). Landing accounted for 34.8% of ankle injuries, 18.2% of knee injuries and 16.7% of injuries in the lumbosacral region.

Figure 8 highlights a clear association between jumping and overuse injury exacerbation (57.1%). It was also linked to sudden-onset overuse injuries, as were defensive actions (37.5% each). Traumatic injuries were evenly distributed across different actions. The relationship between volleyball actions and injury onset was marginally significant (χ^2 (139) = 18.04, p = .049).

Associations with Severity

Figure 9 illustrates the recurrence of injuries across different body parts, with shoulder and elbow injuries being the most recurrent (60.0%), followed by the ankle (38.3%), knee (33.3%), and head, neck, and upper trunk (33.3%). The distribution of injured body parts across severity classes is shown in Figure 10. Among injuries classified as moderate, 40.0% were to the ankle joint, followed by injuries to the knee joint (14.3%). For major injuries, ankle ranked first again (37.5%), followed by the knee and the distal upper limb (hand, fingers, wrist and forearm) – 21.9% each. Severe injuries were predominantly localised to the knee (37.5%), followed by shoulder and elbow (25.0%). From the season-ending injuries, knee injuries stood out, accounting for 60% of such cases.

Severity was unrelated to age (p = 0.779) and BMI (p = 0.614). Moreover, although no significant association was found between sex and severity (p = 0.302), Figure 11 shows that a higher proportion of season-ending injuries occurred among female athletes (75.0%).

A significant association was found between severity and treatment type (χ^2 (4) = 55.64, p < 0.001), with athletes experiencing severe or season-ending injuries (absence > 3 months) being more likely to undergo surgical intervention (Figure 12).

Despite the overall higher proportion of injuries occurring during training, Figure 13 indicated that season-ending injuries resulted more frequently from competition. Injuries of lower severity followed the global pattern, predominantly occurring during technical training sessions. Figure 14 illustrates the recurrence rate across severity classes, with minor and moderate injuries exhibiting the highest recurrence.

Specific Injuries

Among the specific injuries evaluated (n = 107), ankle ligament injuries were the most prevalent (Figure 15). In particular, grade 2 and 3 injuries (ligament ruptures) were more frequent (n = 27) than grade 1 injuries (ankle sprains) (n = 17). Other specific injuries showed similar frequencies ranging from 9 to 12 cases. Grade 1 and 2 knee ligament injuries were not represented due to their low occurrence (n = 4), in contrast to grade 3 injuries, with or without meniscus or cartilage involvement, which were more frequent (n = 12).

The association between sex and specific injuries was significant (χ^2 (7) = 14.38, p = 0.040). Ankle sprains (grade 1) were more frequent among male athletes, whereas ankle ligament ruptures

(grade 2 or 3) were more common in female athletes (Figure 16). Knee injuries involving the meniscus or cartilage, either isolated or combined with complete ligament rupture (grade 3 ligament injury) were more commonly associated with female athletes. However, knee tendinopathy (overuse) was more commonly associated to male athletes. Women sustained more groin and thigh strains, whereas men experienced more traumatic fractures of the distal upper limb.

The association with age was also significant (F (7, 99) = 2.71, p = 0.013), reflecting higher mean ages for knee injuries, with the highest mean age observed for isolated lesions of the meniscus or cartilage (Figure 17). The association with BMI was not significant (p = 0.516).

The most prevalent season-ending injury was complete knee ligament rupture (grade 3), with or without meniscus or cartilage involvement (n = 10). The second most severe injury was ankle ligament rupture, with 11 cases leading to one to three months of absence, and another 11 cases requiring only two weeks to one month of rest. Most cases of traumatic fractures in the forearm, wrist, hand, or fingers (n = 5) resulted in one to three months of absence. In contrast, ankle sprains and knee tendinopathy, which also led to absence from competition, typically required only one to two weeks of rest.

The association between specific injuries and recurrence was significant (χ^2 (7) = 24.89, $p < 0.001$) (Table XXI). Most specific injuries did not recur (Table XXII). The exceptions were knee meniscus or cartilage lesions, ankle ligament injuries of grades 2 and 3, and knee tendinopathy. Among these, only knee tendinopathy showed a higher proportion of recurrence.

The association between specific injuries and volleyball moment (match vs. training) was also significant (χ^2 (79) = 23.37, $p < 0.001$). Although most specific injuries occurred during training, ankle injuries and especially complete knee ligament ruptures showed a significantly higher incidence during competition (Figure 18).

Ankle ligament ruptures were most associated with landing from block or attack (15 out of 26), as shown in Figure 19. Knee tendinopathy resulted mostly from jumping (7 out of 8), whereas ligamentous, meniscal or cartilaginous knee injuries were associated either with both jumping and landing. Abdomen strains were more frequently related to attacking (7 out of 8), while groin and thigh strains were predominantly linked to defence or reception (5 out of 6). Collisions were mainly associated with traumatic fractures of the upper limb or ankle sprains (5 cases each, out of 11).

The distribution of specific injuries by player position showed that, except for groin and thigh strains, all assessed specific injuries were more common in outside hitters (Figure 20).

Assessment of Specific Groups: Younger versus Older Athletes

Among all participants, 20 athletes (11.7%) were under 19 years old, of whom 11 reported at least one injury during the five-season assessment period (Table XXIII). The majority of the participants were 19 years or older (n = 151, 88.3%), with 103 (68.2%) reporting at least one injury.

Although a negative correlation was observed between age and the number of reported injuries (r = -0.05), this association was not significant (p = 0.602) (Table XXIV and Table XXV). This result was further supported by the comparison of the total number of injuries between the two groups, which was also not statistically significant (p = 0.936) (Table XXVI).

Regarding exposure, among the injured athletes, the older individuals spent proportionally more hours on technical ball training (r (152) = 0.179, p = 0.014) and gym training (r (153) = 0.244, p = 0.001) during the season of their injuries, as supported by the positive and significant correlations shown in Table XXVII.

DISCUSSION

The Current Landscape of Elite Volleyball in Portugal

This study highlights the increasing professionalisation of volleyball in Portugal. Nearly half of the athletes were full-time professionals, and 90% attended all training sessions. Although many maintained additional occupations, the majority adhered to professional-level training routines, with approximately 70% training between six and ten times per week.

Among injured athletes, most were first-string players. Over 75% trained for at least 13 hours per week, combining technical and gym sessions, excluding official match time. Furthermore, a significant proportion of athletes reached exposure levels of 18 or more hours per week.

As early as 1996, Aagaard and Jørgensen[12] observed that elite volleyball athletes had doubled their number of training sessions over the preceding decade. Nearly 30 years later, the present findings confirm that this trend has continued. Therefore, it would be prudent for future studies to investigate the impact of current exposure times on injury incidence.

Over an estimated 4.5-season assessment period, the **injury risk** was 66.7%, corresponding to a crude estimate of 0.25 injuries per athlete per season. This timeframe accounts for the fact that questionnaire responses were collected approximately midway through the season 2024/25. Although this result is lower than those reported in some previous studies[13,14,17,27], direct comparison may be inappropriate, as the referenced studies do not clarify whether the off-season period was included in their assessments. Comparison with studies on the Portuguese Men's National Team [19,22] is also not possible, as those studies were not conducted during a whole season, covering only 4–5 months. Finally, comparison with other studies in elite-level[29], such as the FIVB-ISS implementation study[6], is not possible due to differing incidence metrics.

Certain intrinsic risk factors – namely sex, age, and BMI – were evaluated to assess their influence not only on injury risk but also on other variables. Comparison of the influence of these factors with existing literature warrants caution, as studies differ in methodology and player population.

While some authors have reported higher injury rates among male athletes, particularly for ankle and knee injuries[29], the present study found no association between **sex** and overall injury risk, incidence, onset, or severity, aligning more closely with the findings of Bere et al.[6]. However, female athletes sustained significantly more season-ending injuries (75%). Additionally, differences in location and specific injuries were also observed between sexes, which may support studies attributing sex-specific injury risk to biomechanical characteristics[33,35]. It is important to note that the results regarding specific injuries are based on absolute frequencies, with female athletes representing a greater proportion of the total sample (59.1%).

Few studies have examined the impact of **BMI** on injury risk, with some suggesting that a higher BMI increases the risk of injury[46]. In this study, although some participants were overweight, it was found not to influence the overall injury risk, total number of injuries, severity, onset, body part or injury type.

Unlike sex and BMI, **age** was associated with injury occurrence, as injured players were slightly older than those who remained uninjured, consistent with the findings of De Azevedo findings[46], but not

with those of Augustsson et al.[13]. However, it was not associated with the number or severity of injuries, nor with injury onset, despite the slightly higher mean age observed for overuse injuries. This may reflect a greater cumulative training load over more years of practice and reduced tissue resilience with age, although this association was not significant. Moreover, older athletes were more frequently affected by knee injuries, particularly those involving the meniscus or cartilage.

Although younger athletes (< 19 years) had proportionally lower exposure to volleyball practice during the seasons in which they sustained injuries, this likely did not influence their injury risk or frequency. However, the small number of younger athletes may limit the interpretation of these findings.

Some authors report a higher incidence of overuse injuries[12,19,21,22], while others report more traumatic injuries[6,20]. These discrepancies can once again be attributed to differences in methodological approaches. The predominance of **acute/traumatic** injuries in this study may be attributed to the injury definition used. As previously noted, injuries were included if they met either the *time loss* or *medical attention* criteria, capturing the most impactful cases. Although *impactful* is a subjective term, it generally refers to injuries that impair performance and require time away from the sport. Despite concerns about recall bias – which will be discussed shortly – the chosen definition likely mitigated this bias, as athletes would better recall injuries with significant impact on their careers.

In terms of **location**, the lower limb was by far the most frequently injured region, primarily due to ankle and knee injuries, which is consistent with previous literature[1,6,29]. Ligament injuries were the most common **type**, accounting for 44 of the 47 recorded ankle injuries, as evidenced by combining data from Table XI and Table XII and Figure 15**.** While 70% of all ligament injuries involved the ankle, 25% affected the knee — mostly complete ruptures with or without meniscal or cartilage damage. Strains were the second most common injury type, particularly in the abdominal region (all 11 cases) and the groin–thigh region (9 out of 12 cases). These findings are broadly in line with earlier studies[6,21,27].

Ankle ligamentous injuries were the most frequent **specific injury**, followed by various knee injuries – including ligamentous, meniscal or cartilaginous, and overuse injuries (tendinopathies) – all occurring in similar proportions. Distal upper limb fractures were also notable, with 9 out of 14 injuries to the forearm, wrist, hand, or fingers being fractures.

In line with previous evidence[6,17,21,39], liberos, followed by setters, were the least frequently injured players. However, in contrast to the studies referenced, outside hitters were the most affected, rather than middle blockers or opposite hitters, who followed. Even when considering injured players who played multiple positions during the season of injury, proportions remained similar. **Playing position** did not show a strong correlation with injury type or onset, although some patterns were observed in relation to injury location. These patterns differed somewhat from those reported in previous studies, which also present inconsistent findings[1,6,21].

Injuries were most commonly associated with jumping, followed by landing and defensive **actions**. Attacking, blocking, and collisions showed lower but comparable levels of injury association, while serving and setting were rarely implicated. However, these results cannot be directly compared with the widely accepted evidence in the literature that blocking is the riskiest action in volleyball[7,12–14,20,27,30], as, in this study, the specific act of blocking was distinguished from the actions of jumping

and landing. In addition, a **limitation** exists in this analysis: only 84.8% of injuries were linked to specific actions due to how the relevant question was phrased; nonetheless, overuse injuries perceived as resulting from a particular action were also included in the analysis.

Certain associations were identified between specific actions and injured body regions, helping to clarify injury patterns that link playing position and anatomical location. The abdomen was associated with attack, while the distal upper extremity (including hand and fingers) with blocking and collisions. Injuries to the thigh, hip, and groin were related to defensive actions. Knee injuries were clearly linked to jumping, though with associations with landing and defensive actions, too. Interestingly, injured athletes associated ankle injuries with jumping and landing in similar proportions, with jumping even showing a higher – though not significant – association. These findings contrast with previous literature[16,25], which consistently and strongly links ankle injuries to landing, particularly during blocking actions. The shoulder-elbow complex was mostly associated with attack and block. For purposes of cross-tabulation, these two joints were grouped together, but it is likely that the shoulder was more affected during attack and the elbow during blocking, due to injury mechanisms and biomechanical factors. Actions also influence the onset of injuries; for instance, jumping was associated with nearly 60% of overuse injuries.

The comparison of injury **severity** across studies is hampered by heterogeneity in injury definitions and the cut-off points used to determine absence duration. In this study, nearly 75% of athletes missed at least one official game, while the remainder missed a minimum of one week of training (based on the injury inclusion criteria). In contrast to the findings of Bere et al.[6], who reported a low incidence of injuries resulting in an absence exceeding one month, approximately 37% of injuries led to time-loss of one month or more, comprising major, severe and season-ending injuries. Most severe and season-ending injuries required surgical intervention. Still, most of injured athletes did conditioned training, mostly physical conditioning, with a significant proportion being able to engage in conditioned volleyball training.

Ankle injuries comprised the majority of moderate and major injuries, while knee injuries predominated in severe injuries (1 to 3 months off competition) and, notably, in season-ending injuries. Following the knee, the shoulder-elbow group accounted for the second highest percentage of severe injuries. However, it is important to note that this category includes only 10 injuries.

The relative frequency of injuries during **training** *versus* **competition** varies across the literature. In this study, injuries were significantly more frequent during training overall, consistent with the findings of Augustsson et.al[13], Oliveira[22], Beneka et al.[17], Haupenthal et al.[39] and Magalhães[21], but contrary to the results reported by Bere et al.[6], Aido et al.[19] and Bahr and Bahr[30]. Despite this overall findings, ankle injuries and complete knee ligament ruptures were more common during competition.

