



# Playing for Profit, Healing for Survival: The Economics, Risks and Legal Protection of Portuguese Professional Football

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## Doutoramento

**Playing for Profit, Healing for Survival:  
The Economics, Risks and Legal Protection of Portuguese Professional  
Football**

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The Economics, Risks and Legal Protection of Portuguese  
Professional Football**

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# DEDICATORY

Dedico esta tese a todos os que, ao chegarem ao mundo, escolheram não apenas viver, mas edificar - pontes, sonhos, caminhos, conhecimentos e um amanhã.

A cada um que, com gestos silenciosos ou marcas indeléveis, moldam o Homem que me vou tornando.

Este trabalho carrega o reflexo das vossas mãos, o eco das vossas palavras, a força da vossa presença e o silêncio da vossa ausência, que me ensinam a caminhar, resistir e acreditar.

*“Ser lutador não é um estado de espírito, é um modo de vida”*

**ALMA**



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This thesis finds its roots in my childhood, where the values of perseverance and belief, instilled by my foundational pillars, became the bedrock of my character. The tradition that has always guided and inspired me, rooted in the greatness of my Father and Mother, has been both the spark of my ambition and the foundation of my will.

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## ABSTRACT

Sport is increasingly recognised as a major economic and social phenomenon, contributing to employment, tourism, infrastructure, and national identity. Within this context, football stands out as the most global and economically significant sport, combining mass popularity, commercialisation, and international reach.

Within this landscape, Portuguese professional football represents a distinctive case. Unlike the major European leagues, where revenues largely derive from ticket sales, broadcasting rights, and sponsorships, Portuguese sport societies rely structurally on the transfer market, positioning players as their most valuable assets in a producer-driven economy. Clubs play for profit by developing and exporting talent, yet their survival depends on the health, availability, and legal protection of those same players. Injuries, therefore, emerge as a critical disruptor of financial stability, sporting performance, and institutional governance.

The overarching objective of this research is to underscore the pivotal role of players in the Portuguese football industry, where the business model predominantly depends on the transfer market and relies on homegrown talent within a producer-driven structure. To achieve this, the thesis pursues four objectives: (i) to analyse the economic structure of Portuguese professional football and the role of players as strategic assets; (ii) to identify and evaluate predictors of injury severity using artificial intelligence applied to real-world data; (iii) to assess the incidence and severity of injuries across competitive tiers and identify risk patterns; and (iv) to critically evaluate the legal and regulatory framework of occupational risk and insurance, with a particular focus on Law No. 48/2023 and its comparative implications. These objectives were addressed through four scientific articles, each dedicated to one of these dimensions, providing complementary perspectives on the economics, risks, and regulation of Portuguese professional football

Methodologically, the thesis adopts an interdisciplinary and predominantly deductive approach, combining quantitative and qualitative techniques. It integrates financial and macroeconomic analysis of revenues and transfers; predictive modelling through a deep neural network applied to 1,639 injury records across five seasons; epidemiological and statistical methods, including descriptive, inferential, and cluster analysis, to examine injury patterns; and qualitative legal and regulatory analysis, situating Portugal's high-risk insurance regime in comparative perspective with other major jurisdictions.

Taken together, the four studies confirm that football players constitute the most important assets of Portuguese professional football, with their economic rights standing as the most highly valued intangible within the transfer-driven business model, directly shaping both club sustainability and macroeconomic outcomes. The thesis advances theoretical understanding by demonstrating the interdependence of economics, clinical risk, and legal governance in a system where injury risk undermines asset value and exposes structural fragility. Empirically, it provides original evidence on the predictors of injury severity, the incidence and distribution of injuries across leagues and player profiles and confirms that Portugal has established a unique work accident insurance system for professional football players, offering stronger protection than comparable international frameworks. Practically, it offers guidance for clubs, policymakers, and insurers, highlighting the need for balanced financial management, data-driven injury prevention and rehabilitation, and statutory protection that secures player welfare, financial resilience, and competitive fairness.

**Keywords:** Portuguese professional football industry, Player transfers, Players' Injury risks, Players' injury management, Players' occupational insurance.



# **JOGAR PARA O LUCRO, TRATAR PARA SOBREVIVER:**

## **A Economia, os Riscos e a Proteção Jurídica do Futebol Profissional Português**

### **RESUMO**

O desporto é cada vez mais reconhecido como um fenómeno económico e social de grande relevância, contribuindo para o emprego, o turismo, o desenvolvimento de infraestruturas e a própria identidade nacional. Neste contexto, o futebol destaca-se como o desporto mais global e economicamente significativo, combinando popularidade, com elevado grau de comercialização e alcance internacional.

Neste enquadramento, o futebol profissional português constitui um caso distintivo. Ao contrário das principais ligas europeias, onde as receitas provêm sobretudo da bilhética, dos direitos de transmissão televisiva e dos patrocínios, as sociedades anónimas desportivas portuguesas dependem estruturalmente do mercado de transferências, posicionando os jogadores como os seus ativos mais valiosos, numa economia orientada para a produção e exportação de talento. Os clubes rivalizam pelo lucro através do desenvolvimento e venda de jogadores, mas a sua sobrevivência depende da preservação da saúde, disponibilidade e proteção jurídica desses mesmos atletas. As lesões, por conseguinte, assumem-se como um fator crítico de disrupção da estabilidade financeira, do desempenho desportivo e da própria governação institucional.

O objetivo central desta investigação é sublinhar o papel fulcral dos jogadores na indústria do futebol português, cujo modelo de negócio assenta predominantemente no mercado de transferências e na valorização de talento nacional no quadro de uma estratégia orientada para a exportação. Para alcançar este propósito, a tese estabelece quatro objetivos: (i) analisar a estrutura económica do futebol profissional português e o papel dos jogadores enquanto ativos estratégicos; (ii) identificar e avaliar preditores da gravidade das lesões através da aplicação de inteligência artificial a dados empíricos; (iii) avaliar a incidência e gravidade das lesões em diferentes níveis competitivos e identificar perfis de risco; e (iv) avaliar, criticamente, o enquadramento jurídico e regulatório dos riscos profissionais e do seguro, com particular destaque para a Lei n.º 48/2023 e as suas implicações numa perspetiva comparativa. Estes objetivos foram desenvolvidos em quatro artigos científicos, cada um dedicado a uma destas dimensões, oferecendo perspetivas complementares sobre a economia, os riscos e a regulação do futebol profissional português.

Metodologicamente, a tese adota uma abordagem interdisciplinar e predominantemente dedutiva, combinando técnicas quantitativas e qualitativas. Integra a análise financeira e macroeconómica das receitas e transferências; a modelização preditiva através de uma rede neuronal profunda aplicada a 1.639 registos de lesões ao longo de cinco épocas; métodos epidemiológicos e estatísticos, incluindo análises descritivas, inferenciais e de clusters, para examinar padrões de lesão; e uma análise qualitativa jurídico-regulatória, que enquadra o regime português de seguro em perspetiva comparada com outras jurisdições relevantes.

No seu conjunto, os quatro estudos confirmam que os jogadores constituem os ativos mais importantes do futebol profissional português, sendo os seus direitos económicos o ativo intangível de maior valor no modelo assente em transferências, influenciando diretamente tanto a sustentabilidade dos clubes como os resultados macroeconómicos. A tese avança no plano teórico ao demonstrar a interdependência entre economia, risco clínico e

governança jurídica num sistema em que o risco de lesão compromete o valor dos ativos e expõe fragilidades estruturais. No plano empírico, fornece evidência original sobre os preditores da gravidade das lesões, a incidência e distribuição das mesmas entre ligas e perfis de jogadores, e confirma que Portugal estabeleceu um sistema singular de seguro de acidentes de trabalho para futebolistas profissionais, oferecendo níveis de proteção superiores aos de quadros jurídicos internacionais comparáveis. Do ponto de vista prático, apresenta orientações para clubes, decisores políticos e seguradoras, sublinhando a necessidade de uma gestão financeira equilibrada, de estratégias de prevenção e reabilitação baseadas em dados, e de um quadro legal que assegure simultaneamente o bem-estar dos jogadores, a resiliência financeira e a equidade competitiva.

**Palavras-chave:** Indústria do futebol profissional português, Transferência de jogadores, Riscos de lesões dos jogadores, Gestão do risco de lesões, Seguro de acidentes de trabalho de jogadores profissionais.



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# CHAPTER 1 - INTRODUCTION

## 1.1. Contextual Framework and Rationale

Sport is increasingly recognised as a multifaceted economic and social phenomenon, contributing significantly to national economies through employment, tourism, infrastructure development, social cohesion, and national identity (Ishac, 2024; Rääkkönen & Hedman, 2024; Zhang et al., 2024). The global sports market, valued at \$388.28 billion in 2020, is projected to reach \$440.77 billion in 2021, reflecting a compound annual growth rate of 13.5%. The sports market comprises the sale of sports services and related goods by entities, including organizations, sole traders, and partnerships, that provide live sporting events. (Kumar & Bhala, 2021).

Within this landscape, football (soccer) has emerged as the most globally widespread and economically significant sport, combining mass popularity, commercialisation, and international exposure to form a complex business ecosystem (Memari et al., 2021; Yiapanas et al., 2024; Sauer et al., 2024). With over 5 billion fans worldwide, played on every continent and supported by truly global media coverage, football's reach is unparalleled (FIFA, 2024). Over the last three decades, football has evolved from a largely cultural and recreational practice into a globalised industry characterised by intricate economic, social, and institutional dimensions (Yiapanas et al., 2024). Today, professional football operates within an interconnected ecosystem driven by multi-billion euro broadcasting deals, expansive sponsorship arrangements, global merchandising networks, and a transfer market whose annual turnover rivals the GDP of several countries (Millward, 2011; Peeters & Szymanski, 2014). This evolution has been accompanied by profound changes in the governance of clubs, leagues, and governing bodies, which must balance sporting integrity, financial sustainability, and stakeholder expectations (Plumley et al., 2018). In parallel, football clubs have increasingly evolved into sophisticated business entities, attracting foreign investment from individuals, corporations, and sovereign wealth funds. Their ownership structures now reflect football's dual status as both a financial asset and a tool of soft power (Rohde & Breuer, 2017).

Within this global industry, the professional football player occupies a unique position: far beyond being a performer on the pitch, the player has become a strategic asset whose market value, availability, and performance are decisive determinants of a club's competitive success and financial stability (Ascari & Gagnepain, 2007; Frick, 2007; Herm et al., 2014; Stolowy & Wu, 2025). The monetisation of players' performance and image rights, coupled with the volatility of the transfer market, renders clubs increasingly dependent on

maximising player availability while mitigating risks that could undermine both sporting and economic objectives. Thus, players are simultaneously the most valuable and the most vulnerable assets of football organisations.

The professional football industry is underpinned by a stark occupational reality: professional footballers face injury rates that far exceed those of traditionally high-risk professions (Ekstrand et al., 2021; López-Valenciano et al., 2023). The occupational risk profile of elite football is among the highest in professional sports (Ekstrand et al., 2011; López-Valenciano et al., 2020). Severe injuries (such as anterior cruciate ligament ruptures, recurrent hamstring strains, or degenerative joint conditions) often result in long-term absences, devaluation of the player's market worth, disruption of tactical planning, and deterioration of transfer (Drawer & Fuller, 2002; Pulici et al. 2023; Nieto Torrejón et al., 2024). These consequences extend well beyond the medical domain, reverberating across the economic and organisational dimensions of the game by affecting matchday revenue, sponsorship activation, broadcasting value, and even prize money distribution (Eliakim et al., 2020; Dallmeyer et al., 2025).

In Portugal, football is not only the most popular sport but also a key economic sector with global relevance, where clubs rely predominantly on player development, valuation, and transfers as primary revenue sources, unlike in larger leagues where broadcasting, sponsorship, and matchday income dominate (Behravan & Razavi, 2021).

For many Portuguese clubs, trading players is not merely supplementary but constitutes the primary source of income, frequently accounting for over 50% of total revenues (FBG, 2024; EY & Liga Portugal, 2025). This structural dependency highlights both the strategic economic value of players and the financial vulnerability of Portuguese sports societies to performance volatility and fluctuations in the transfer market (Rohde & Breuer, 2017; FBG, 2025). Portugal's longstanding tradition of nurturing elite football talent, exemplified by figures such as Luís Figo and Cristiano Ronaldo, has entrenched player development and transfers as a central economic pillar of the industry. Preserving and enhancing the value of this human capital is therefore critical not only for sporting success but also for financial sustainability. Against this background, understanding injury dynamics becomes essential: injuries affect not only on-field performance but also carry significant economic repercussions through their impact on player valuation and transfer potential (Kowalski, 2022).

Despite the centrality of this issue, limited research has examined how player health intersects with club economics in the Portuguese context, revealing a critical gap in the literature on risk management and financial sustainability. Addressing this, recent work has underscored the need for integrated injury prevention and management policies, framing them not only as ethical responsibilities but also as economic necessities for safeguarding

key assets within a globalised market (Memari et al., 2021; Zhang et al., 2024). While considerable academic research has focused on the drivers of football injuries and their severity (e.g., Smpokos et al., 2018; Lopez-Valenciano, 2020; Ekstrand et al., 2021; Robles-Palazón, 2022; Dada et al, 2024), far fewer studies have done so within the context of Portuguese professional football (Brito et al., 2016; Martins et al., 2022; Teixeira et al., 2024). The limited evidence available in Portugal is often based on small or non-representative samples, which restricts the generalisability of findings and hinders the development of concrete, evidence-based policies for injury prevention and management.

This doctoral thesis aims to address these gaps by conducting in-depth analyses based on all players who sustained injuries in Portugal's First and Second Leagues over five consecutive seasons. By encompassing the full population of injured professional players during this period, the study seeks to provide robust, generalisable insights into injury severity and its implications for both sporting performance and club economics.

Complementing economic and medical perspectives, the Portuguese legal and regulatory framework formally recognises professional football as a high-risk occupation and establishes compulsory insurance coverage, including disability safeguards (Law N° 48/2023). Portugal is one of the few countries worldwide where occupational accident insurance is mandatory for football players. Cross-country comparisons reveal persistent disparities in legal standards, insurance scope, and institutional coordination, complicating risk allocation in an increasingly globalised football market. Although complete harmonisation remains elusive, identifying core regulatory principles can inform policy reform and international cooperation. These insights contribute to understanding occupational risk regulation in sport and offer guidance for designing sustainable and equitable protection systems for professional athletes.

Researchers often classify academic literature addressing injury risk in football into three disciplinary silos:

- Economics and management, analysing the financial implications of player availability on club budgets, transfer market behaviour, and competitive balance (Frick, 2007; Peeters & Szymanski, 2014; Plumley et al., 2018);
- Sports medicine and epidemiology, focusing on injury mechanisms, incidence, prevention strategies, and rehabilitation outcomes (Ekstrand et al., 2011; López-Valenciano et al., 2020);
- Law and insurance, exploring contractual obligations, occupational risk classifications, and the design of insurance mechanisms tailored to the needs of elite athletes (Siekman, 2012; Weatherill, 2017; Soek & Siekman, 2023).

Despite progress in each field, there remains a critical gap in integrating these perspectives into a unified analytical framework. This doctoral thesis responds to that gap by bridging Management and Health Sciences across three interconnected sectors- Economy, Health, and Sport, to offer a holistic view of injury risk as both a medical and an economic governance issue (Drawer, & Fuller, 2002).

## **1.2. Personal and Academic Motivation**

The motivation for this research stems directly from the candidate's professional experience as a strategic manager of injuries in sport, with a particular focus on professional football. From this experience, five converging realities underpin and drive the present study:

1. Professional football holds strategic importance in the Portuguese economy, with football players' economic and sporting rights serving as the principal intangible assets that underpin both value creation and the operational sustainability of sports societies.
2. The player holds a dual status as both a productive agent and a high-value asset in the Portuguese football industry.
3. The persistently high incidence of injuries jeopardises not only individual careers but also the financial sustainability and competitive balance of clubs.
4. The need to identify strategic instruments that enable clubs to prevent injuries and manage players as core assets.
5. The ongoing evolution of the legal and technological landscape calls for interdisciplinary approaches to risk management that integrate medical, economic, and regulatory considerations.

There is a marked scarcity of studies combining economic, medical, and legal perspectives on football injuries, especially in the Portuguese context. As Portuguese researchers, we occupy a unique position to address this gap, leveraging our proximity to the sector and our familiarity with its institutional environment. Moreover, the interdisciplinary convergence of Management and Health Sciences applied to Economy, Health, and Sport provides a rare analytical lens with significant academic and practical value, motivating us to respond to the real-world challenges and realities experienced within the professional football industry.

Injury risk in professional football is not merely a medical or legal concern; it is a systemic issue that shapes financial planning, competitive balance, and player health and welfare. Its complexity and societal visibility make it both scientifically urgent and broadly engaging. These considerations lie at the heart of *Playing for Profit, Healing for Survival: The Economics, Risks and Legal Protection of Portuguese Professional Football*. This thesis seeks to illuminate this multifaceted reality through an integrated and policy-relevant academic inquiry.

### **1.3. Research Objectives**

As indicated by the title of this doctoral thesis - *Playing for Profit, Healing for Survival: The Economics, Risks and Legal Protection of Portuguese Professional Football*, the research aims to provide an integrated understanding of the economic and management impact of injuries in Portuguese professional football, examining their intersections with clinical management, player valuation, sporting performance, and legal protection frameworks.

Rooted in the interdisciplinary rationale outlined above, the overarching objective of this research is to underscore the pivotal role of players in the Portuguese football industry, where the business model predominantly depends on the transfer market and relies on home-grown talent within a producer-driven model.

The present doctoral thesis is articulated through four core objectives. The thesis aims to:

1. Analyse the economic structure of Portuguese professional football, with a particular focus on the strategic role of professional players' economic and sporting rights as the key intangible assets within a transfer-driven business model. It further aims to examine clubs' reliance on player development and transfer activity as primary revenue sources, and to assess the associated microeconomic and macroeconomic risks, including the financial and market implications of player injuries for both club sustainability and Portugal's position within the global football economy.
2. Identify and evaluate the key predictors of injury severity among professional football players in Portugal. This objective involves designing and validating predictive models based on real-world data, aimed at enhancing injury prevention strategies, supporting personalized rehabilitation and medical decision-making,

and informing risk management and actuarial processes within sports insurance frameworks.

3. Analyse the incidence and severity of injuries among professional football players in Portugal's First and Second Leagues, considering intrinsic and extrinsic factors, and to identify patterns that inform tailored prevention strategies and resource allocation at the club level.
4. Critically evaluate the legal and regulatory architecture governing occupational risk and injury insurance in professional football, with a particular focus on Portugal's Law (Law N° 48/2023). This includes analysing its implications for mandatory occupational accident insurance, its alignment with international legal frameworks, its capacity to reconcile player protection with the financial resilience of clubs, and the implications of cross-country regulatory disparities for risk management and policy development.

We operationalise these four overarching objectives through four scientific articles, which together form the core of this doctoral thesis. Each article examines a specific dimension of professional football injuries in Portugal, reflecting the integrated economic, medical, and legal perspective that underpins our research. Therefore:

Article 1. *Players as Strategic Assets in Portuguese Professional Football: Micro and Macroeconomic Perspectives of a Transfer-Driven Industry* examines the unique economic model of Portuguese football, highlighting clubs' reliance on player development and transfers as primary revenue sources. This study demonstrates that players are the most strategically valuable assets, whose health and performance are pivotal for both club sustainability and the broader national economy.

Article 2. *Predicting Injury Severity in Portuguese Professional Football: An AI-Driven Analysis Using Deep Neural Networks* focuses on the determinants of injury severity. Using machine learning techniques to record injuries, the study identifies key predictors such as recovery time, injury history, tactical position, and nationality, emphasising the importance of evidence-based, personalised injury management and rehabilitation strategies.