However, ankle and knee injuries, as well as season-ending injuries, were more common during competition. Although this may suggest greater severity during games, ankle injuries ranged in severity (recovery time between 1 week to 3 months), while knee injuries were more often severe injuries (more than three months off) or season-ending. Therefore, the association between competition and season-ending injuries likely reflects the higher risk of knee injuries—injuries that

tend to be inherently more severe—during matches, rather than competition itself being linked to greater severity.

Literature still cannot establish an association between the **timing within the season** and injury occurrence, probably because studies differ in their assessment periods, varying in length and in whether they capture both in-season and off-season phases (e.g. studies may comprise only specific tournaments or one season, multiple seasons but only assessing the in-season period, several years, covering both in-season and off-season periods, etc.). This study found no increased injury risk during the pre-season or playoffs compared to the regular season, during which injuries were more frequent. Similarly, the initial and final **sets** of matches did not appear to increase injury risk.

Shoulder and elbow injuries, as well as knee tendinopathy, were particularly recurrent. **Recurrence** rate was also relevant in other injuries to the ankle, knee and head-neck-upper trunk regions. However, the relatively low incidence of injuries in the shoulder, elbow, head, neck and upper trunk warrants consideration.

In the course of the investigation, the question emerged: 'Is recurrence a marker of severity?'. The findings provided some insight, as recurrent injuries were predominantly minor to moderate in nature, suggesting that recurrence is not a reliable indicator of increased severity, being likely multifactorial. There is solid evidence[16,20,31,46,47] suggesting that a prior history of injury constitutes a risk factor for subsequent ankle sprains. Further research is needed to determine whether the same applies to other types of injury.

Limitations of the study

Injury incidence calculation

Athletes' circumstances often change over their careers (e.g., transitioning from student-athlete to professional or switching teams). Consequently, individual exposure — particularly training load — likely varied across the five-season period, making it difficult to precisely quantify total exposure hours. Therefore, injury incidence could not be expressed as injuries per unit of person-time, as time-at-risk data were not collected for uninjured athletes; this would have required gathering participants' total exposure time for each of the five seasons. Instead, we reported injury risk, defined as the proportion of athletes sustaining at least one injury during the evaluation period, and "clinical incidences," expressed as the number of new injury occurrences per athlete and per season[48].

The inability to calculate incidence rates per person-time, prevented direct comparison with other volleyball injury studies, constituting the main limitation of this study.

Recall Bias

This study presents a significant risk for recall bias, mainly due to the retrospective design, questionnaire-based data collection, and the extended assessment period (starting in 2020).

Sample and Selection Bias

With a participation rate of only 50.1%, the sample may not fully represent the elite volleyball population in Portugal. A higher response rate would have been desirable and might have been

achieved, for example, if the questionnaire had been administered in person, in physical (paper) format.

Limitations Related to Injury Definition

A major challenge in sports injury research is the lack of a standardised injury definition and reporting methods, leading to inconsistent reporting and making direct comparisons difficult[1,15,26]. Although the predominance of traumatic injuries is understandable, as previously explained, it highlights a limitation: overuse injuries, though often more prevalent, were likely underreported. Athletes frequently continue training or competing despite symptoms and do not always seek medical care. Consequently, this study likely underestimates the true burden of overuse injuries, reinforcing the need for further research following examples such as Bahr[15] or Haupenthal et al[39].

Limitations of the Original Questionnaire Design

Using an original, non-validated questionnaire introduced potential limitations, including confounding factors and the limited reliability of some questions. Some confounding variables may relate to the retrospective nature of the study and to unexamined risk factors, such as environmental aspects (e.g. playing surface, equipment, or training methods).

Moreover, the set of questions designed to identify injury onset required refinement. Many athletes linked their injuries to a single event, but their answers often did not align. This likely reflects how overuse injuries are commonly misattributed to a specific incident, not only in the present work, but frequently in other studies. Consequently, the classification of injuries as traumatic, overuse exacerbation, or overuse with sudden onset was ultimately based on the physiopathology of the reported injuries.

Although extrinsic factors such as exposure, player level and position, specific actions, and timing (training vs. competition) were assessed, they could not be considered risk factors since data were collected only from injured athletes. The same applies to changes in body weight, sleep duration, and gym supervision at the time of injury. These variables were thus reported descriptively, limiting their use in risk analysis and comparison with other studies.

The study initially aimed to assess the influence of athletes' context and exposure on injury risk and number. However, statistical associations were not deemed appropriate, as the questions addressing these variables were limited to the athletes' context and weekly training frequency during the 2024/25 season, rather than encompassing the entire assessment period.

Finally, player position was linked to injury patterns, but the varying number of players per position due to tactical reasons (e.g., teams typically have more spikers than setters and liberos, who, in the end, appear to be the least injured positions) limits comparisons. Ideally, injury rates by position would have been adjusted for the number of players in each position.

CONCLUSIONS

Injury risk among elite volleyball athletes in Portugal appears to be lower, but comparison with other international studies is hindered by methodological differences. Traumatic injuries predominated, likely due to the injury definition used. Despite volleyball's non-contact nature, the literature indicates a high proportion of both acute and overuse injuries. Hence, prospective studies with bigger samples and standardised methods are needed to allow reliable comparisons, avoid underreporting of certain injuries and to assess the effect of current training and competition loads in the context of the growing professionalisation of the sport in Portugal.

Ankle ligamentous injuries were the most frequent injury, followed by knee injuries, including ligamentous, meniscal or cartilaginous, and tendinopathies – all occurring in similar proportions. Muscle strains – especially in the abdominal and groin/thigh regions – and traumatic hand, wrist, and finger fractures were also frequent. Outside hitters and middle blockers were at higher risk, with most injuries associated with jumping, followed by landing and defensive actions.

Volleyball-specific actions were associated with specific injuries, locations and types. Playing positions had greater influence on the location of overall injuries. The type of activity may also affect both the type and site of injury, as ankle and knee injuries – specifically complete knee ligament ruptures – were the only injuries observed more frequently during competition.

Among biological characteristics, sex and to a lesser extent age, appeared to influence the distribution of specific injuries. Age was the primary factor influencing overall injury risk, and particularly for knee injuries. In turn, sex had more influence in injury characteristics such as location, possibly due to differences in biomechanical profiles.

A considerable number of athletes were absent for over a month, highlighting that despite its relatively low overall injury risk, volleyball can lead to severe, potentially season-ending injuries. The knee was the most frequent site of severe and season-ending injuries, while ankle injuries were mainly moderate to major. In both these locations, ligament ruptures were the most severe.

Overall injury recurrence was significant, particularly in shoulder and elbow injuries and knee tendinopathy. Future research should explore the causes of recurrence and focus on prevention strategies. While prevention was not the primary focus of this study, the data presented contribute a foundational step toward evidence-based prevention planning.

APPENDIX

1. Existent data on injury incidence

A pioneering epidemiological study in volleyball was conducted in the first division of the Scottish National League during the 1989-1990 season[14]. It reported 46 injuries, and an incidence of 0.53 injuries per player.

Another prior study conducted in elite male and female divisions in Denmark during the 1993/94 sports season[12] reported an overall incidence of 3.8 injuries per player per 1,000 volleyball hours played — a 20% increase compared to a decade earlier. The authors attributed this rise to a greater incidence of overuse injuries, which they linked to an increase in training hours.

Another study conducted in the top male and female divisions in Norway during the preceding sports season (1992/93)[30], analysed only acute injuries and reported a total acute injury incidence of 1.7 per 1,000 hours of play. Subsequently, a 2006 study of elite Swedish volleyball players[13] found that 52% were injured, with a total of 121 injuries, resulting in an injury incidence of 0.77 per player.

The four-year FIVB-ISS study (2010-2014)[6] of 32 major FIVB events recorded 440 injuries, 275 in matches and 165 in training, with a match injury incidence of 10.7 per 1,000 player hours.

In the Turkish male main league study (2011-2016)[7], injuries were classified as *temporary* (allowing continued play with minor treatment) or *serious* (resulting in match absence). Temporary injuries were more common (68.72% vs 31.38%), with incidences of 0.19 per player and 0.47 per 1,000 hours, compared to 0.12 and 0.21 for serious injuries.

More recently, a 2019 study on elite Spanish volleyball[27] reported a 66.9% injury prevalence and 0.94 injuries per player. A Brazilian study[39] (2018–2021, 2020 was discarded) assessed *injuries* (requiring at least one day of absence) and *complaints* (medical attention without time loss) in 41 national team players. The study recorded 28 injuries among 12 players and 402 complaints among 38 players.

In Portugal, as previously mentioned, studies remain limited. In 2006, a five month study the Men's National Team[22], recorded 16 injuries among 13 players (1.23 per player). Later, Aido[19] reported 55 injuries in 18 of 20 Portuguese international players over four months (11 injuries per athlete per 1000 hours of sports activity). In Women's National Team in 2008/09 season[20], 100 injuries were reported (2.6 per 1,000 hours). The latest study, conducted over two seasons (2014–2016) on a Portuguese First Division women's team[21], found an incidence of 11 injuries per 1,000 athlete-hours of exposure.

Finally, a 2017 systematic review of 28 studies[29] reported volleyball injury rates ranging from 1.7 to 10.7 per 1,000 player hours, highlighting the variability in incidence across different levels of play.

2. Evidence-Based Risks of Specific Actions

In the FIVB's first study using the ISS[6], contact injuries (mainly ankle sprains) accounted for a significant proportion of cases. This aligns with previous studies[12–14,20,27], which repot that since blocking and attacking are typically confined to a small area at the net, these actions increase the

risk of contact trauma injuries, mainly because players may step on each other´s feet or contact above the net.

From the 1997 Norwegian study[30], blocking (in particular the landing) was the principal action associated with ankle injuries, while most other injuries were associated with take-off, landing or the actual spiking motion during attack.

In Men's Turkish League study[7], blocking was by far the technical action more associated with injury (63.9%), followed by spiking (14.5%).

3. Evidence-Based Risks by Player Position

The FIVB-ISS study[6] found middle blockers had the highest overall injury incidence, while liberos had the lowest. Liberos sustained more finger injuries and notably fewer ankle sprains, whereas outside hitters had the highest rate of shoulder injuries. Knee injuries were comparable across all positions, except for setters, who had a lower incidence. Lower back injuries affected all positions similarly, with slightly lower rates observed in liberos and outside hitters.

Similar patterns were observed in Greek elite volleyball[17], in Magalhães' study[21], and in the Brazilian national team[39]. Among Portuguese female players[21], middle blockers accounted for 32.1% of injuries, followed by outside hitters with 22.6%. Opposites had the highest shoulder injury rate, while setters sustained the most ankle sprains. Among Brazilian players[39], middle blockers accounted for 50% of all injuries, outside hitters for 25%, opposites for 14%, and setters for 11%, with no injuries reported among liberos. Overuse complaints followed a similar trend, distributed as follows: 32% for middle blockers, 30% for outside hitters, 17% for opposites, and 8% for liberos.

In contrast, findings from Portuguese male international athletes[19] showed opposites, rather than middle blockers, as the most affected position.

4. Injury Risk in Competitive Contexts: Match versus Training

During the major FIVB events, injury incidence was significantly higher during matches than in training (62.5% vs. 37.5%), with a similar distribution of injury locations. For match injuries, the incidence did not appear to differ between sets[6]. In the Portuguese Men's National Team (2011), injury incidence was 10.11 per 1000 hours during matches and 5.56 during training[19]. In Norwegian elite volleyball (1997)[30], match injury rates were also higher than in training (3.5 vs. 1.5 per 1,000 hours), especially among men.

However, some studies report the opposite. In the 2006 Portuguese men´s national team[22], 14 out of 16 injuries occurred during training. In Swedish elite volleyball[13], only 7% of injuries occurred in matches, while 47% happened during training and 41% developed gradually. Similarly, Greek elite volleyball[17] showed a higher incidence in training compared to matches (69.4% vs. 30.6%).

More recently, in Brazilian men's national team[39], 75% of injuries occurred during training and 25% during competition, although in one season the incidence was higher in competition (7/1,000h) than in training (2/1,000h). Magalhães[21] found no injuries in Portuguese female elite athletes during matches, with 70% occurring in training and the remainder from non-volleyball activities.

5. Injury Onset: Traumatic versus Overuse

Traumatic injuries occur suddenly due to a clearly defined event, such as a fall (direct trauma), or leg twisting during an improper landing (indirect trauma). The force involved causes immediate and irreversible tissue damage. These injuries are more common in sports that involve high forces on joints and tissues (e.g. surface impacts), rapid direction changes, or a higher risk of collisions[24]. Ligament injuries are the most frequent, particularly in the ankle, knee, and hand, although muscle strains are also prevalent[26].

Overuse injuries develop gradually from repetitive stress, overloading, and/or insufficient recovery. While each individual movement may not cause harm, repeated strain over time leads to tissue breakdown and injury. These injuries are common in endurance sports or technical sports that involve repeated actions[24]. In volleyball, common overuse injuries include patellar tendinitis, rotator cuff and biceps tendinitis, suprascapular neuropathy, and low back injuries[26].

Overuse injuries may go unnoticed until symptoms become severe, and athletes might either experience progressive symptoms or mistakenly associate 'new' symptoms with a single event, which is not the cause but rather the precipitating factor of the injury. For example, a stress fracture may develop over time but only become noticeable after a specific movement. This misunderstanding of the injury´s onset and mechanism can interfere with the establishment of an effective treatment[15,24]. Additionally, overuse injuries can weaken tissues and joints, increasing the risk of acute injuries, with both potentially occurring simultaneously.

6. Comparative Findings on Traumatic and Overuse Injury Rates

Studies on the Brazilian national team[39] and the Turkish league[7] categorised injuries differently, likely leading to a higher assessment of overuse injuries, named *complaints* in the Brazilian study and *temporary injuries* in the Turkish study. However, despite using this categorisation, researchers ultimately did not classify the injuries as overuse or traumatic.

The studies on Portuguese male international athletes[19,22] assessed new and previous injuries, reporting more overuse (n=21) than traumatic injuries (n=8), mainly affecting the knee in attackers. However, the authors found no correlation between the type of injury (overuse vs. traumatic) and the player's position. In contrast, in the Portuguese female international athletes in the same year[20], traumatic injuries were significantly more common (2.0/1000h vs. 0.6/1000h for overuse).

In FIVB tournaments[6], 20.7% of injuries were overuse-related and 79.3% were traumatic, with 17.3% caused by noncontact trauma (e.g., ball impact causing finger injuries), and 23,0% from player collisions (mostly ankle injuries). Overuse and noncontact trauma were the primary causes of knee injuries. The authors acknowledged that the incidence of overuse injuries was likely underestimated.

In the Portuguese women's first division team[21], 57.7% of injuries were overuse-related (27.7% with a gradual onset, and 16.1% had an acute onset), affecting mostly middle blockers and opposites. Traumatic injuries were more common among outside hitters and middle blockers.

In the previous study on Danish male and female elite volleyball[12], overuse injuries were more common in training (55%), while traumatic injuries occurred more in competition (74%). The rate of overuse injuries was the same between sexes, even though males had more hours of training.

90% of shoulder injuries and 88% of knee injuries were overuse-related, while 97% of finger injuries and 86% of ankle injuries were acute. Over 10 years (1983–1994), the injury rate increased due to a rise in overuse injuries (from 16% to 47%).

The 2017 systematic review[29] found that volleyball players experience both acute and overuse injuries. Among acute injuries, the knee was the most affected site (33%), followed by the ankle and shoulder (17% each). For overuse injuries, the knee accounted for 24% and the shoulder 12%, with no reports of ankle overuse injuries.

7. Injury Definition and Characterisation

Epidemiological sports injury studies must first define *injury* and understand injury patterns. A key step toward standardisation of injury definition was the consensus statement established at the *1st World Congress on Sports Injury Prevention* (Oslo, 2005)[42], which defined an injury as "any physical complaint sustained by a player that results from match or training, irrespective of the need for medical attention or time loss". Injuries were then classified into "medical attention injuries" (those requiring medical care) or "time loss injuries" (those causing absence from matches or training)[15].

The *FIVB Injury Surveillance Program*[18] follows the "medical attention" injury definition, including only new injuries that require treatment during specific tournaments, and excluding pre-existing or rehabilitated injuries, illnesses, or diseases.

Beyond definitions, injuries should be categorised based on severity, cause, onset, body location, injury type (affected tissue and damage type), and player-related risk factors or recovery aspects, as understanding injury patterns and physiopathology is essential for accurate classification.

Across studies, injury severity is generally measured by time lost from training or competition and may vary depending on the time intervals used. Definitions of injury also influence severity classification, affecting the number of injuries included in a study.

8. TABLES

Table I – Biological Characteristics of the Participants

N = 171	**Mean (*SD*)**	**Median**	**Minimum - Maximum**
Age (years)	24.6 (5.5)	24	15 – 40
Height (m)	182.2 (9.8)	182	153 – 205
Weight (Kg)	76.0 (11.9)	75	46 – 107
BMI (Kg/m^2)	22.8 (2.0)	22.6	18.6 – 27.2

Table II – BMI intervals

BMI interval	**N**	**%**
> 18.5	0	0.0
18.5 - 20.0	13	7.6
20.0 - 22.5	67	39.2
22.5 - 25.0	63	36.8
25.0 - 27.5	28	16.4
27.5 - 30.0	0	0.0
≥ 30.0	0	0.0
Total	171	100.0

Table III – Athlete Context

Athlete Context	**N**	**%**
Professional	77	45.0
I have another job	36	21.1
Student-Athlete	57	33.3
I practice another sport simultaneously	1	0.6
Total	171	100.0

Table IV – Training Attendance Context

Training Attendance Context	**N**	**%**
Non-Professional	17	9.9
Professional	77	45.0
Professional-Like	77	45.0
Total	171	100.0

Table V – Number of Training Sessions per Week

Number of Training Sessions per Week	N	%
1 - 3	1	0.6
4 - 5	41	24.0
6 - 10	120	70.2
More than 10	9	5.3
Total	171	100.0

Table VI – Total Number of Injuries

Number of Injuries	N	%
1	58	33.9
2	40	23.4
3	10	5.8
4	5	2.9
More than 4	1	0.6
Total	114	66.7

Table VII – Injury Occurrence Across Seasons

Season	N	%
20/21	31	18.1
21/22	37	21.6
22/23	36	21.1
23/24	46	26.9
24/25	21	12.3
Total	171	100.0

Table VIII – Injury Timing Throughout the Season

Time In the Season	N	%
Pre-season	35	20.5
Regular season	106	62.0
Playoffs	17	9.9
National Team during the off-season period	10	5.8
Off season training without competition	3	1.8
Total	171	100.0

Table IX – Activity Performed at the Time of Injury

Activity Performed at the Time of Injury	N	%
Missing	45	26.3
During a game.	45	26.3
During ball training.	74	43.3
During a physical conditioning/gym/stretching session.	4	2.3
During a warm-up for training or a game without a ball.	3	1.8
Total	171	100.0

Table X – Distribution of Injuries by Major Body Regions

Body Region	N	%
Head, Face and Neck	4	2.3
Upper Limb	24	14.0
Lower Limb	113	66.1
Trunk	24	14.0
Not defined	6	3.5
Total	171	100.0

Table XI – Distribution of Injuries by Specific Body Parts (original categories)

Body Part	N	%
Head & Face (incl. eye, ear, nose)	3	1.8
Neck & Cervical spine	1	0.6
Upper Trunk (chest, thoracic spine, upper back)	2	1.2
Lumbosacral region: lumbar spine/sacrum/coccyx/SI joints/lower back/buttock	11	6.4
Abdomen (below diaphragm and above inguinal canal, includes abdominal organs)	11	6.4
Shoulder (includes all shoulder joints, clavicle, scapula, rotator cuff, biceps tendon origin)	7	4.1
Elbow (includes ligaments, insertional biceps and triceps tendon)	3	1.8
Forearm & Wrist	3	1.8
Hand & Fingers	11	6.4
Hip & Groin & Thigh	12	7.0
Knee (includes patella, patellar tendon, quadriceps tendon, pes anserinus)	42	24.6
Lower leg (includes Achilles tendon)	9	5.3
Ankle (includes syndesmosis, talocrural and subtalar joints)	47	27.5
Foot & toes	3	1.8
Not defined	6	3.5
Total	171	1.8

*Low absolute frequencies warrant caution in the interpretation of percentages.

Table XII – Distribution by Injury Type (original categories)

Injury Type	N	%
Concussion (regardless of loss of consciousness)	2	1.2
Traumatic Fracture	12	7.0
Stress Fracture	4	2.3
Other bone injuries	1	0.6
Dislocation, subluxation	3	1.8
Tendon rupture	2	1.2
Ligament injury Grade 1 (sprain)	22	12.9
Ligament injury Grade 2 (partial rupture)	21	12.3
Ligament injury Grade 3 (complete rupture)	17	9.9
Lesion of Meniscus OR Labrum OR Cartilage	15	8.8
Strain/Rupture/Tear (Muscle or intramuscular tendon)	28	16.4
Contusion/ Haematoma/Bruise	1	0.6
Tendinosis/Tendinopathy	16	9.4
Arthritis & Synovitis & Bursitis	3	1.8
Spinal cord injury & Nerve injury or compression	7	4.1
Muscle cramps or Spasm	1	0.6
Other/not well defined	12	7.0
Ligament injury + Lesion of meniscus OR Labrum OR cartilage	4	2.3
Total	171	100.0

*Low absolute frequencies warrant caution in the interpretation of percentages.

Table XIII – Actions Associated with Injury Occurrence

Action	N	%
Did not respond.	26	15.2
Attacking action	15	8.8
Blocking action	13	7.6
Collision with another player (teammate or opponent) or structure	16	9.4
Defence or reception	26	15.2
Jumping for block or attack	44	25.7
Landing from block or attack	25	14.6
Service	4	2.3
Setting	2	1.2
Total	171	100.0

Table XIV – Distribution of Injuries by Player Position

Player Position	N	%
Setter	22	12.9
Libero	13	7.6
Middle blocker	45	26.3
Opposite hitter	32	18.7
Outside hitter	50	29.2
Multiple Positions*	9	5.3
Total	171	100.0

Table XV – Players with Multiple Positions: Specification

Multiple Positions Specified	N
Middle blocker, Opposite hitter	4
Outside hitter, Opposite hitter	3
Setter, Opposite hitter	1
Setter, Outside hitter	1
Total	9

Table XVI – Severity Classes (Absence Time from Games)

Absence Time from Games	N	%
No absence from games	43	25.1
Minor: 1-2 weeks (maximum)	28	16.4
Moderate: 2 weeks - 1 month (maximum)	37	21.6
Major: 1-3 months (maximum)	35	20.5
Severe: More than 3 months, but I still played that season	8	4.7
Season-ending: I did not return to competition that season	20	11.7
Total	171	100.0

Table XVII – Type of Training Prior to Return to Play

Type of Training	N	%
No absence from games.	43	25.1
Conditioned ball training.	6	3.5
Conditioned gym training.	58	33.9
Conditioned gym training + Conditioned ball training.	50	29.2
I did not do any kind of training.	13	7.6
I did not need conditioned training.	1	0.6
Total	171	100.0

Table XVIII – Weekly Hours of Ball (Technical) Training in Injured Athletes

Ball Hours per Week	N	Valid %	Total %
< 8h	11	6.8	6.4
8 – 10h	17	10.6	9.9
10 – 13	68	42.2	39.8
≥ 13h	65	40.4	38.0
Total Valid	**161**	**100.0**	**94.2**
I do not remember	10		5.8
Total	**171**		**100.0**

Table XIX - Weekly Hours of Gym (Strength/Physical Conditioning) Training in Injured Athletes

Gym Hours per Week	N	Valid %	Total %
< 3h	30	18.3	17.5
3 – 4h	91	55.5	53.2
≥ 5h	38	23.2	22.2
I did not do gym training	5	3.0	2.9
Total Valid	**164**	**100.0**	**95.9**
I do not remember	7		4.1
Total	**171**		**100.0**

Table XX – Percentage of Official Game Time Played by Injured Athletes

Played Game Time (%)	N	%
< 10% of the game	17	9.9
10 – 50% of the game	14	8.2
50 – 80% of the game	24	14.0
≥ 80% of the game	116	67.8
Total	171	100.0

Table XXI – Association between Recurrence and Specific Injuries

Chi-Square Tests					
	Value	df	Monte Carlo Sig. (2-sided)		
			p-value	99% Confidence Interval	
				Lower Bound	Upper Bound
Pearson Chi-Square	24.889	7	<.001	0.000	0.001
N of Valid Cases	107				

Table XXII – Recurrence in Specific Injuries

Specific Injuries * Recurrence Crosstabulation		Recurrence		Total
		No	Yes	
Specific Injuries	Ankle sprain (grade 1)	11	6	17
	Ankle Ligament Rupture (grade 2 or 3)	15	12	27
	Knee complete ligament rupture (grade 3) ± meniscus or cartilage	12	0	12
	Knee lesion of meniscus or cartilage (isolated)	5	5	10
	Knee Tendinosis/Tendinopathy	4	8	12
	Abdomen Strain/Rupture/Tear	10	1	11
	Groin & Thigh Strain/Rupture/Tear	8	1	9
	Traumatic Fracture of forearm,wrist, hand and fingers	9	0	9
Total (N)		74	33	107
Total (%)		69.2%	30.8%	100.0%

Table XXIII – Injury Occurrence by Agre Group

Age Group		Injury Occurrence		Total athletes
		No	Yes	
< 19 years old	N	9	11	20
	%	45.0%*	55.0%*	11.7%
≥ 19 years old	N	48	103	151
	%	31.8%	68.2%	88.3%
Total athletes	N	57	114	171
	%	33.3%	66.7%	100.0%

*Percentages should be interpreted with caution due to low absolute frequencies.

Table XXIV – Number of Injuries by Age Group

Number of Injuries	< 19 years old	≥ 19 years old	Total injured athletes
1	5	53	58
	45.5%*	52.0%	51.3%
2	4	36	40
	36.4%*	35.3%	35.4%
3	1	9	10
	9.1%*	8.8%*	8.8%*
4	1	4	5
	9.1%*	3.9%*	4.4%*
Total injured athletes	11	102†	113†
		100.0%	100.0%

*Percentages should be interpreted with caution due to low absolute frequencies.
†*One response is missing, corresponding to an athlete with more than four injuries.*

Table XXV – Correlation between Age and Number of Injuries

Correlations				
Spearman's rho	**Number of Injuries**	**Age group** (< 19 years *versus* > 19 years old)	**Correlation**	-0.050
			p-value	0.602
			N	113†

†1 missing, with more than four injuries

Table XXVI – Comparison of Number of Injuries between Age Groups (< 19 years versus > 19 years old)

Chi-Square Tests					
	Value	df	Monte Carlo Sig. (2-sided)		
			p-value	99% Confidence Interval	
				Lower Bound	Upper Bound
Pearson Chi-Square	0.686	3	0.936	0.929	0.942
N of Valid Cases	113[†]				

[†]1 missing, with more than four injuries

Table XXVII - Correlation between Exposure and Age Group (<19 versus ≥19 years old)

Correlations				
N = 152[†] (valid)			**Ball Hours per Week**	**Gym Hours per Week**
Spearman's rho	**Age group** (< 19 years versus > 19 years old)	**Correlation Coefficient**	0.179	0.244
		p-value	0.014	0.001

[†]N reflects the number of injuries, not individual players. N = 152 (out of 171 reported injuries) due to missing responses (lack of recollection).