Article 3. *Real-World Injury Patterns in Portuguese Professional Football: Risk Profiles and Socioeconomic Concerns* investigates the incidence and severity of injuries across the First and Second Leagues over five seasons. By analysing intrinsic and extrinsic factors, including age, nationality, match participation, tactical position, and league level, the article uncovers distinct risk profiles, showing higher incidence among non-European players and greater severity in the Second League, thereby linking player characteristics and league context to strategic risk management considerations.

Article 4. *Occupational Safety and Injury Risk in Professional Football: The Portuguese Legal Framework in Comparative Perspective* addresses the regulatory and legal dimensions of player protection. Focusing on Portugal's Laws No. 48/2023 and situating them within a cross-country comparison, the study evaluates how legal frameworks and insurance requirements safeguard player welfare while imposing financial pressures on clubs, offering practical insights for policy reform and sustainable risk governance.

Collectively, the four underlying objectives of the thesis and their articles provide a comprehensive and interdisciplinary examination of injuries in Portuguese professional football, integrating economic, medical, and legal perspectives to inform both academic knowledge and practical policy interventions. By linking the objectives to the articles, this thesis bridges economic theory, sports medicine, and legal governance within a unified analytical framework for managing injury risk. The contribution is twofold: academically, by advancing the interdisciplinary literature on sports injury risk; and practically, by supporting the development of sustainable, equitable, and data-driven strategies to protect players' health, preserve their economic value, and enhance their sporting contribution as the game's most valuable assets.

The core doctoral thesis model illustrated in Figure 1.1. encapsulates the analytical pathway underpinning this research.

Figure 1.1. Core Doctoral Thesis Model



Source: Own elaboration

The analysis follows a structured approach, moving from the general to the specific. It begins with the macroeconomic significance of the Portuguese professional football industry, emphasising its structural dependence on the transfer of players' economic rights. From this foundation, it recognises professional players as the most important and strategic assets of sports societies, whose preservation is critical not only for sporting success and club sustainability but also for the broader Portuguese economy through capital balance. The subsequent step addresses players' injury by exploring and developing data-driven methodologies to predict and manage injuries, thereby strengthening clubs' capacity to safeguard these assets and optimise performance outcomes. The analysis concludes with a legal perspective on the mandatory occupational accident insurance framework.

## **1.4. Methodology**

### **1.4.1. General Methodological Framework**

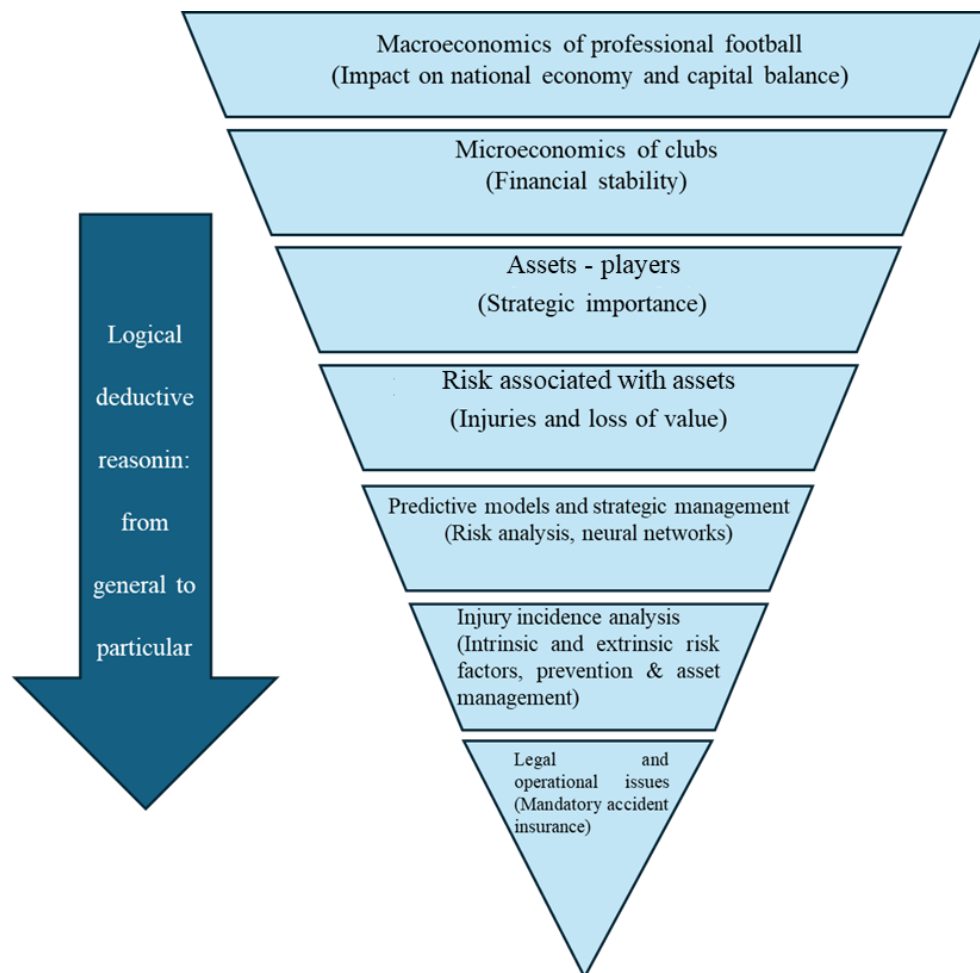
The methodological framework of this doctoral research is designed to support an integrated and rigorous analysis of the economic, sporting, and legal aspects of Portuguese professional football. Given the multidisciplinary nature of the study, combining economics, sport management, and law, the overall approach is both quantitative and qualitative, adopting data-driven techniques alongside theoretical and regulatory analysis.

From an epistemological perspective, economic and management research typically draws on three types of reasoning: deductive, inductive, and abductive (Johnson, 1996; Haig, 2005; Salmon, 2014; Bradfield, 2016). Deductive reasoning, which underpins the present thesis, moves from general theoretical frameworks to cases, providing a structured logic for hypothesis formulation and testing (Blachowicz, 2009; Mahootian & Eastman, 2009). This research primarily employs deductive reasoning, while acknowledging abductive reasoning, which explains observations through hypothesis formulation (Shelley, 1996; Haig, 2005), and inductive reasoning, which generalises from empirical observations (Blachowicz, 2009; Mahootian & Eastman, 2009), as less central approaches.

The research strategy is structured to ensure consistency and comparability across the multiple studies that comprise the thesis. It incorporates macroeconomic analyses to evaluate the structural and financial significance of professional football, statistical and econometric methods to examine the incidence, severity, and determinants of player injuries, and legal-analytical approaches to assess occupational risk protection, particularly in the context of mandatory insurance schemes. Figure 1.2. illustrates this deductive model, which progressively narrows the analytical lens through seven interconnected stages. It moves from the macroeconomic environment (Step 1) to microeconomic dynamics,

focusing on sports clubs' financial stability (Step 2); then to the strategic management of players as key assets (Step 3); followed by injury risk modelling (Step 4) and comprehensive epidemiological and statistical analysis of injury incidence and severity (Steps 5 and 6); and finally culminates in the legal-institutional framework governing risk mitigation (Step 7).

Figure 1.2. Research Scientific Method



Source: Own elaboration

This structure ensures that each empirical study builds upon the conceptual and analytical foundations of the preceding stage, providing an integrated framework that bridges economics, strategic management, clinical risk assessment, and sports law in the governance of injury risk in Portuguese professional football.

Each subsequent article applies tailored methodological tools appropriate to its research questions, including descriptive and inferential statistics, advanced modelling techniques, and comparative regulatory analysis, providing a robust foundation for interdisciplinary insights and evidence-based policy recommendations.

### **1.4.2. Chapter-Specific Methodology**

Each chapter of this thesis adopts a distinct methodological approach, reflecting the interdisciplinary nature of the research and the specific analytical needs of the four scientific articles that form its core. The organisation of the work follows a logical progression.

Chapter 2. relies on publicly available secondary data retrieved from the Bank of Portugal, the Portuguese National Institute of Statistics, Transfermarkt, and the Football Yearbooks of the sport societies to conduct a descriptive quantitative analysis of the industry's impact on the Portuguese GDP and capital balance over five consecutive seasons (2016/17 - 2020/21). The chapter also synthesises information on the overall revenues of sport societies, with particular emphasis on income generated from the transfer of players' economic rights during the same period.

Chapter 3 applies quantitative predictive modelling techniques through a deep neural network, using data from 1,639 injuries recorded over five consecutive seasons (2016/17–2020/21) in Portugal's First and Second Leagues. This approach predicts the severity of football players' injuries based on real-world evidence.

Chapter 4 adopts a quantitative approach to examine the drivers of injury incidence and severity in Portuguese professional football over five seasons (2016/17–2020/21). The analysis considers intrinsic factors (age, nationality) and extrinsic factors (tactical position, match participation, competition intensity, and environmental conditions). Statistical methods, including descriptive statistics, inferential tests, and cluster analysis, were employed to identify high-risk player profiles and patterns of injury distribution across the First and Second Leagues.

Chapter 5 adopts a qualitative, descriptive methodology combining statutory analysis, regulatory review, and economic impact assessment. It examines Portugal's Law No. 48/2023, which mandates occupational accident insurance for professional athletes, as a legal and operational risk mitigation tool. The chapter analyses the law's implementation and economic consequences for clubs, players, and insurers, and situates the Portuguese model in an international context through comparison with six jurisdictions (Spain, Germany, England, Italy, France, and Brazil). This comparative framework highlights best practices,

regulatory gaps, and policy trade-offs between player protection, financial sustainability, and competitive equity.