9. FIGURES

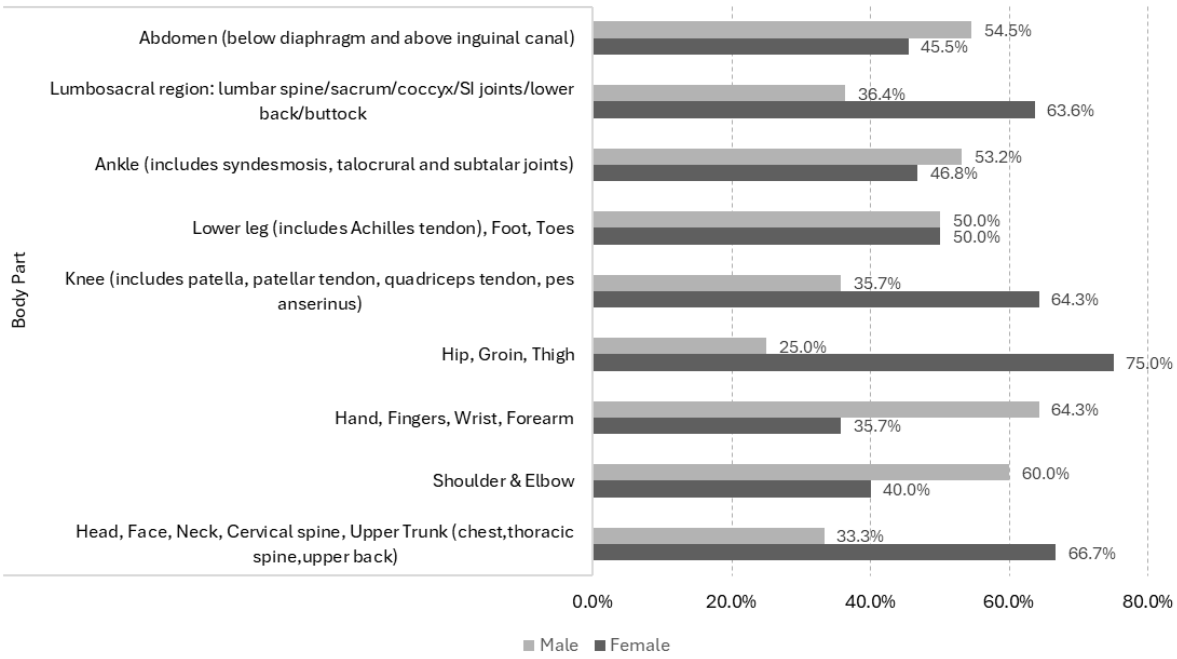


Figure 1 - Sex Distribution by Injured Body Part

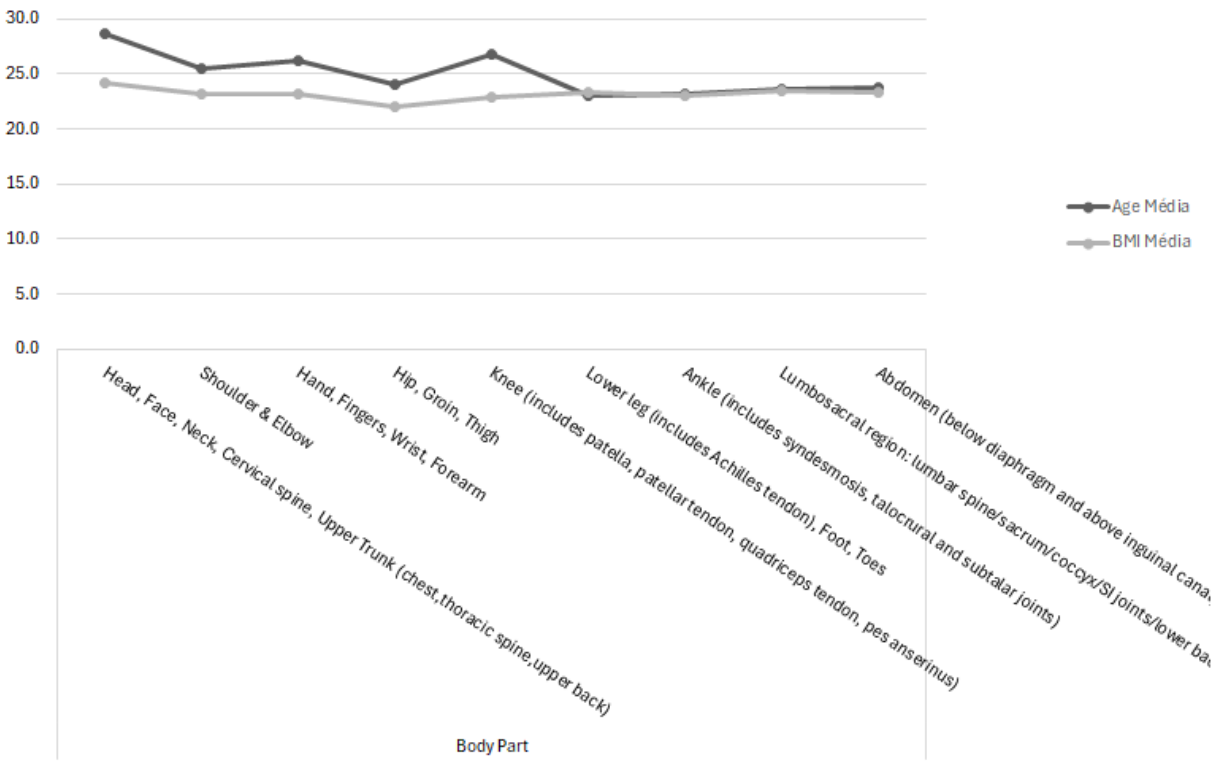


Figure 2 – Mean Age and BMI Distribution by Injured Body Part

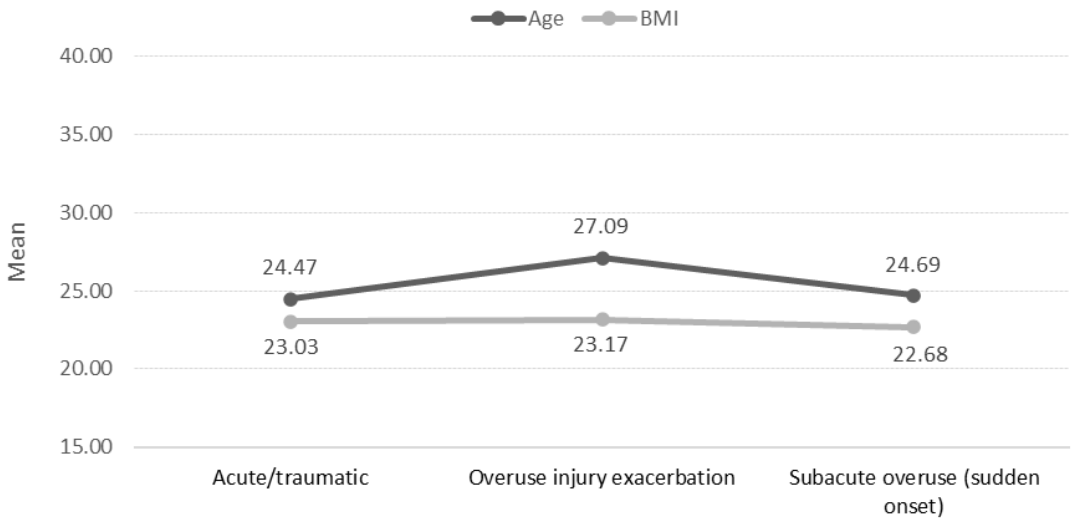


Figure 3 – Mean Age and BMI by Injury Onset

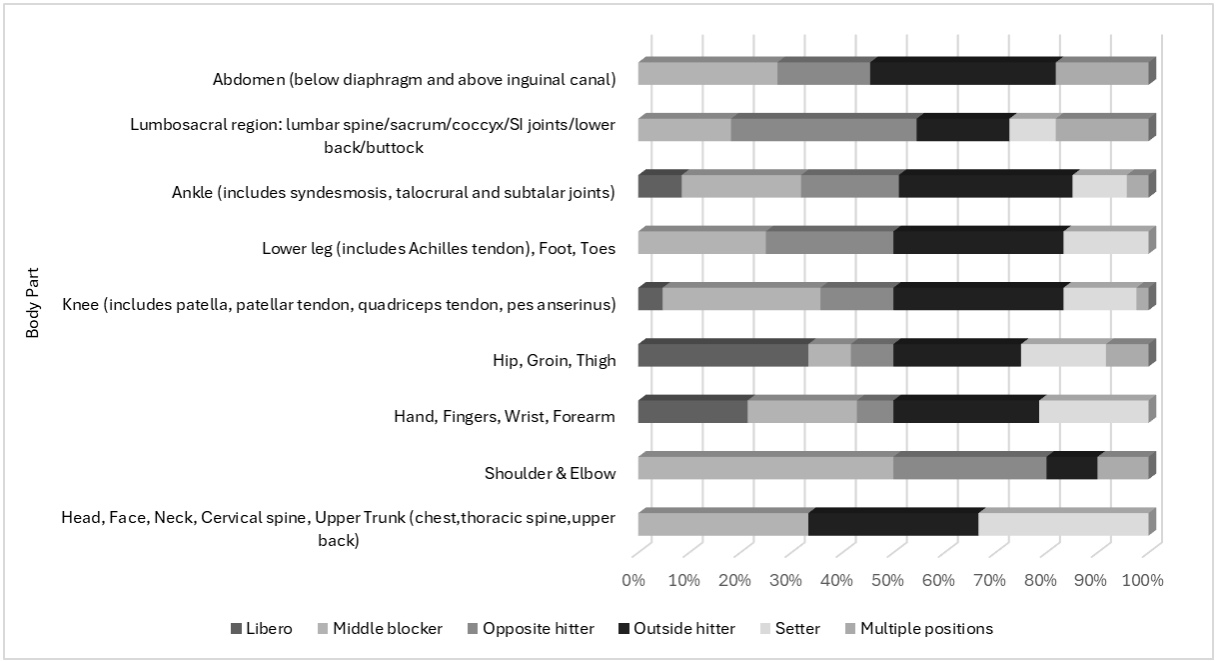


Figure 4 – Distribution of Injured Player Positions by Injured Body Part

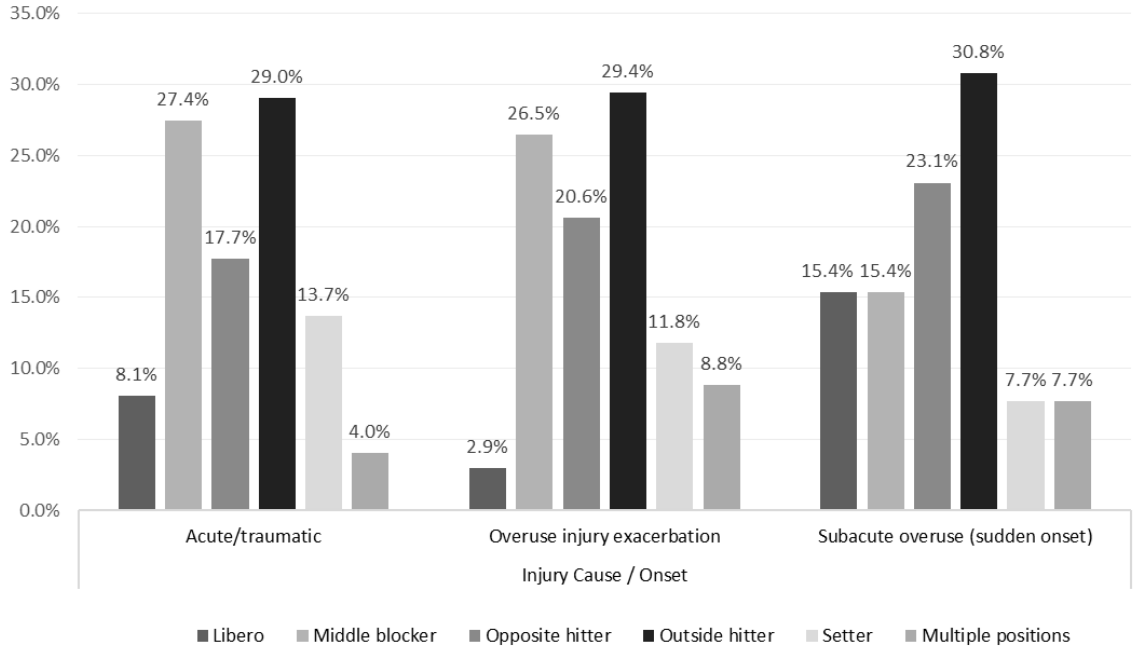


Figure 5 – Distribution of Injured Player Positions by Injury Onset

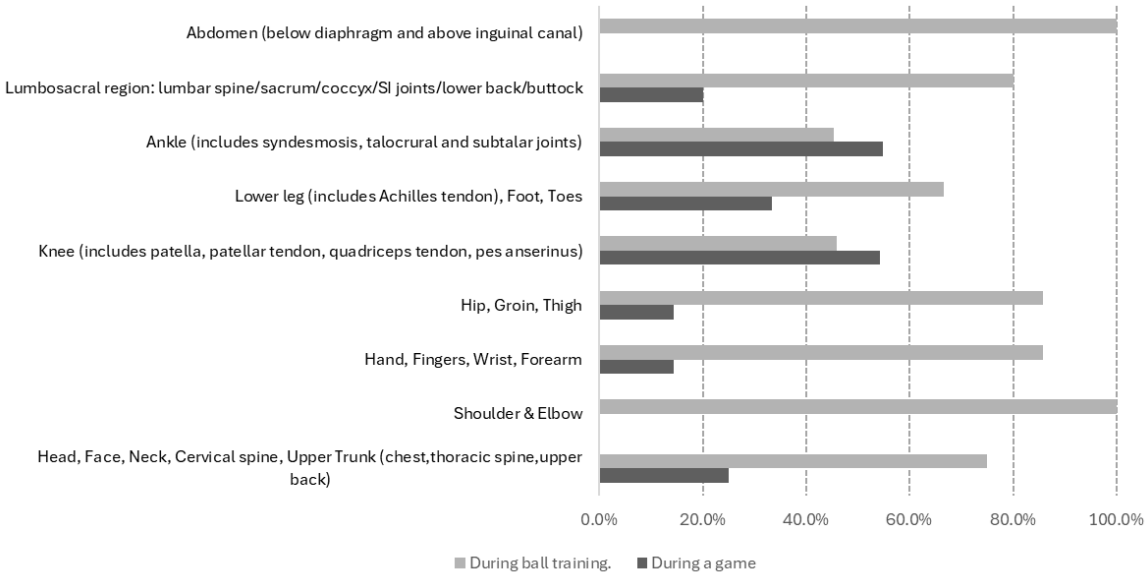


Figure 6 – Distribution of Game vs. Training Injuries by Injured Body Part

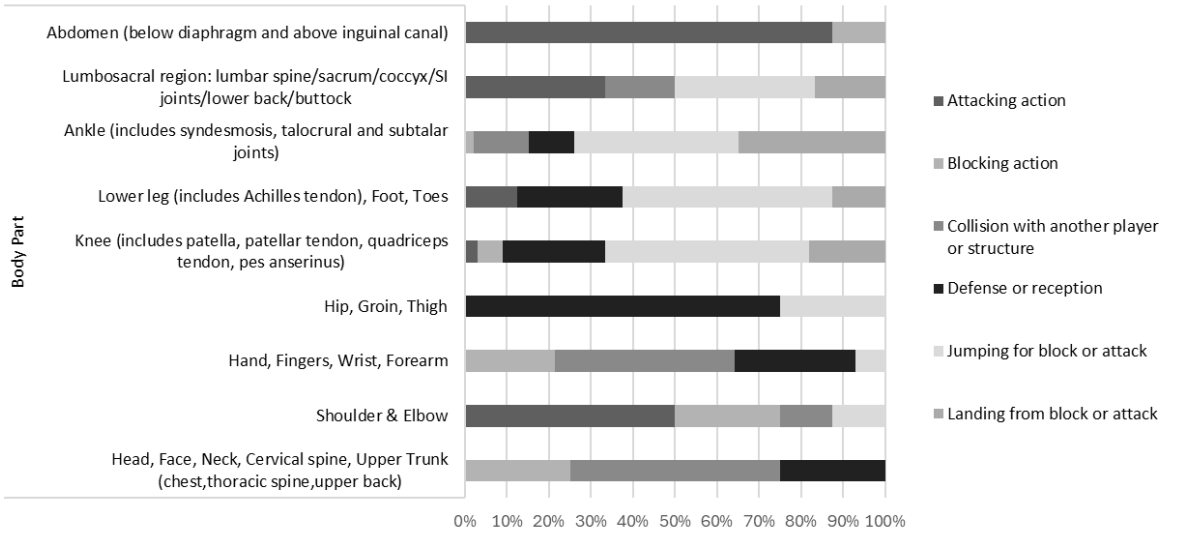


Figure 7 - Actions Associated with Injury Occurrence by Injured Body Part

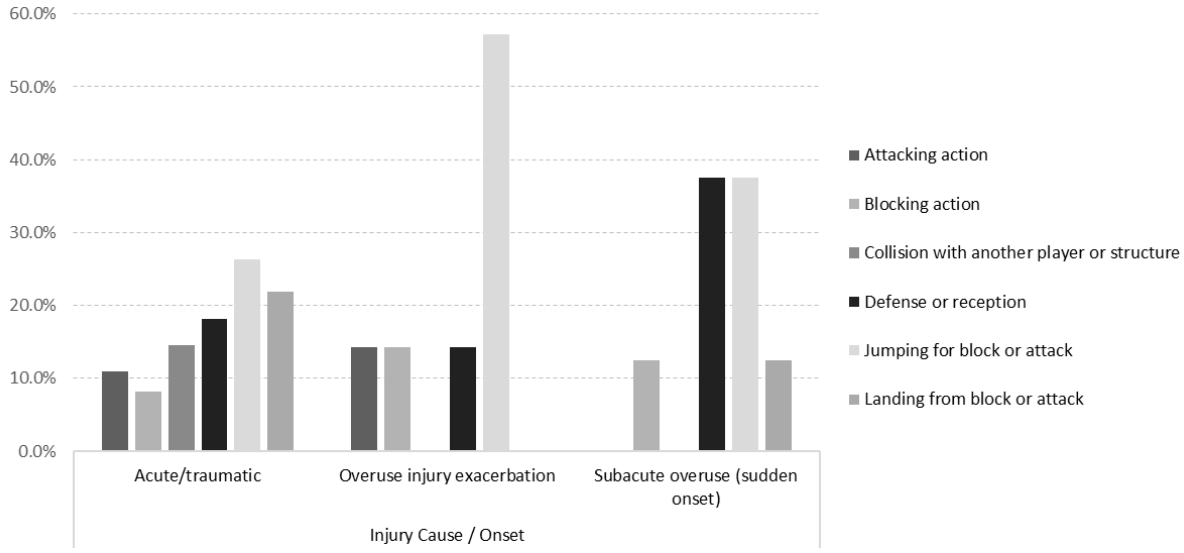


Figure 8 – Actions Associated with Injury Occurrence by Injury Onset

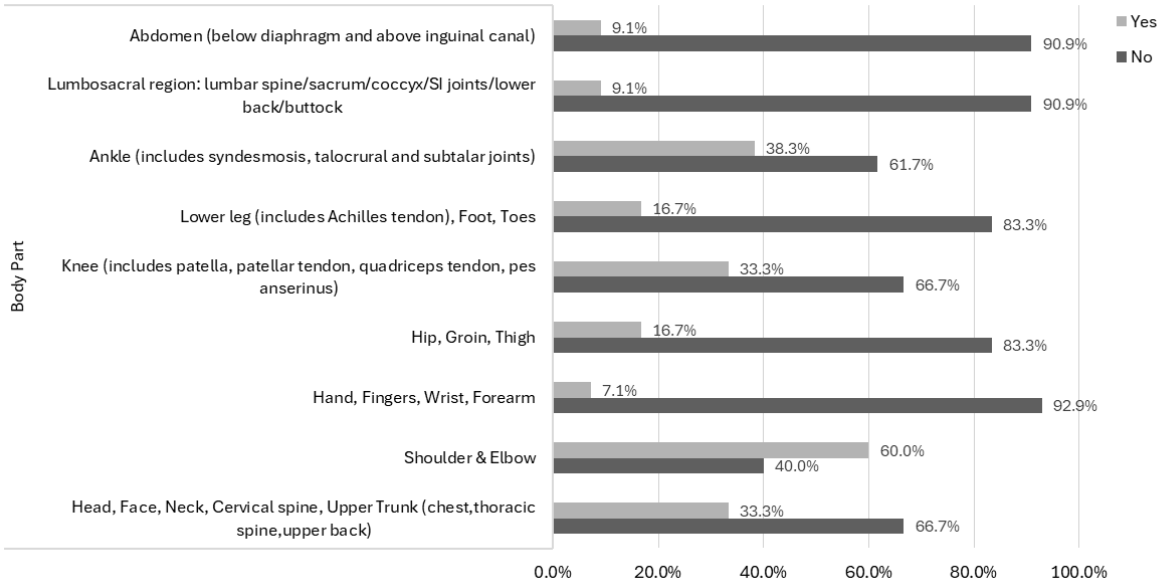
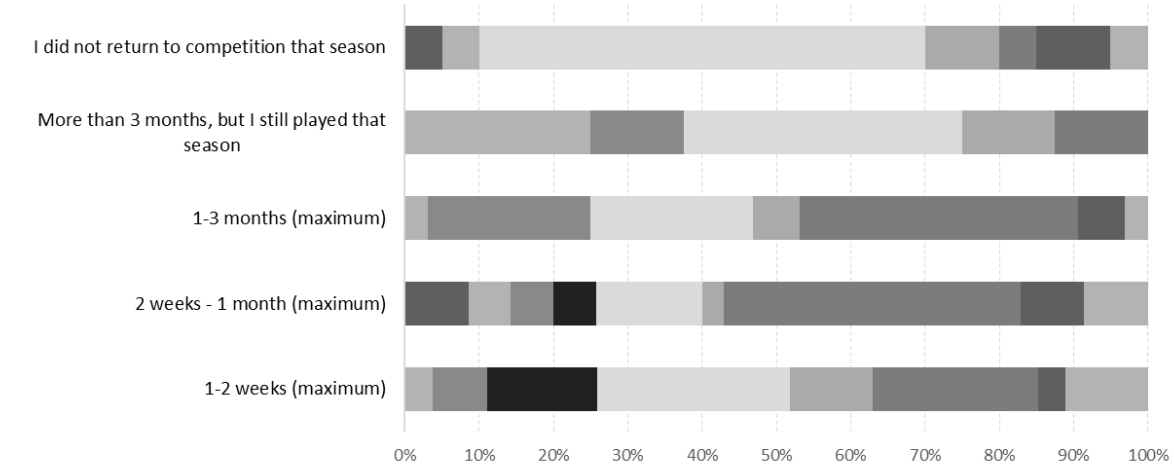


Figure 9 – Recurrence by Injured Body Part



	1-2 weeks (maximum)	2 weeks - 1 month (maximum)	1-3 months (maximum)	More than 3 months, but I still played that season	I did not return to competition that season
Head, Face, Neck, Cervical spine, Upper Trunk		8.6%			5.0%
Shoulder & Elbow	3.7%	5.7%	3.1%	25.0%	5.0%
Hand, Fingers, Wrist, Forearm	7.4%	5.7%	21.9%	12.5%	
Hip, Groin, Thigh	14.8%	5.7%			
Knee (includes patella, patellar tendon, quadriceps tendon, pes anserinus)	25.9%	14.3%	21.9%	37.5%	60.0%
Lower leg (includes Achilles tendon), Foot, Toes	11.1%	2.9%	6.3%	12.5%	10.0%
Ankle (includes syndesmosis, talocrural and subtalar joints)	22.2%	40.0%	37.5%	12.5%	5.0%
Lumbosacral region: lumbar spine/sacrum/coccyx/SI joints/lower back/buttock	3.7%	8.6%	6.3%		10.0%
Abdomen (below diaphragm and above inguinal canal)	11.1%	8.6%	3.1%		5.0%

Figure 10 – Distribution of Injured Body Parts by Severity Class

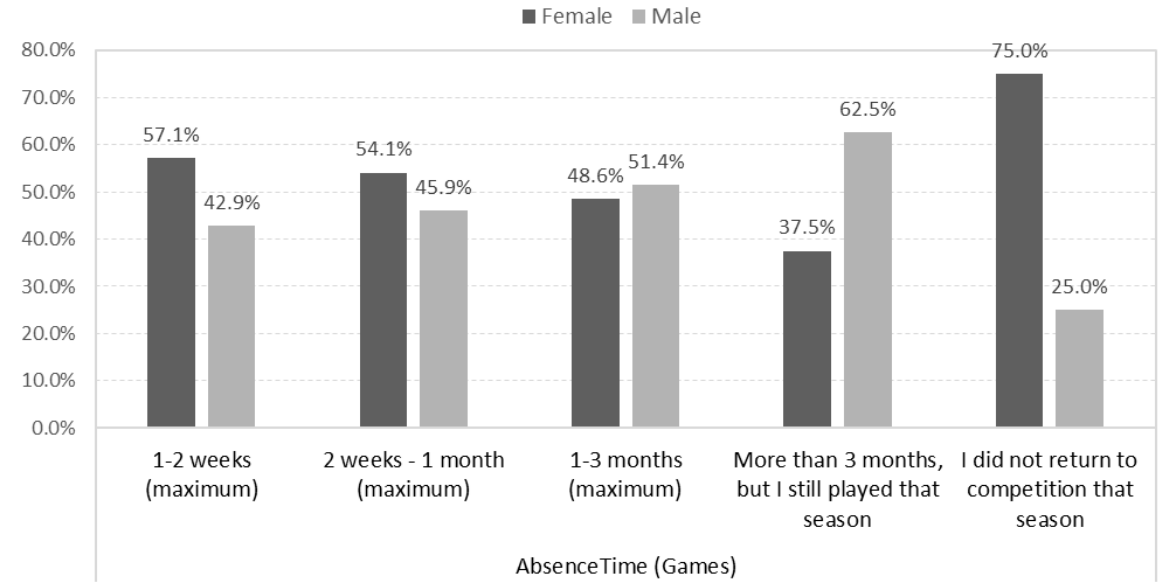


Figure 11 – Sex Distribution by Severity Class

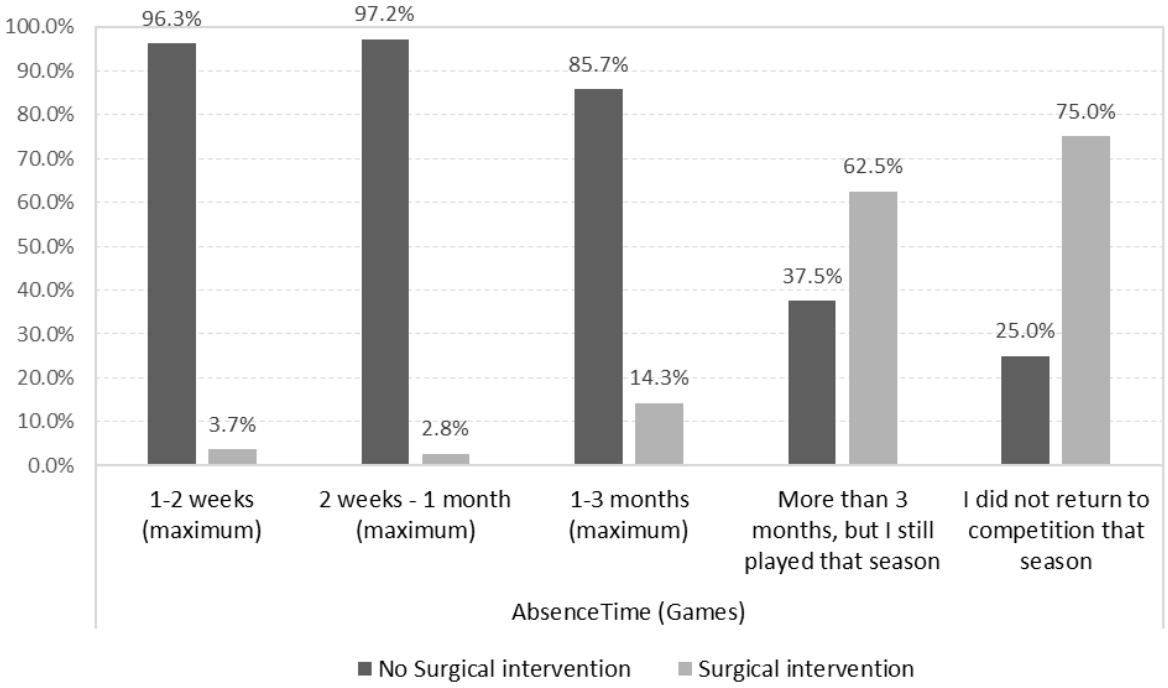


Figure 12 – Distribution of Surgical vs Non-Surgical Intervention by Severity Class