## 1.5. Thesis Outline

This thesis is structured into six chapters, each contributing to a comprehensive understanding of the economic, clinical, and legal dimensions of injury risk in Portuguese professional football. The organisation reflects a deductive progression, moving from broad conceptual and macroeconomic perspectives towards increasingly specific, operational, and policy-oriented analyses. Figure 1.3. illustrates the thesis outline

### ➤ **Chapter 1 – Introduction**

This opening chapter presents the contextual framework and rationale, the motivations, objectives, and the methodological foundations of the thesis. It contextualises the research within the intersections of sports economics, injury epidemiology, and law, and introduces the theoretical and empirical gaps addressed by the study. It also outlines the thesis' core analytical framework, detailing the relationship between the research questions and objectives. This chapter concludes with the *Thesis Outline*, providing readers with a roadmap of the work.

### ➤ **Chapter 2 – *Players as Strategic Assets in Portuguese Professional Football: Micro and Macroeconomic Perspectives of a Transfer-Driven Industry* (submitted to the *Sport, Business, Management: an International Journal*, 21 July 2025)**

The article examines the economic structure of Portuguese professional football, underscoring its strategic dependence on player development and transfers as the primary revenue sources. From both macro and microeconomic perspectives, it highlights the central role of football players' economic and sporting rights as the most important intangible assets of the industry. The analysis assesses the industry's contribution to national GDP, incorporates financial data from Portuguese sports societies, and evaluates the role of player transfers in the country's capital balance. Particular attention is given to the risks arising from the depreciation of these assets, most notably through injuries. In addition, the article characterises the Portuguese football model as a producer-driven system, in which clubs concentrate

on the development and training of players with the primary objective of subsequently trading their economic rights.

- **Chapter 3 – *Predicting Injury Severity in Portuguese Professional Football: An AI-Driven Analysis Using Deep Neural Networks* (submitted to *BMC Sports Science, Medicine and Rehabilitation*, 17 April 2025)**

This chapter develops and validates predictive models for estimating injury severity among professional football players, using deep neural networks applied to five consecutive seasons of injury and match data (2016/17–2020/21) from Portugal’s two top leagues. The analysis demonstrates the potential of artificial intelligence to support preventive strategies, optimise rehabilitation planning, and enhance actuarial risk assessments for sports insurance.

- **Chapter 4 – *Real-World Injury Patterns in Portuguese Professional Football: Risk Profiles and Socioeconomic Concerns* (submitted to the *European Journal for Sport and Society*, 16 May 2025)**

This chapter investigates intrinsic and extrinsic risk factors associated with injury incidence and severity, using descriptive, inferential, and cluster analyses of five seasons (2016/17 – 2020/21) of Portuguese professional football data. It explores how intrinsic factors such as age and nationality, together with extrinsic variables such as tactical position, match participation, competition level, and environmental factors, shape injury patterns. Finally, it discusses the socioeconomic implications of these findings for clubs, players, and league competitiveness.

- **Chapter 5 – *Occupational Safety and Injury Risk in Professional Football: The Portuguese Legal Framework in Comparative Perspective* (submitted to *Safety*, 12 August 2025)**

This chapter offers a qualitative and descriptive analysis of the evolution of Portugal’s legal framework on occupational accident protection in professional football, culminating in Law No. 48/2023, which consolidates the high-risk status of the activity and strengthens the mandatory insurance regime for athletes. The study situates this reform within the broader economic model of Portuguese professional football, structurally dependent on the commercialisation of players, and contrasts it with regulatory frameworks in Spain, Germany, England, Italy, France, and Brazil. It highlights the dual effect of the reform: enhanced player protection through universal coverage and disability safeguards, alongside increased financial pressures on clubs due to a concentrated insurance market and rising premium costs. The

chapter further shows that cross-country disparities in legal standards and institutional coordination hinder full harmonisation, though shared principles can guide policy reform. It concludes with evidence-based recommendations aimed at reconciling player protection, financial sustainability, and competitive equity.

➤ **Chapter 6 – Conclusions**

The final chapter synthesises the main findings from the four empirical studies, presents the conceptual and practical contributions of the thesis, discusses its limitations, and proposes directions for future research. It also reflects on the broader implications of the research for sports governance, risk management, and the sustainable development of professional football.

Figure 1.3. Thesis Outline



Source: Own elaboration



# CHAPTER 2 – PLAYERS AS STRATEGIC ASSETS IN PORTUGUESE PROFESSIONAL FOOTBALL: MICRO AND MACROECONOMIC PERSPECTIVES OF A TRANSFER-DRIVEN INDUSTRY

Manuscript submitted to Sport, Business, Management: An International Journal on 21 July 2025

## Abstract

**Purpose:** Sport is increasingly recognised as an important economic sector, with football being the most commercially influential and globally followed sport, holding significant socio-economic value in Portugal. This paper examines the economic structure of Portuguese professional football, highlighting its strategic dependence on player development and transfers as primary revenue sources, and discussing the implications of this model at both the micro and macro levels. **Design/methodology/approach:** Using financial and operational data from five consecutive seasons (2016–2021), this study provides a descriptive analysis of the industry's business model and its economic impact, considering revenue composition, talent export, and associated risks. **Findings:** Unlike most major European leagues, where revenues stem mainly from broadcasting rights, ticket sales, and sponsorships, Portuguese teams rely heavily on the development and transfer of players, positioning athletes as the primary intangible assets of sports societies. Findings highlight the strategic role of talent development and transfer activity in driving club revenues and reinforcing Portugal's status as a key supplier of elite players to international markets. This structural dependence makes teams highly vulnerable to market volatility and injury risks, which can undermine both sporting performance and asset value. Integrated injury prevention policies are economically essential, as they impact team risk management and have significant macroeconomic effects on Portugal's integration into global football markets. **Originality:** The paper offers a comprehensive perspective that integrates sports economics and health risk management, examining the microeconomic and macroeconomic implications of a distinctive business model and highlighting the strategic significance of protecting player welfare.

**Keywords:** Portuguese football industry, Sports economics, Player transfers, Players' economic and sporting rights, Intangible assets, Talent development, Injury risk management, Microeconomic impact, Macroeconomic impact, Capital account balance.

## 2.1. Introduction

Sport is increasingly recognised as a multifaceted economic and social phenomenon, contributing significantly to national economies through employment, tourism, infrastructure development, social cohesion, and national identity (Ishac, 2024; Rääkkönen & Hedman, 2024; Zhang et al., 2024).

Within this landscape, football has emerged as the most globally widespread and economically significant sport, evolving into a truly multinational industry present in over 211 countries. Despite global economic challenges, football has maintained robust growth, with its mass popularity, media exposure, and commercialisation transforming it into a complex business ecosystem (Memari et al., 2021; Kowalski, 2022; Sauer et al., 2024; Yiapanas et al., 2024). In 2017, European football clubs generated an estimated \$27 billion in revenue (Behravan and Razavi, 2021). By 2024, the combined Enterprise Value of Europe's (total economic worth of a club combining equity and net financial debt adjusted for cash holdings) 32 leading clubs reached EUR 59.1 billion, a 124% increase since 2016 and a 14% rise from the previous year (FBG, 2025), confirming football's growing status as a dominant force in the global entertainment sector.

Football clubs have increasingly become sophisticated business entities, attracting foreign investment from individuals, corporations, and sovereign wealth funds, with ownership structures reflecting football's status as both a financial asset and a tool of soft power (Rohde & Breuer, 2017). Structural and legal changes, such as the Bosman ruling in 1995, enhanced labour mobility and commercialisation (Goddard et al., 2012), while soaring transfer fees, totalling \$8.59 billion globally in 2024 (FIFA, 2025), underscore the sport's expanding financial footprint.

Beyond economics, football also holds significant social impact, with empirical research suggesting that international football success can be correlated with macroeconomic indicators such as GDP per capita and the Human Development Index (Mendoza, 2017). Football has even been likened to a form of global cultural heritage, reflecting its deep-rooted societal impact (Hammerschmidt et al., 2021; Fan et al., 2023). In Portugal, football is not only the most popular and widely followed sport but also a key economic sector with global significance (Nuno Coelho & Tiesler, 2007). However, academic research on the economic and financial dimensions of Portuguese professional football remains limited, particularly regarding its most valuable intangible asset: players. Unlike clubs in larger markets, where revenues derive mainly from broadcasting, sponsorship, and matchday income, the financial sustainability of Portuguese football clubs relies predominantly on player development, valuation, and international transfers. Within

this transfer-driven model, the English Premier League is particularly vital, as it constitutes the principal destination and leading purchaser of Portuguese players, thereby underpinning the financial stability of domestic clubs.

This paper addresses this gap by analysing the transfer of players' economic and sporting rights, where economic rights refer to entitlements to financial benefits from transfers, and sporting rights concern the entitlement to register and field a player. It demonstrates how these rights are significant to the national economy and to the financial stability of football clubs, providing a comprehensive assessment of the economic relevance of professional football in Portugal, with particular emphasis on the strategic role of players. Drawing on data from five consecutive seasons (2016–2021), the study examines how players' transfers, youth development, and international mobility not only shape sporting success but also sustain the financial viability of Portuguese sport societies (or SADs, an acronym for *Sociedades Anónimas Desportivas*, the term used in the Portuguese context). By positioning players as key strategic assets within the global transfer market, this research highlights the central role they play in the industry's sustainability. Furthermore, it highlights the crucial importance of safeguarding players' health, particularly through the prevention and management of injuries, as players' availability, performance, and market value are closely intertwined. In this context, ensuring player well-being is not only an ethical imperative but also a fundamental economic concern for football clubs operating in increasingly competitive national and international markets.

## **2.2. The Economic and Institutional Context of Professional Football in Portugal**

### **2.2.1. Institutional and Legal Framework - Sports Societies (SADs) and Professional Leagues in Portugal**

The legal and institutional framework governing professional football in Portugal is rooted in the 1st Basic Law of the Sports System (Law no. 1/90), which introduced the formal creation and regulation of legal entities specifically designed for the management of professional sports competitions, including sports societies or SADs (terms that will be used interchangeably throughout this paper) and the professional leagues. Although Liga Portugal, the body responsible for organising professional football competitions, was officially founded in 1978, its structure and governance have evolved significantly through successive legislative reforms aimed at increasing financial transparency, competitive balance, and organisational autonomy (Law no. 19/96; Law no. 5/2007).