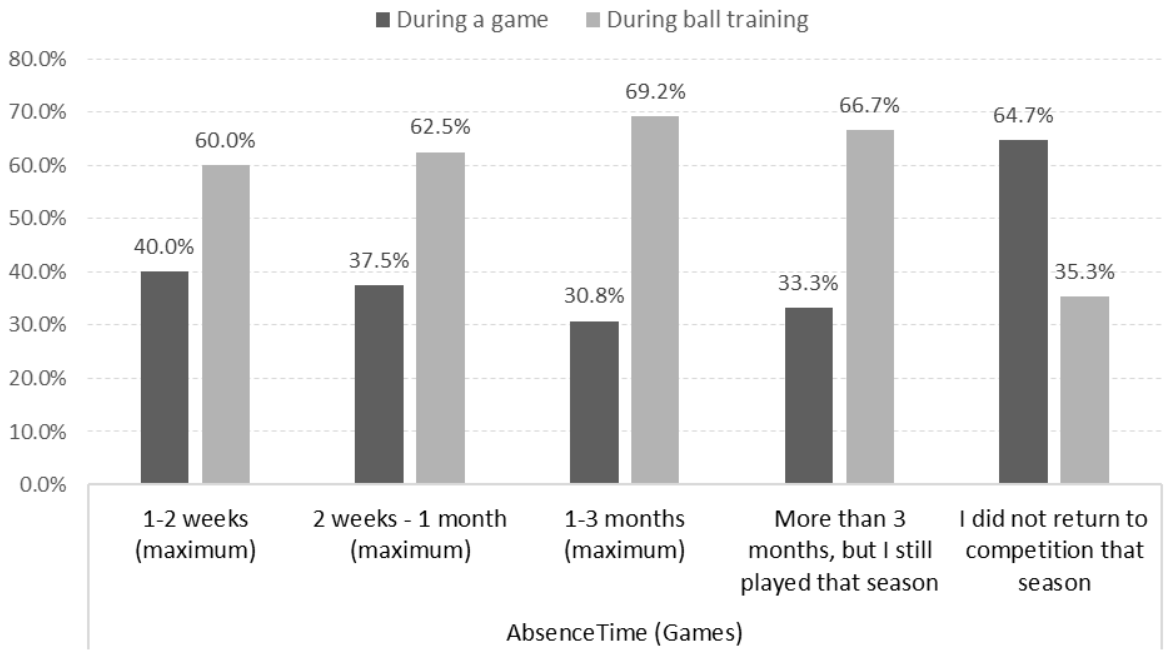


Figure 13 – Distribution of Game vs. Training Injuries by Severity Class

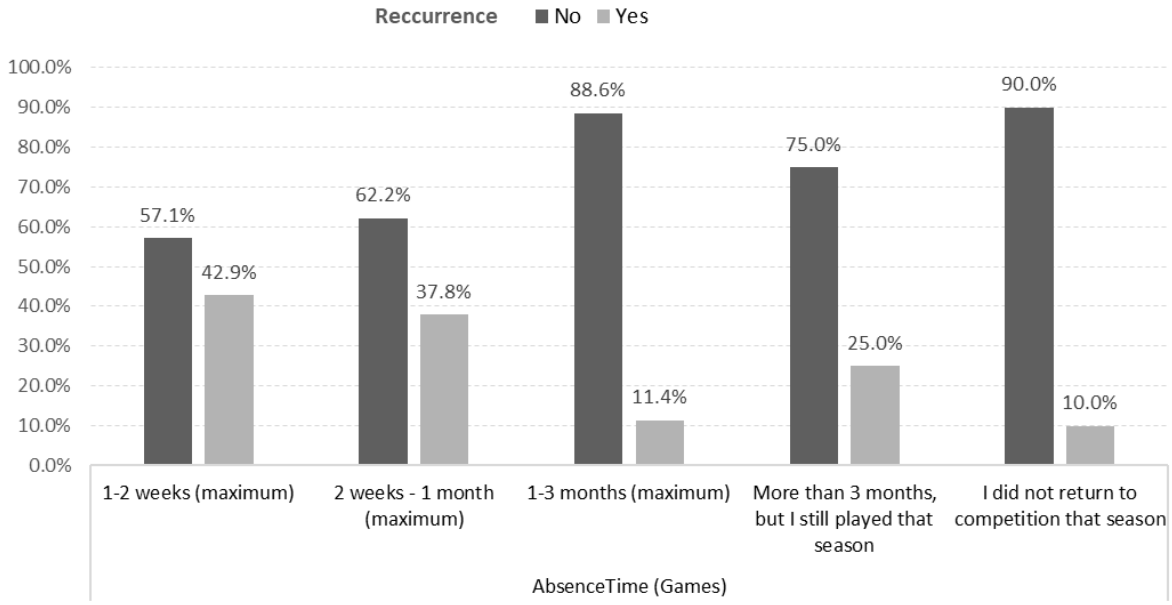


Figure 14 – Recurrence by Severity Class

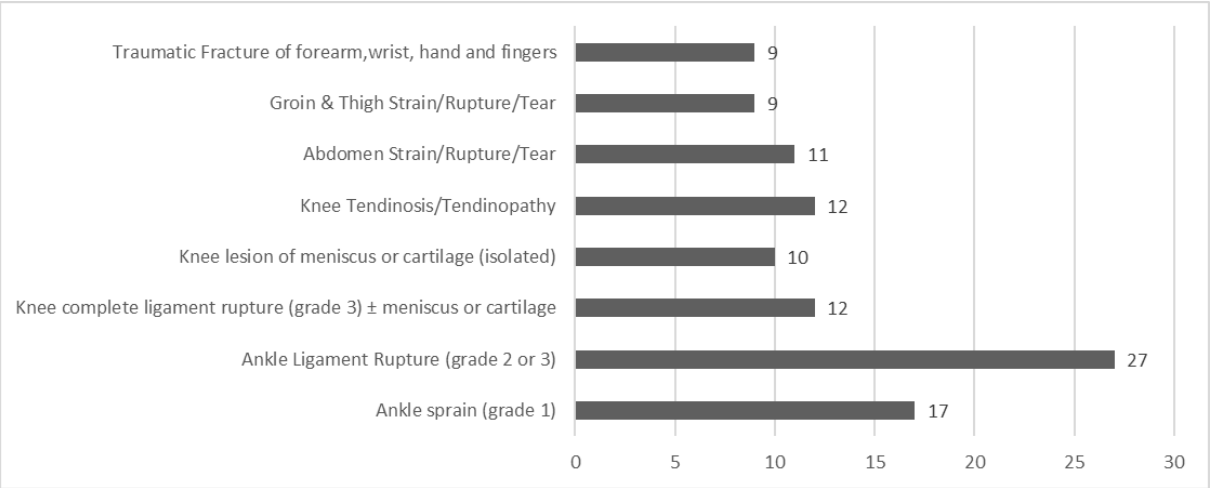


Figure 15 – Absolute Frequencies of Specific Injuries

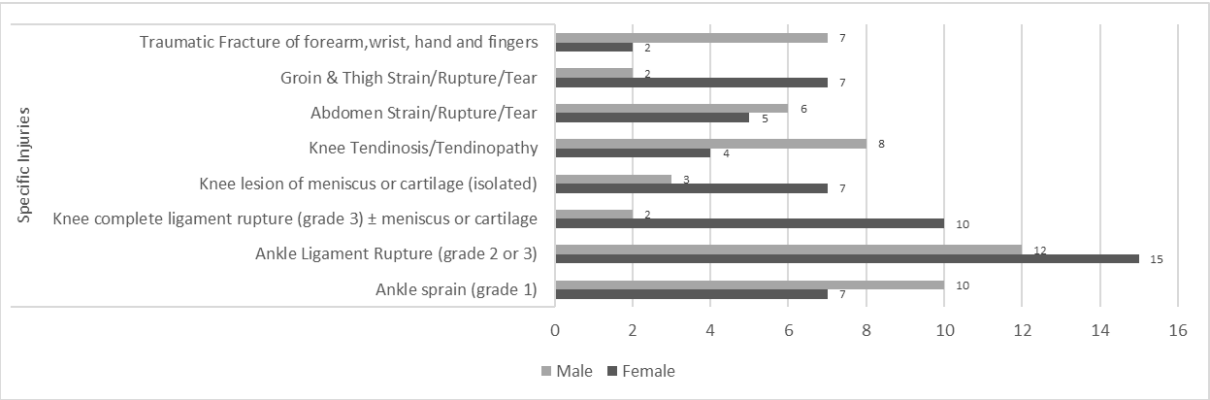


Figure 16 – Sex Distribution by Specific Injuries

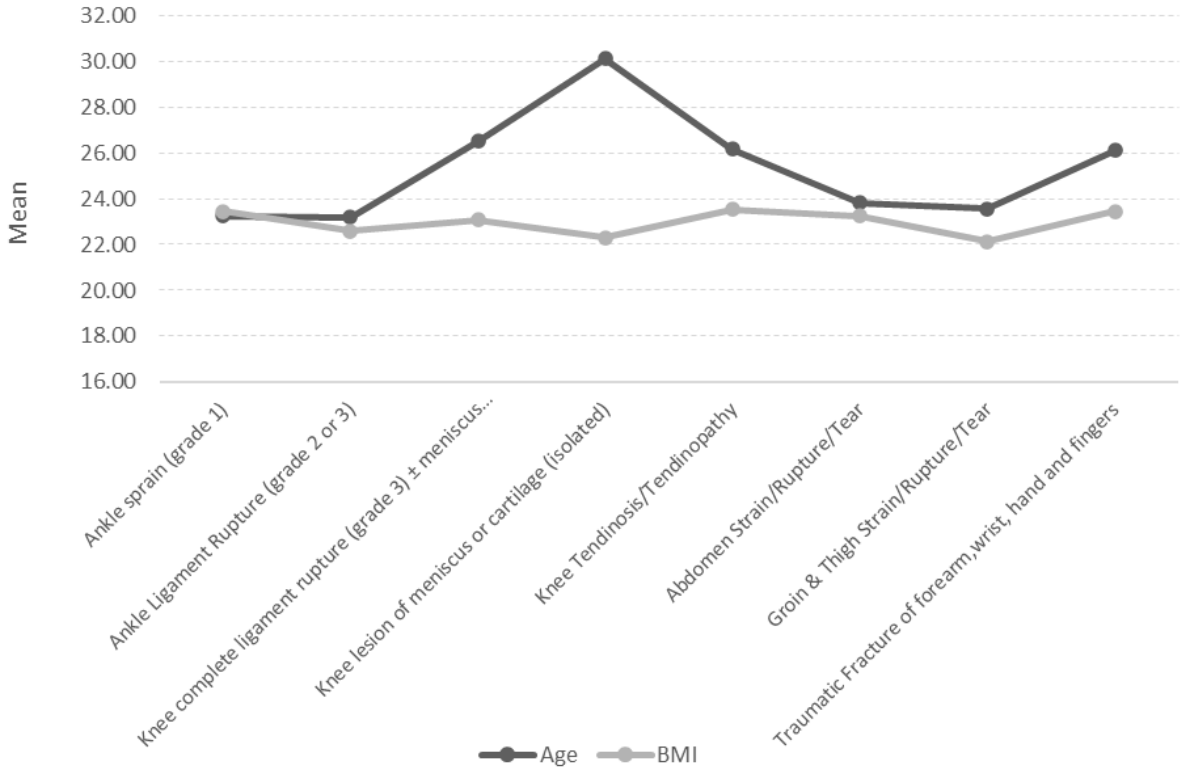


Figure 17 – Mean Age and BMI by Specific Injuries

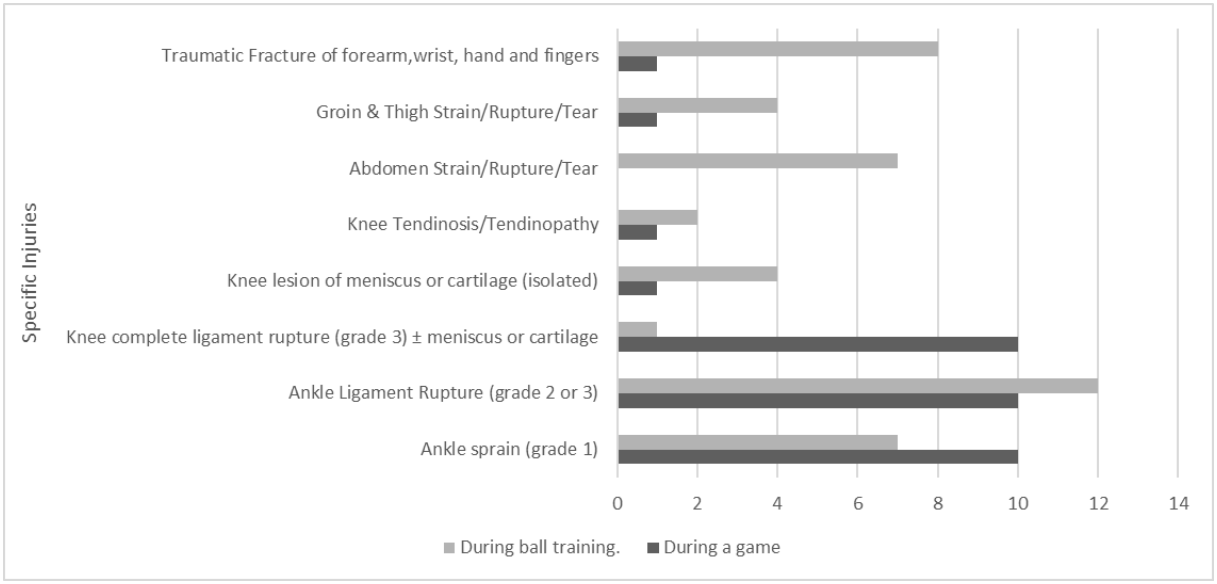


Figure 18 – Distribution of Game vs. Training by Specific Injuries

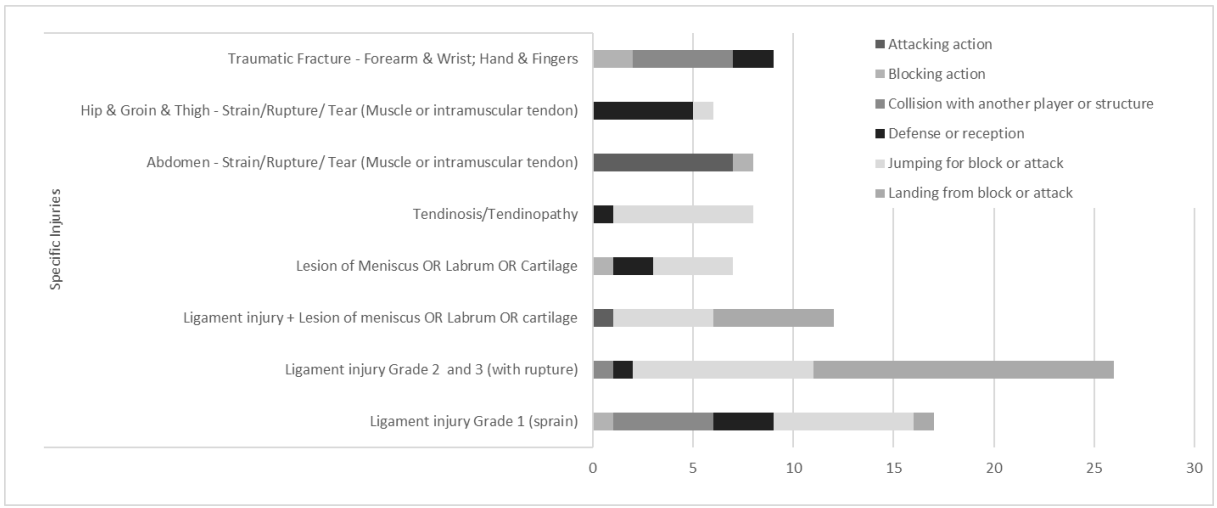


Figure 19 – Actions Associated with Specific Injuries

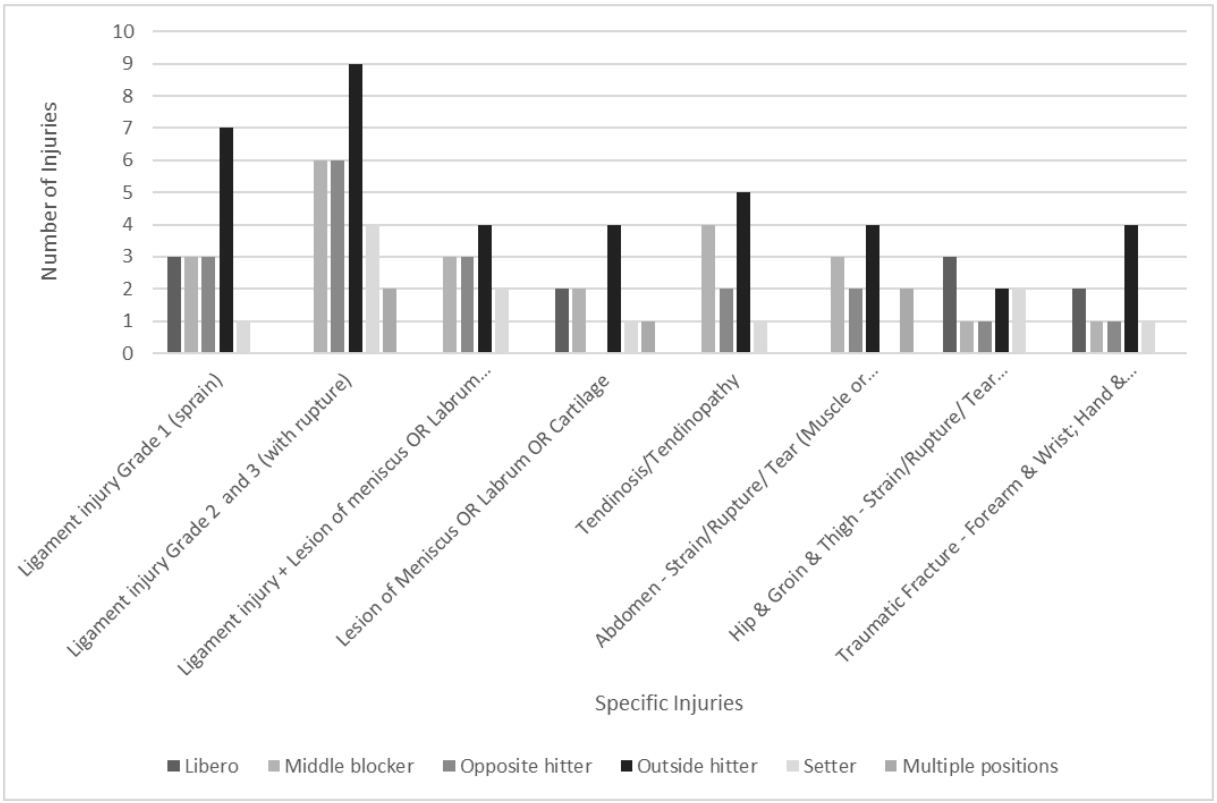


Figure 20 - Distribution of Injured Player Positions by Specific Injuries

10. Questionnaire – English version

Adapted to Google Forms format. Available at:
https://docs.google.com/forms/d/e/1FAIpQLScsJ1gWXAfavPPjvU5Vivlrsbvjfb TNIA7ZmE0p_CDiqVl-WA/viewform?usp=sf_link

INFORMATION LEAFLET FOR PARTICIPANTS

Dear athlete,

My name is Beatriz Costa Basto, and I am a Medicine student at the Institute of Biomedical Sciences Abel Salazar, University of Porto.

As part of my Master's Thesis, with the knowledge of the Portuguese Volleyball Federation, I am requesting your collaboration in the study I am developing. This is an epidemiological study aimed at investigating injuries among professional and semi-professional volleyball players over the last five sports seasons. It applies to all registered athletes in senior teams participating in the I Division of the National Volleyball Championship, both Women's and Men's leagues, respectively Liga Solverde and Liga Una Seguros, in the current sports season (2024/2025).

Participation in the study is straightforward and involves completing an anonymous questionnaire with multiple-choice or short-answer questions. The average time to complete it is approximately 5 minutes (maximum 10 minutes).

Considering the importance of Volleyball to all of us, your participation will be of great value for research in the areas of Sports and Health, which, as we all know, have much potential for growth in Portugal. For this growth to be possible, we must continue to contribute to the sharing of knowledge related to Sports, particularly Volleyball, so that it spreads across various health fields, especially among Specialist Doctors who often work with us, athletes. By consolidating, expanding, and disseminating this knowledge, we will be able to improve the prevention, diagnosis, treatment, and rehabilitation of sports injuries more effectively.

Participation in the study is voluntary and anonymous, and all data related to your identification is confidential. You may refuse to participate or withdraw from the study at any time without any penalty. The results will be treated collectively and used solely for research purposes. I am providing the Informed Consent for your review and completion, in order to authorise your participation in the study.

Thank you very much for your attention. If you have any questions, please do not hesitate to reach out to me.
E-mail: beatriz.c.basto@gmail.com

Sincerely,
Beatriz Costa Basto

EPIDEMIOLOGICAL QUESTIONNAIRE ON INJURIES IN ELITE VOLLEYBALL IN PORTUGAL

Participant Characterisation

1. Gender: Female ☐ Male ☐
2. Age: _____
   Write **only the number** (e.g. "20")
3. Height: _____
   Write only the number, in **centimetres** (e.g. '175')
4. Weight: _____
   Write only the number, in **kilograms** (e.g. '60')

5. What is your context as a volleyball athlete?
   ☐ Professional
   ☐ Student-Athlete
   ☐ I have another job
   ☐ I practice another sport simultaneously
   ☐ Other:
   _____

6. Do you attend all training sessions with your team?
   Yes ☐ No ☐

7. How many training sessions do you do in total per week?
   ☐ 1-3
   ☐ 4-5
   ☐ 6-10
   ☐ More than 10

8. **Between 2020 and today** (including the 20/21 season and the current season), have you had any injury that:
   - Required any **medical intervention/treatment**?
   OR
   - Prevented you / is currently **preventing you from training or playing volleyball for at least one week**, without requiring medical intervention/treatment?

   Yes ☐ No ☐

9. If you answered "Yes" to the last question, how many of those injuries?
   ☐ 1
   ☐ 2
   ☐ 3
   ☐ 4
   ☐ More than 4.

If you have had more than one injury, please continue to the following pages to answer the questions for each of them individually.

Thank you for your time. Have a good season!

Template Injury Report Form (for Injuries 1, 2, 3 and 4)

1. In which **season** did the injury occur?
   - ☐ 20/21
   - ☐ 21/22
   - ☐ 22/23
   - ☐ 23/24
   - ☐ 24/25

2. In which **moment of the season / time of the year** did the injury occur? By selecting one of the last three options, you should consider the injury occurred during the season that ended immediately before the off-season.
   - ☐ Pre-season
   - ☐ Regular season
   - ☐ Playoffs
   - ☐ Off season training without competition
   - ☐ National Team during the off-season period
   - ☐ Beach volleyball

3. Can you specify the **type** of injury and its **location**? Describe it as completely as possible, including the region and side of the body (e.g. "right ankle sprain grade 2", "left knee ACL tear" or "muscle tear in the left thigh / calf / in the abdomen").

   _____

4. Were you prevented from playing **at least one official game** due to your injury? Yes ☐ No ☐

5. During that season, how long were you **unable to participate in official games** due to your injury?
   - ☐ 1-2 weeks (maximum)
   - ☐ 2 weeks - 1 month (maximum)
   - ☐ 1-3 months (maximum)
   - ☐ < 3 months, but I still played that season.
   - ☐ I did not return to competition that season.

6. **Until your return** to competition (official games), how were your **training sessions**? You can select more than one option.
   - ☐ I did not do any kind of training.
   - ☐ Conditioned gym training.
   - ☐ Conditioned ball training.
   - ☐ Conditioned gym training + Conditioned ball training.

7. If you did not return to competition that season, **how long did you stop** before returning to **volleyball training**? (including any ball training you did during the off-season or beach volleyball training)

   _____

8. What was the **treatment** for your injury? You can select more than one option.
   - ☐ **Non-Pharmacological Medical** Treatment (e.g., radiofrequency, manual therapy, muscle strengthening, etc.)
   - ☐ **Pharmacological Medical** Treatment (includes oral medication, local injection, intravenous medication)
   - ☐ **Surgical intervention**
   - ☐ Other (e.g., Alternative Medicines): _____

9. Background
   - 9.1. Do you associate the injury with a single event? Yes ☐ No ☐
   - 9.2. Was this the first time you had complaints in the injured area? Yes ☐ No ☐
   - 9.3. Did you have any complaints in that area in the days before the injury? Yes ☐ No ☐
   - 9.4. Do you associate the injury with any previous symptoms you had? Yes ☐ No ☐

10. If you answered "Yes" to the 4th item of the last question:
    - 10.1. Did that/those symptom(s) require you to take medication at least once a week to be able to train or play? Yes ☐ No ☐
    - 10.2. Did that/those symptom(s) prevent you from training at least once, regardless of whether you took medication or not? Yes ☐ No ☐

11. **If you associate the injury with a single event**, it occurred:
    - ☐ During a game.
    - ☐ During ball training.
    - ☐ During a warm-up for training or a game without a ball.
    - ☐ During a physical conditioning / gym / stretching session.