In the Portuguese context, professional football is structured around an autonomous league system, namely Liga Portugal, which possesses administrative, technical, and financial independence while still operating under the umbrella of the Portuguese Football Federation. Liga Portugal is responsible for managing the Primeira Liga (First league), Segunda Liga (Second league), and Taça da Liga (League Cup), encompassing a total of 34 SADs: 18 in the top tier and 16 in the second league (although there are 18 teams).

Portuguese sports law differentiates between sports clubs and sports societies. Sports Clubs are non-profit associations primarily focused on promoting and practicing sports at the amateur and community levels. In contrast, sports societies are for-profit limited liability companies dedicated to managing professional sports teams and related commercial activities, such as event organisation, merchandising, broadcasting rights, and sponsorship competitions (Law no. 10/2013).

The creation of SADs allowed Portuguese football to adapt to the demands of the modern sports industry, facilitating capitalisation, attracting investment, and enhancing professional management practices. While the SAD model aims to improve financial transparency and operational efficiency, sports clubs remain central to the cultural and historical identity of Portuguese football. This dual structure ensures that while the commercial dimension of football is developed through SADs, the core social and community role of sports clubs is preserved, balancing market-oriented dynamics with the safeguarding of tradition and social impact.

The development of SADs has played a pivotal role in the modernisation and professionalisation of Portuguese football. By enabling clubs to access capital markets, attract foreign and domestic investment, and enhance corporate governance, the sport societies model has fostered greater financial stability and competitiveness in both domestic and European competitions (Barros & Leach, 2006). The increasing professionalisation of the sector has strengthened governance structures and enhanced transparency, aligning it more closely with broader economic development goals (Barros and Leach, 2006).

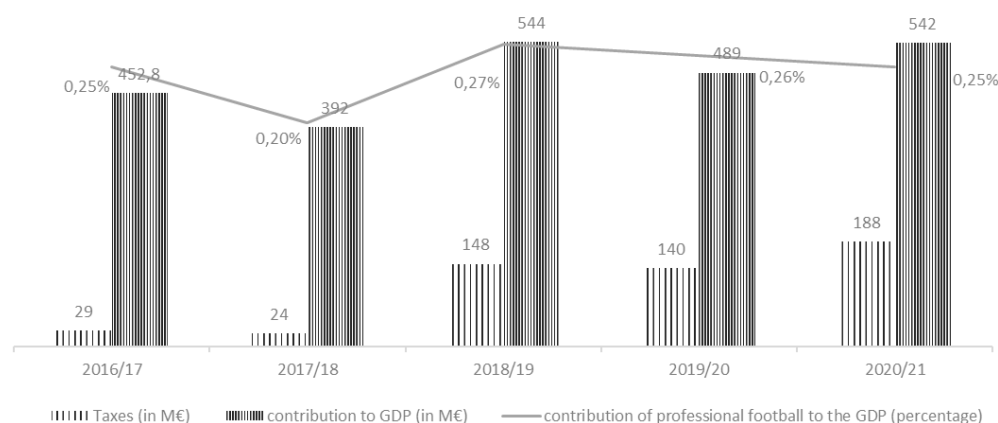
In recent years, several Portuguese clubs have benefited from this structure, securing substantial revenues from player transfers, broadcasting rights, and commercial sponsorships - revenue streams that are crucial for maintaining competitiveness in the highly globalised football industry (Silva & Filipe, 2013). Moreover, the SAD system has facilitated the growing integration of Portuguese teams into international markets, particularly through the export of football talent, which has become a defining characteristic of the country's football economy. However, this commercialisation also raises challenges concerning financial sustainability, competitive inequality, and the tension between sporting success and profit maximisation, issues that continue to attract academic scrutiny (Andreff, 2009; Plumley et al., 2018).

## **2.2.2. Economic Relevance of Sports Societies and Professional Leagues in Portugal**

The Portuguese professional football league and its associated sports societies exert a significant social and economic impact on the country. Socially and culturally, football is profoundly rooted in Portuguese society, serving as a significant source of entertainment and emotional expression for a wide demographic. It plays a key role in shaping local and regional identities, reinforcing community cohesion, and offering a socially acceptable outlet for collective tensions, often functioning as a "social safety valve" (Moreau et al., 2020). Football also permeates various dimensions of Portuguese social life, from neighbourhood rivalries to national pride, thereby embedding itself in the country's social fabric (Armstrong and Giulianotti, 2001). Economically, the professional football sector operates as a powerful engine for ancillary industries, including tourism, media, retail, and betting (Barros & Ibrahimo, 2002). Furthermore, the international visibility of Portuguese clubs and players enhances the country's global prestige and soft power (Rookwood, 2019; Gouveia, 2022).

Economically, the contribution of professional football, namely the two leagues, to the Portuguese economy is also evident in its impact on country's balance of payments through the capital account, GDP and taxes associated with player salaries, club operations, and consumption related to football events. As illustrated in Figure 2.1, the football industry contributes steadily to Portugal's GDP, except for the Covid-19 pandemic period, when most competitions were temporarily halted. The football industry has consistently made a stable contribution to Portugal's GDP over the past five seasons, with its direct contribution varying between 0.2% and 0.27% of national GDP (EY and Liga Portugal, 2018, 2019, 2020, 2021, 2022). This consistent performance underscores the sector's resilience and ongoing economic significance, even amid broader economic fluctuations. Beyond its direct impact on GDP, professional football plays a significant role in strengthening the national tax base through multiple channels. The industry generates measurable revenues for the state through Corporate Income Tax, Personal Income Tax, Value-Added Tax, and Social Security contributions, underscoring its importance not only as an entertainment and cultural asset but also as a key contributor to public finances. It is worth noting that this figure excludes the industry's wider indirect economic effects in related sectors such as catering, accommodation, media, betting, and transportation. In 2024, for example, the total volume of sports betting in Portugal amounted to €2.053 billion, with football alone accounting for approximately 75% of this figure (SRIJ, 2024).

Figure 2.1. Contribution of the Football Industry to GDP (%) and tax revenue (million euros)



Source: Author's own elaboration based on data from EY and Liga Portugal (2018, 2018, 2020, 2021, 2022).

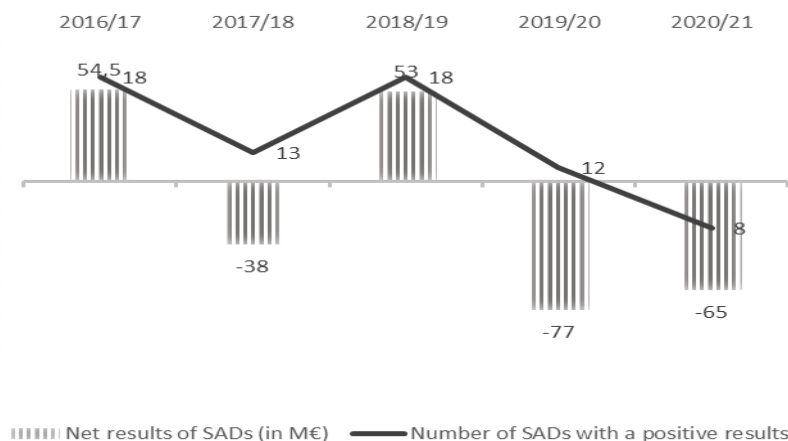
Additionally, the football industry in Portugal plays a crucial economic role by supporting national employment. According to the fifth edition of the Portuguese Professional Football Yearbook, the 2020–21 season recorded a historic high of 3,729 direct jobs, reflecting a 4.2% increase over the previous season (EY & Liga Portugal, 2022). Moreover, football has become a cornerstone of Portugal's sports tourism sector. High-profile matches, most notably international fixtures and European club competitions, regularly attract thousands of visitors, generating significant economic benefits for local industries such as hospitality, catering, transport, and other services (Sousa & Maguire, 2022). Even at the grassroots level, increasing youth participation and regional tournaments stimulate local economies and contribute to sustainable economic development (Sousa & Maguire, 2022). Consequently, professional football in Portugal operates as a vibrant economic activity and occupies a strategically important position within the national economic landscape.

In a nation with a relatively small domestic market, Portugal's football infrastructure and international reach render the sport not only a cultural emblem but also an essential economic instrument aligned with national development and global visibility objectives.

### 2.2.3. Financial Performance and Sustainability of Sports Societies

Despite the football sector's overall economic importance, individual SADs in Portugal reveal persistent structural weaknesses. This is particularly concerning, as the financial performance of clubs has been recognised as a key determinant of their long-term viability (Ati et al., 2024). Most Portuguese SADs face financial instability, often operating under conditions that verge on technical bankruptcy. As depicted in Figure 2.2, aggregated net results for sports societies across five consecutive seasons show negative results in three of them. Financial statements confirm that most Portuguese sports societies regularly report negative net results, with many technically operating under conditions of bankruptcy. Even in the best-performing years, no more than 18 societies (just over 50%) have reported positive net outcomes (EY & Liga Portugal, 2018, 2019, 2020, 2021, 2022). In the 2020/21 season, only eight societies achieved positive results, underscoring the fragile financial health of the sector (EY & Liga Portugal, 2022).

Figure 2.2. Results of sports societies competing in Portuguese professional leagues (million euros).

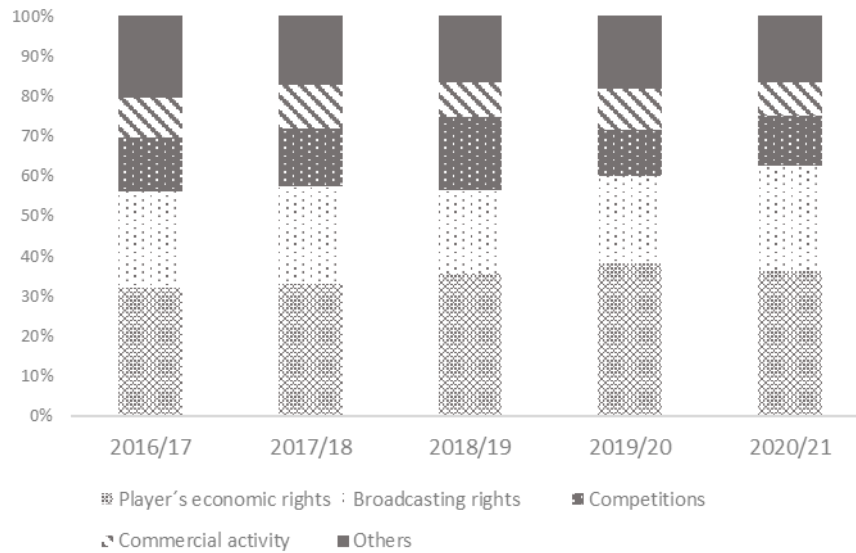


Source: Author's own elaboration based on data from EY and Liga Portugal (2018, 2018, 2020, 2021, 2022).

The sale of players' economic and sporting rights emerges as a crucial factor in restoring financial balance. As shown in Figure 2.3., income from the development and sale of economic rights over football players constitutes the primary source of revenue for most sports societies, on first league, surpassing other streams such as broadcasting rights, competitions, and commercial sponsorships. This revenue dependency not only underscores the strategic economic value of players' economic and sporting rights but also

exposes SADs to considerable financial risk stemming from performance volatility and fluctuations in the transfer market.

Figure 2.3. First League Sport Societies Revenues



Source: Author's own elaboration based on data from EY and Liga Portugal (2018, 2018, 2020, 2021, 2022).

In this context, the role of players as the foremost economic asset of Portuguese football becomes even more evident, with the sale of their economic and sporting rights accounting for over 32% of total revenues across the five seasons analysed. The ability to develop, retain, and transfer talent is not only a sporting imperative but also an economic necessity for clubs seeking sustainability and growth. Understanding the economic dynamics surrounding players is therefore essential to fully appreciating the broader economic relevance of professional football in Portugal, a theme further explored in the following sections.

### 2.3. The Strategic Role of Football Players as the Primary Asset of Sports Societies

The continuous expansion of grassroots participation highlights the crucial role of football players as the primary asset of sports societies, ensuring both sporting excellence and economic sustainability. In the 2023/24 season, the Portuguese Football Federation (FPF) registered approximately 242,000 football and futsal players, representing a 9%

increase from the previous season, which demonstrates the strong grassroots appeal of the sport (FPF, 2024a). The continued growth in youth participation is especially evident in the under-7 category, which saw an increase of over 11% in registered players during the same period (FPF, 2024b). This sustained growth ensures a robust talent pipeline essential for both sporting success and the long-term economic sustainability of football in Portugal.

At the heart of this system are football players, whose development and progression from grassroots to elite levels make them the principal asset of sports societies. More than mere employees, players generate sporting performance and financial value, with their economic rights recognised as intangible assets in club balance sheets (Stolowy & Wu, 2025). Their market valuation, transferability, and on-field impact directly influence both competitive outcomes and financial performance. From an accounting perspective, footballers meet the criteria for recognition as intangible assets: they generate future economic benefits and can be reliably measured (Limba & Sapulette, 2021). Their value fluctuates based on performance, age, potential, and contractual conditions, making human capital management a strategic priority for professional clubs (Morrow, 2003). Player registrations often represent the most significant asset category for clubs in top leagues, influencing not only balance sheets but also investor confidence and access to credit (Sauer et al., 2024).

Framing this dynamic within a global value chain perspective reveals two dominant governance structures in world football: “producer-driven” models, where clubs invest in player development (common in the Global South), and “buyer-driven” models, where wealthier clubs in the Global North concentrate on acquiring talent (Brewer, 2017). These structures generate asymmetric resource flows and reinforce global inequalities, with Southern clubs acting as talent producers and Northern clubs capturing the highest value returns. It reinforces the strategic role of football players not only as key organisational assets but also as central nodes in global sporting and economic circuits. This strategic role creates a virtuous cycle: clubs with greater financial capacity can invest in talented players, increasing their chances of sporting success, which in turn boosts revenues and enhances the club's ability to attract further talent and capital (Lago et al., 2006).

Data from the Deloitte Annual Review of Football Finance on Europe's "Big Five" leagues reveals that player salaries consume a significant share of revenues, averaging around 75% and reaching up to 98% in France (Deloitte, 2023). In the English Premier League, for most clubs, the net value of players exceeds total net assets (Deloitte, 2023). Figures A2.1. and A2.2., in the appendix, provide detailed illustrations.

In Portugal, this dependency is particularly pronounced: limited revenues from ticket sales, broadcasting, and sponsorship have made the sale of players' economic rights, accounting for over 32% of sports societies' income in recent years, the cornerstone of

financial sustainability. The country's tradition of producing elite talent, from Luís Figo and Cristiano Ronaldo to Bernardo Silva and João Félix, underscores the strategic role of player development and transfer as a key pillar of the industry. This model has been reinforced by macro-level policies of the Portuguese Football Federation (FPF) and Liga Portugal, including the creation of the national under-23 league (Liga Revelação), rules promoting home-grown players (FPF, 2024c), and the authorisation of 'B teams' in the Second League (FPF, 2020). Preserving and enhancing this human capital is essential not only for sporting success but also for the financial survival of Portuguese clubs, with injuries representing a critical risk that can simultaneously undermine performance and revenues.

## **2.4. The global market for professional football players transfers and its micro- and macro-economic Impact**

The global football transfer market has evolved into a multi-billion-euro industry that plays a pivotal role in shaping the financial and sporting landscapes of professional clubs. Transfers involve the movement of players between clubs, typically in exchange for financial compensation. They are regulated by both international governing bodies, such as FIFA and UEFA, and by national football associations. Over the past decade, the football transfer market has emerged as a growing area of interest within the academic literature (Dieles et al., 2024; Minchuk, 2024; Van der Burg, 2024), reflecting its expanding economic and strategic significance.

### **2.4.1 International Mobility of Football Players and the Bosman Ruling**

The international mobility of professional footballers is a hallmark of the modern football industry, shaped by both push and pull factors, including performance ambitions, financial incentives, and improved training environments (Magee et al., 2022). Many athletes follow self-initiated expatriation paths, migrating temporarily by their own volition to pursue sporting careers abroad (Cerdin & Selmer, 2013). These individuals often rely on agents or scouts but ultimately make autonomous career decisions (Dolles & Egilsson, 2017).

This trend has reached significant scale: over 18,000 foreign players were active globally in top-tier leagues in 2015, and professional footballers change clubs on average six times, with around 40% of these moves being international (Poli et al., 2015; Velema, 2016). However, player migration is not evenly distributed. Economic disparities, regulatory

frameworks, and labour laws shape selective mobility patterns that favour wealthier leagues and regions (Maguire & Stead, 1998; McGovern, 2002; Poli & Ravenel, 2005).

A landmark in this trajectory was the Bosman Ruling in 1995, which eliminated transfer fees for out-of-contract players within the EU and lifted squad quotas for EU nationals. This legal shift aligned football with broader EU labour laws, securing freedom of movement for. Its impact was profound: the proportion of foreign players in major European leagues rose from 15% in 1995 to 35% by 2000 (Ichniowski & Preston, 2014). It also intensified global talent competition, prompting clubs to invest in youth development and player trading as core financial strategies (Norbäck et al., 2021).

For Portuguese clubs, the globalised player market underscores the strategic importance of developing domestic talent and safeguarding player value. As transfers constitute a major revenue source, particularly in countries with smaller commercial markets, the health, performance, and marketability of players are crucial to both sporting and financial sustainability. England has emerged as the leading destination for Portuguese player transfers, generating around 30% of international transfer revenues between 2014 and 2023, followed by Spain (19%) and France (13%) (CIES Football Observatory, 2023).

## **2.4.2. Types of Transfers and Legal Framework**

Football transfers take different forms, including permanent transfers, loans, and free transfers, each carrying distinct financial and strategic implications for clubs (Liu et al., 2016; Velema, 2019). Permanent transfers involve a player moving between clubs with a transfer fee (economic and sporting rights), although fees may sometimes be undisclosed or involve player swaps, which are treated as free transfers in some analyses (Liu et al., 2016). Loan deals (temporary sporting rights), while temporary, also generate financial flows and are increasingly used as strategic tools for player development or financial management, often reflecting a player's market value, similarly to permanent transfers (Velema, 2019, 2025). Free transfers occur when a player's contract expires, allowing the player to move without incurring a transfer fee. Although cost-effective, these deals can involve substantial signing bonuses or wages, making them strategically complex (Amand et al., 2023).

The regulatory framework for these transactions is set by the FIFA Regulations on the Status and Transfer of Players (FIFA, 2024a), which aim to uphold contractual stability, protect minors, and establish mechanisms such as training compensation and solidarity contributions to reward clubs that invest in youth development. These mechanisms, along with release clauses in employment contracts, provide clubs with safeguards over their most valuable human assets - the players, particularly in a globalised market where players'

rights trading constitutes a critical source of revenue. The enforcement of training compensation and solidarity mechanisms under FIFA rules further supports the sustainability of talent development models in Portuguese clubs, ensuring that formative clubs benefit financially when players rights are transferred to other clubs (FIFA, 2024a).

### **2.4.3. The micro-economic impact of players' transfers on Portuguese Sports Societies**

Players are widely recognised as the most valuable assets of professional football teams a reality particularly pronounced in Portugal due to its distinctive business model. Unlike most top European leagues, where revenues stem mainly from matchday income, broadcasting, and sponsorships, Portuguese clubs rely primarily on the transfer market for financial sustainability (Barros & Leach, 2006). Transfer activity accounts for a substantial share of total revenues, making the trading of players' economic and sporting rights the central pillar of the Portuguese football economy.