12. If the injury occurred during a **game** or **practice**, which of the following actions were you performing?

- ☐ Jumping for block or attack
- ☐ Landing from block or attack
- ☐ Block action
- ☐ Attack action
- ☐ Defence or reception
- ☐ Not applicable
- ☐ Service
- ☐ Pass/Distribution
- ☐ Collision with another player (teammate or opponent) or structure (bench, post, wall, etc.)
- ☐ Other _____

13. If the injury occurred during a **game**, in which set did it happen?

- ☐ 1st set
- ☐ 2nd or 3rd set
- ☐ 4th or 5th set

14. What **position** were you playing that season? (You can select more than one option)

- ☐ Setter
- ☐ Middle blocker
- ☐ Outside hitter
- ☐ Opposite hitter
- ☐ Libero

15. On average, how many hours per week were you doing **ball training** during the season you were injured?

- ☐ < 5h/week
- ☐ 5-8h/week
- ☐ 8-10h/week
- ☐ 10-13h/week
- ☐ > 13h/week
- ☐ I do not remember.

16. How many official games did you usually have per week during the season you were injured?

- ☐ 1 game
- ☐ 2 games occasionally
- ☐ 2 games for most of the season
- ☐ 3 games occasionally

17. During the **season** you were injured, how much time did you play in an official game on average?

- ☐ > 80% of the game
- ☐ 50-80% of the game
- ☐ 10 – 50%
- ☐ < 10% of the game

18. On average, how many hours **per week** were you doing **physical conditioning** (gym/weight training) during the season you were injured?

- ☐ I used not to do.
- ☐ < 3h/week
- ☐ 3-4h/week
- ☐ ≥ 5h/week
- ☐ I do not remember.

19. Regarding your **physical conditioning training** (gym/weight training), did you:

- ☐ Perform >50% of the sessions with the Team's physical trainer.
- ☐ Perform >50% of the sessions with an external physical trainer.
- ☐ Perform >50% of the sessions without the support of any physical trainer (team or external).
- ☐ 50% alone, 50% with the support of any physical trainer.
- ☐ Not applicable.

20. Do you remember how much you **weighed** at the time of the injury? Select "Other option" to enter your weight at the time, if it was different from your current weight.

- ☐ Approximately the same as now.
- ☐ Other: _____ Kg

21. Do you remember how many hours you used to **sleep** per night at the time of the injury?

- ☐ < 5h
- ☐ 5-6h
- ☐ 6-7h
- ☐ 7-8h
- ☐ > 8h

22. Was there a recurrence of the injury?
Yes ☐ No ☐

23. Continue to answer to the survey for **Injury 2**
Yes ☐ No ☐

11. Questionnaire – Portuguese version

Adapted to Google Forms format. Available at:
https://docs.google.com/forms/d/e/1FAIpQLScAmqfHQcWjYon9RuLIQMH9uzwC6VnGwggPcX08PhQrCvrhXw/viewform?usp=sf_link

FOLHETO DE INFORMAÇÃO AOS PARTICIPANTES

Caro(a) atleta,

O meu nome é Beatriz Costa Basto, sou estudante do Mestrado Integrado em Medicina, no Instituto de Ciências Biomédicas de Abel Salazar da Universidade do Porto.

No âmbito da minha Dissertação de Mestrado, sob conhecimento da Federação Portuguesa de Voleibol, venho solicitar a tua colaboração no estudo que estou a desenvolver. Este é um estudo epidemiológico que visa estudar as lesões dos atletas profissionais e semiprofissionais de voleibol nas últimas 5 épocas desportivas e aplica-se a todos os atletas federados inscritos nas equipas séniores participantes na I Divisão do Campeonato Nacional de Voleibol, Feminino e Masculino, respetivamente Liga Solverde e Liga Una Seguros, na presente época desportiva (2024/2025).

A participação no estudo é simples, sendo feita através do preenchimento de um questionário com perguntas de escolha múltipla ou resposta curta. O tempo médio de preenchimento é de aproximadamente 5 minutos (máximo 10 minutos).

Atendendo à importância que o Voleibol tem para todos nós, a tua participação será de grande valor para a investigação nas áreas do Desporto e da Saúde, que, como todos sabemos, têm muito por onde crescer em Portugal. Para que esse crescimento seja possível, devemos continuar a contribuir para a partilha de conhecimento relativo ao Desporto, e em particular ao Voleibol, de forma que este se difunda pelas várias áreas da saúde, especialmente pelos Médicos Especialistas que tantas vezes lidam connosco, atletas. Ao consolidar, alargar e divulgar este conhecimento, mais facilmente conseguiremos melhorar a prevenção, o diagnóstico, o tratamento e a reabilitação das lesões desportivas.

A participação no estudo é de carácter voluntário e anónimo, e todos os dados relativos à sua identificação são confidenciais. Podes recusar-te a participar ou interromper a qualquer momento a participação no estudo, sem qualquer tipo de penalização. Os resultados serão tratados coletivamente e utilizados apenas para fins de investigação. Disponibilizo o Termo de Consentimento para leitura e preenchimento, de forma a autorizar a tua participação no estudo.

Muito obrigada, desde já, pela tua atenção. Em caso de dúvida, não hesites em contactar-me. E-mail: beatriz.c.basto@gmail.com

Atenciosamente,
Beatriz Costa Basto

QUESTIONÁRIO EPIDEMIOLÓGICO SOBRE AS LESÕES NO VOLEIBOL DE ELITE EM PORTUGAL

Caracterização do participante

1. Sexo: Fem ☐ Masc ☐
2. Idade: _____
   Escreve **apenas o número** (ex: '20')
3. Altura: _____
   Escreve apenas o número, em **centímetros** (ex: '175')
4. Peso: _____
   Escreve apenas o número, em **quilogramas** (ex: '60')

5. Qual o teu contexto de atleta de voleibol?
   ☐ Profissional
   ☐ Atleta – Estudante.
   ☐ Tenho outro emprego.
   ☐ Pratico outro desporto em simultâneo.
   ☐ Outro: _____

6. Fazes todos os treinos com a tua equipa?
   Sim ☐ Não ☐

7. Quantos treinos, no total, fazes por semana?
   ☐ 1-3
   ☐ 4-5
   ☐ 6-10
   ☐ Mais de 10

8. **Entre 2020 e hoje** (inclui a época 20/21 e a presente época), tiveste alguma lesão que:
   - Tenha implicado alguma **intervenção/tratamento médico**?
   OU
   - Te impediu/esteja a **impedir de treinar ou jogar voleibol durante pelo menos 1 semana**, embora sem necessidade de intervenção/tratamento médico?

   Sim ☐ Não ☐

9. Se respondeste "Sim" à questão anterior, quantas dessas lesões?
   ☐ 1
   ☐ 2
   ☐ 3
   ☐ 4
   ☐ Mais de 4.

Se tiveste mais do que uma lesão, por favor continua para as páginas seguintes de modo a responder às diferentes questões para cada uma delas.

Obrigada pelo teu tempo. Boa época!

Formulário-Modelo de Registo de Lesões (para as Lesões 1, 2, 3 e 4)

1. Em que **época** foi a lesão?
   - ☐ 20/21
   - ☐ 21/22
   - ☐ 22/23
   - ☐ 23/24
   - ☐ 24/25

2. Em que **fase da época / altura do ano** foi a lesão? Ao selecionares uma das 3 últimas opções, deves considerar que a lesão ocorreu na época que terminou imediatamente antes da *off season*.
   - ☐ Pre-season
   - ☐ Regular season
   - ☐ Playoffs
   - ☐ Off season training without competition
   - ☐ National Team during the off-season period
   - ☐ Beach volleyball

3. Sabes especificar qual o **tipo de lesão** e a sua **localização**? Descreve o mais completo possível, com a região e lado do corpo (por exemplo, "entorse tipo 2 tornozelo direito" ou "rotura de LCA no joelho esquerdo" ou "rotura muscular na coxa / gémeo esquerdo / no abdómen")

   _____

4. A tua lesão impediu-te de jogar **pelo menos um jogo oficial**? ☐ Sim ☐ Não

5. Nessa época, durante quanto tempo estiveste **impedido de participar em jogos oficiais** devido à tua lesão?
   - ☐ 1 a 2 semanas (máximo)
   - ☐ 2 semanas - 1 mês
   - ☐ 1-3 meses
   - ☐ > 3 meses, mas ainda joguei nessa época.
   - ☐ Não regressei à competição nessa época.

6. **Até regressares** à competição (jogos oficiais), como foram os teus **treinos**? Podes selecionar mais do que uma opção de resposta.
   - ☐ Não fiz nenhum tipo de treino.
   - ☐ Treino condicionado de ginásio.
   - ☐ Treino condicionado com bola.
   - ☐ Treino condicionado de ginásio + Treino condicionado com bola.

7. Se não regressaste à competição nessa época desportiva, **quanto tempo paraste** até voltar aos treinos **de voleibol**? (inclui treinos que tenhas feito na *off season* ou de voleibol de praia)

   _____

8. Qual foi o **tratamento** da tua lesão? (podes selecionar mais do que uma opção de resposta)

   ☐ Tratamento **Médico Não Farmacológico** (ex: radiofrequência, terapia manual, reforço muscular, etc)
   ☐ Tratamento **Médico Farmacológico** (inclui medicação oral, injeção no local, medicação endovenosa)
   ☐ Intervenção **cirúrgica**
   ☐ Outro (por ex. Medicinas Alternativas): _____

9. Antecedentes
   - 9.1. Associas a lesão a um evento único? Sim ☐ Não ☐
   - 9.2. Foi a primeira vez que tiveste queixas no local da lesão? Sim ☐ Não ☐
   - 9.3. Tiveste queixas nesse local nos dias anteriores à lesão? Sim ☐ Não ☐
   - 9.4. Associas a lesão a algum sintoma que já tinhas antes? Sim ☐ Não ☐

10. Se respondeste "Sim" à última alínea:
    - 10.1. Esse(s) sintoma(s) implicou que tomasses medicação pelo menos 1 vez por semana, para conseguires treinar ou jogar? Sim ☐ Não ☐
    - 10.2. Esse(s) sintoma(s) impediu-te de treinar pelo menos uma vez, independentemente de teres tomado ou não medicação? Sim ☐ Não ☐

11. **Se associas a lesão a um evento único**, ela ocorreu:
    - ☐ Durante um jogo.
    - ☐ Durante um treino com bola.
    - ☐ Durante um aquecimento para treino ou jogo, sem bola.
    - ☐ Durante uma sessão de treino de condição física/ginásio/sessão de alongamentos.

12. Se a lesão ocorreu durante um **jogo** ou **treino**, qual dos seguintes fundamentos estavas a executar?

    ☐ Salto para Bloco ou Ataque
    ☐ Receção ao solo no Bloco ou Ataque
    ☐ Movimento de Bloco
    ☐ Movimento de Ataque
    ☐ Defesa ou Receção
    ☐ Serviço
    ☐ Passe/Distribuição
    ☐ Colisão com outro atleta (da mesma equipa ou adversária) ou estrutura (banco, poste, parede, etc)
    ☐ Outro _____

13. Se a lesão ocorreu durante um **jogo**, em que set foi?
    ☐ 1º set
    ☐ 2º ou 3º set
    ☐ 4º ou 5º set

14. Em que **posição** jogavas nessa época? (Podes selecionar mais do que uma opção de resposta.)
    ☐ Distribuidor(a)
    ☐ Central
    ☐ Zona 4
    ☐ Oposto(a)
    ☐ Líbero

15. Quantas horas por semana, em média, treinavas **com bola** na época em que te lesionaste?
    ☐ < 5h/ semana
    ☐ 5-8h / semana
    ☐ 8-10h / semana
    ☐ 10-13h / semana
    ☐ > 13h / semana
    ☐ Não me recordo.

16. Quantos jogos oficiais tinhas por semana, habitualmente, na época em que te lesionaste?
    ☐ 1 jogo.
    ☐ 2 jogos, por vezes.
    ☐ 2 jogos, em grande parte da época.
    ☐ 3 jogos, por vezes.

17. Na **época** em que te lesionaste, quanto tempo, em média, jogavas num jogo oficial?
    ☐ > 80% do jogo.
    ☐ 50-80% do jogo.
    ☐ 10 – 50%.
    ☐ < 10% do jogo.

18. Quantas horas **por semana**, em média, treinavas **condição física** (ginásio/musculação) na época em que te lesionaste?
    ☐ Não fazia.
    ☐ < 3h / semana
    ☐ 3-4h / semana
    ☐ ≥5h / semana
    ☐ Não me recordo.

19. Sobre o teu treino de **condição física** (ginásio/musculação), fazias:
    ☐ >50% das sessões com o apoio do Preparador Físico da Equipa.
    ☐ >50% das sessões com o apoio de um preparador físico Externo.
    ☐ >50% das sessões sem o apoio de um preparador físico (da equipa ou externo).
    ☐ 50% sozinho, 50% com apoio de um qualquer preparador físico.
    ☐ Não aplicável.

20. Lembras-te quanto **pesavas** no momento da lesão?
    ☐ Peso aproximadamente igual ao atual.
    ☐ Outro: _____ Kg

21. Lembras-te quantas horas **dormias** por noite na altura da lesão?
    ☐ < 5h
    ☐ 5-6h
    ☐ 6-7h
    ☐ 7-8h
    ☐ > 8h

22. Houve recorrência da lesão?
    Sim ☐ Não ☐

23. Continuar para responder ao inquérito para a **Lesão 2.**
    Sim ☐ Não ☐

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