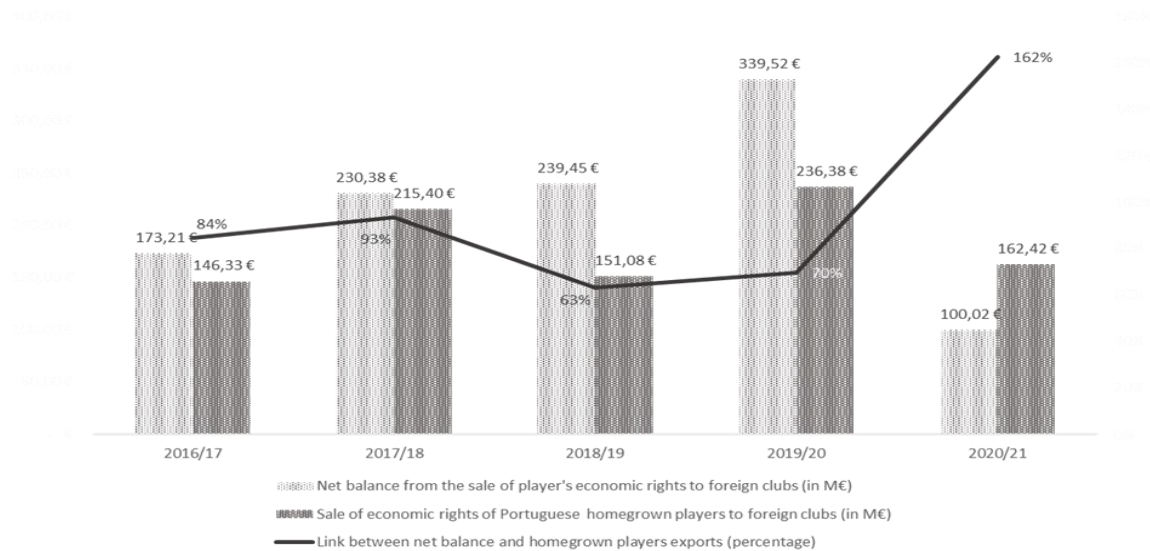
This transfer-based model positions Portugal as both a strategic commercial bridge between Latin America and Europe and a prolific developer of talent. The effectiveness of this approach is reflected in Portugal's consistent ranking among the world's top five countries in international transfers and its positive net transfer balance (FIFA, 2024b). Between 2011 and 2020, Portuguese clubs generated a net surplus of approximately €2.5 billion from player sales (€3.6 billion earned versus €1.1 billion spent), with 2023 transfer revenues reaching \$671.8 million (FIFA TMS, 2021; FIFA, 2024b). High-profile transfers, such as João Neves and Gonçalo Ramos to PSG, further highlight the financial significance of this model.

Central to this business model is youth development, which has become both a sporting imperative and a financial cornerstone. Early identification and training of players enhance competitive standards while ensuring a pipeline of talent for future transfers (McLean et al., 2019). Portugal reputation is reinforced by CIES Football Observatory data, which show that Portugal is the only nation with three clubs - SL Benfica, FC Porto, and Sporting CP, among the top 10 European teams in terms of locally trained players active in the "Big Five" leagues (Poli et al., 2024). These three clubs, combine sporting excellence with sustained leadership in net transfer profits (Deloitte, 2023).

Figure 2.4. illustrates the critical role of homegrown players in ensuring the economic sustainability of Portuguese SADs by comparing total revenues from player transfers with those generated specifically through the sale of the economic and sporting rights of Portuguese-developed talent across five consecutive seasons. The data reveal that transfers of homegrown players accounted for between 63% (2018/19) and 162% (2020/21)

of total transfer net income. The financial logic of youth development is evident. Homegrown players, developed at relatively low cost, generate higher profit margins compared to players purchased abroad (Relvas et al., 2010). This considerable share highlights not only the financial significance of domestic talent development but also its strategic advantage within the Portuguese football economy.

Figure 2.4. Weight of players trained in Portugal in total economic rights over transfers among five seasons.



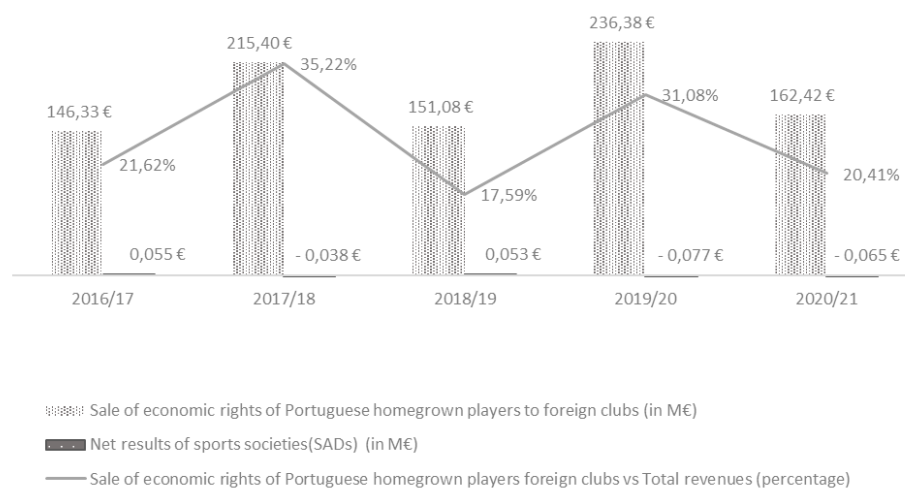
Source: Author's own elaboration based on data from EY and Liga Portugal (2018, 2018, 2020, 2021, 2022).

Historically, the success of Portugal's player development strategy can be traced back to the late 1980s, when two FIFA U-20 World Cup titles signalled the country's capacity to produce top-level talent. Since then, investment in grassroots football and academy infrastructure has created one of the world's most respected training systems, delivering high-quality technical, tactical, and psychological preparation (FBG, 2025). The country's deep-rooted football culture also plays a significant role, with children across Portugal engaging in informal play from an early age and benefiting from a wide array of competitive youth leagues.

However, the transition from youth academies to professional football remains highly uncertain, as talent identification and development demand substantial time, infrastructure, and financial investment. To protect training clubs and incentivise youth development, FIFA established the Solidarity Mechanism, which allocates 5% of any international transfer fee to the clubs responsible for a players' training (between 12-23 years old) (FIFA, 2022). This mechanism mitigates financial risk, supports sustained investment in youth academies, and reinforces both their profitability and their strategic role within the football ecosystem.

The dominance of transfer revenues is also reflected in SAD's financial performance. As illustrated in Figure 2.5., the net results of sports societies remain close to zero, while revenues from selling players' economic rights, particularly homegrown talent, represent a substantial share of their total revenue. This pattern aligns with research by Havran and András (2014) and Morrow (2023), which emphasises the critical role of player transfers in sustaining more minor European leagues.

Figure 2.5. Weight of the sale of economic rights of homegrown players on sports societies' revenues



Source: Author's own elaboration based on data from EY and Liga Portugal (2018, 2018, 2020, 2021, 2022).) and Transfermarket (n.d.)

This structural dependence on player transfers makes football players exceptionally valuable economic assets within the Portuguese system, while simultaneously exposing teams to significant vulnerabilities, most notably the risk of injury. Injuries not only impair team performance but also diminish players' market value, jeopardising financial stability. Consequently, effective injury prevention and management become critical strategic priorities.

Given the strategic value of players as economic assets, Portugal mitigates this risk through mandatory work accident insurance (Law no. 48/2023), which provides comprehensive coverage despite its relatively high premiums. This legal framework is notably distinct from those in other European and global contexts, offering a unique approach to player protection. Although the insurance premiums paid by SADs are substantial, the policies provide broad protection, offering added security to both players and clubs. This system enhances financial resilience against injury-related risks; however,

it does not prevent the depreciation of players' transfer value, an especially critical concern in a transfer-dependent football economy.

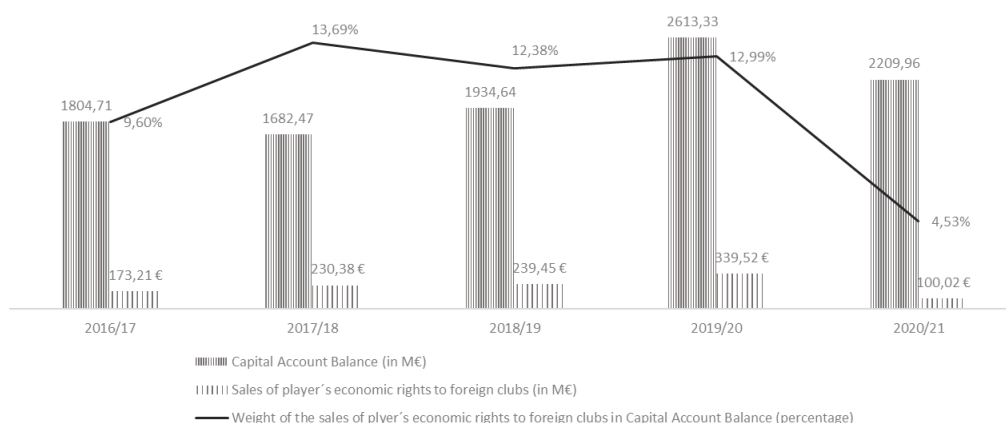
In summary, the Portuguese football economy is characterised by a high degree of financialization and structural reliance on player transfers. Youth development not only underpins competitive performance but also constitutes the most profitable and sustainable strategy for ensuring long-term viability in a market constrained by lower broadcasting, sponsorship, and matchday revenues (Deloitte, 2022; FBG, 2024). Given the critical economic dependence on player transfers, it is essential to implement effective injury prevention strategies to protect player health, preserve transfer value, and maintain club revenues. Looking forward, the integration of artificial intelligence and big data analytics is expected to enhance talent identification and predictive modelling, further strengthening Portugal's position as a global leader in player development (Chang et al., 2024).

#### **2.4.4. The macro-economic Impact of players' transfers on Portuguese Payment accounts**

Portugal's professional football industry plays a strategic role not only within the domestic economy but also in the country's external financial position. The international transfer of players' economic rights generates significant capital inflows for Portugal, contributing positively to the country's balance of payments through the capital account. Portugal's dual role as both an importer of talent and an exporter of homegrown talent is reflected in its capital account through the continuous flow of non-financial, non-produced intangible assets, in this case, the economic rights to football players. These flows are not marginal; they have a measurable impact on the country's balance of payments, reinforcing the significance of the football industry beyond its cultural and social dimensions.

As illustrated in Figure 2.6., the contribution of the transfer market to the Portuguese capital account has been consistently high over five consecutive seasons (2016/17 to 2020/21). During this period, revenues from international player transfers accounted for between 9.6% and 13% of the capital account balance, reaching their highest point in the 2019/20 season. Even during the COVID-19 pandemic, when global transfer spending contracted sharply, Portugal maintained a positive transfer balance, albeit reduced to around 4.5%. It highlights the vulnerability of countries with transfer-dependent football economies to global shocks (Gouveia & Pereira, 2020, for a review).

Figure 2.6. Capital account impact of the Portuguese football industry through players' economic rights



Source: Author's own elaboration based on data from EY and Liga Portugal (2018, 2018, 2020, 2021, 2022), Transfermarket (n.d.), INE (2021) and Banco de Portugal (n.d.)

The magnitude of these figures suggests that the financial health of Portuguese football is not only a microeconomic issue affecting individual clubs but also a macroeconomic factor of national relevance. The sustainability of this model, however, is exposed to risks, including global market fluctuations, regulatory changes, and, importantly, the physical health of the players themselves, who are the core assets of this economic system. This structural dependency highlights the crucial role of player availability and performance, which are directly impacted by player injuries. The economic repercussions of injuries can extend beyond SADs and teams, potentially impacting the broader financial performance of the Portuguese football industry and its contribution to the national economy. Given the centrality of this issue, exploring the economic impact of player injuries represents a crucial avenue for further research.

## 2.5. Conclusion

This study set out to examine the strategic importance of professional football for the Portuguese economy, with particular emphasis on the role of players as the core assets of sports societies. The findings demonstrate that football, beyond its sporting and entertainment dimensions, constitutes a major economic sector in Portugal, contributing to GDP, employment, tax revenue, and international visibility, while also strengthening the country's capital account balance. A symbolic illustration of this global projection is Cristiano Ronaldo, who epitomises how homegrown talent can embody national identity and act as one of Portugal's most recognisable global ambassadors.

The development, valuation, and transfer of players have emerged as the cornerstone of the financial sustainability of Portuguese sports societies. Faced with a limited domestic market and restricted commercial revenues, Portuguese SADs, together with the FPF and Liga Portugal, have strategically positioned themselves as talent incubators within the global football economy.

The present study highlights that the export of homegrown talent, developed through robust youth academies, generates substantial financial returns at relatively low cost. Football, beyond its sporting and entertainment dimensions, is confirmed as a significant economic sector in Portugal, contributing to GDP, employment, tax revenues, international visibility, and particularly to the capital account balance. More than 30% of club revenues derive from the sale of players' economic and sporting rights, the main income stream and often the decisive factor enabling Portuguese SADs to offset negative results. This model has sustained Portugal's competitiveness at national and international levels while reinforcing its capital account through the transfer of non-financial intangible assets. It has also fostered the development of talent, reflected in the achievements of the national team, including the European Championship title and two UEFA Nations League victories.

Nevertheless, the strong reliance on the transfer market exposes Portuguese football to vulnerabilities. External shocks, such as the COVID-19 pandemic, and internal risks, particularly player injuries, can jeopardise both sporting performance and financial stability. This underlines the need for continued investment in talent development, sound financial governance, and player welfare.

This article provides a comprehensive overview of the economic significance of Portuguese professional football, offering a solid theoretical and empirical foundation for future research. Subsequent studies will examine in greater depth the impact of player injuries on the performance and financial sustainability of Portuguese sports societies, thereby advancing the understanding of the interconnections between sport, health, and the economy.

### **2.5.1. Limitations and Future Research**

This study is not without limitations. The analysis is primarily based on aggregated financial data and publicly available reports, which may not fully capture the complexity of individual SADs' strategies or private contractual arrangements. Additionally, while the study highlights the economic significance of player transfers, it does not provide a detailed microeconomic analysis of individual transactions, or the valuation methodologies used for players.

Future research should explore the long-term sustainability of the current economic model, considering the increasing financial polarisation within European football and the evolving regulatory landscape. Further investigation into the economic impact of player injuries, the effectiveness of player welfare policies, the impact of insurance policies in the transfer market, the indirect impact of the football industry in Portuguese economy, and the resilience of sports societies to global economic shocks would provide valuable insights to both scholars and practitioners.

### **2.5.2. Theoretical and Practical Implications**

This study offers several theoretical and practical contributions to the fields of sports economics, management, and public policy. From a theoretical perspective, it reinforces the understanding of professional football as an industry where intangible assets, specifically football players, play a decisive role in shaping both organisational performance and national economic outcomes. The research highlights the interconnectedness between sporting success, financial sustainability, and macroeconomic indicators, contributing to the growing literature on the economics of sport and the valuation of human capital.

The findings also provide empirical evidence on the strategic importance of youth development systems as a source of competitive advantage for countries with smaller domestic markets. By framing football players as key economic assets, this study offers a conceptual bridge between micro-level club management and macroeconomic performance, encouraging future research to explore this relationship in greater depth.

From a practical standpoint, the article emphasizes the importance of sports societies adopting balanced management strategies that strike a balance between financial prudence and sustained investment in talent development. Policymakers may also draw important lessons from the study, particularly regarding the role of football in contributing to employment, tax revenues, and the country's balance of payments. Moreover, the heavy reliance on the player transfer market highlights the need for improved risk management practices, particularly in areas such as player health, welfare, and mitigating economic shocks.

Ultimately, the findings of this research underscore the importance of monitoring the impact of external crises, such as global pandemics, on sports-related economic sectors. This knowledge is essential not only for sports organisations but also for national economic planning and resilience building.

# CHAPTER 3 - PREDICTING INJURY SEVERITY IN PORTUGUESE PROFESSIONAL FOOTBALL: AN AI-DRIVEN ANALYSIS USING DEEP NEURAL NETWORKS

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## **Abstract**

The Portuguese professional football industry plays a significant role in the national economy, contributing approximately 0.26% of the Gross Domestic Product. In this context, injuries, particularly their severity, directly impact the performance of this industry. This study explores the key predictors of injury severity among professional football players. An Artificial Intelligence model - deep neural network was used to model data from 1,639 injuries recorded over five consecutive seasons (2016–2017 to 2020–2021) in Portugal's two top football leagues. The model attained an overall predictive accuracy of 76%, identifying recovery time, injury history, player tactical position, and nationality (in that order) as the most significant predictors of injury severity. In contrast, player age, usage, and league affiliation were found to have minimal predictive value for injury severity. These findings emphasize the importance of comprehensive injury management systems and personalized rehabilitation protocols, particularly for players with substantial injury histories.

**Keywords:** Professional football injuries; Injury severity; Injury severity prediction; Deep neural network.

### 3.1. Introduction

Injuries in professional football have severe consequences that cross numerous aspects of the game. Economically, injuries are a costly burden to clubs, with the average cost of an injured player estimated at around EUR 500,000 per month (Cardoso-Marinho et al., 2022). Such economic costs transcend the clubs to the broader socioeconomic systems, which need comprehensive analyses and prevention strategies (Cardoso-Marinho et al., 2022). Indeed, a 2020/21 season study revealed that injuries cost clubs in the top five European leagues approximately EUR 472 million, including the wages paid to injured players but excluding treatment and rehabilitation costs (Fraser & Burrows, 2022). However, the cost of injuries has increased, as shown by a study of the last season (2023/24), which revealed that injuries cost top leagues EUR 732 million (Herman, 2024). Performance-wise, injury negatively impacts the performance of teams through a reduction in the availability of key players, hence a direct impact on match results, league standings, and overall team performance (Windt et al., 2018; Suarez-Arrones et al., 2020; Goggins et al., 2021). The lack of star players forces teams to use lesser-skilled substitutes, resulting in altered tactics and possibly inferior technical ability (Windt et al., 2018; Goggins et al., 2021).

For athletes, injuries not only hinder their physical functioning but also have psychological effects that persist even after recovery (Goggins et al., 2021). Recent studies concluded that injuries negatively affect players' quality of life in the long term (Teixeira et al., 2024; Teixeira et al., 2025). The risk of re-injury is an additional problem, especially in the case of serious injuries, as it leads to prolonged absences and a drop in the player's performance on his return (Armitage et al., 2022).

Football is a physically demanding sport that requires advanced technical skills and peak physical performance. Depending on their playing position, players must cover long distances, frequently change direction, sprint, jump, and execute various technical actions such as shooting and dribbling, often at high or maximal intensity. The sport's physical demands, coupled with frequent collisions, contribute to a high incidence of injuries, which can often have long-term consequences (Ekstrand et al., 2011). In addition, the risk is further increased by the long training and competition periods of professional footballers, which increases the cumulative physical strain. As a result, footballers, despite starting their careers at a young age, often must accept a premature end to their careers due to the physical wear and tear of sport. A systematic review of epidemiological studies concluded that match injury incidence was 36 injuries per 1000 hours of exposure and that this incidence rate was identical among all professional leagues (López-Valenciano et al., 2020). Moreover, most time-loss injuries in professional football players resulted in an absence of up to four weeks (Ekstrand et al., 2020). It is, therefore, important to place injury

prevention and adequate treatment at the forefront to guarantee team performance and minimize economic losses. Risk-mitigation strategies for injury and accelerated recovery are of utmost concern to individual players and teams, respectively, highlighting the central role of medical and training personnel in professional football ( Bahdur et al., 2018; Armitage et al., 2022). The rooted implications of the injury bring about the necessity for continuous investment and research work in managing and avoiding injuries in terms of facilitating the ultimate sustainability and efficiency of football clubs. The above claim is also supported by the report presented by Goggins et al. (2021) and Turnbull et al. (2024). Comprehensive warm-up programs, such as FIFA 11+, have been employed to reduce injury rates among footballers, establishing the importance of preventive interventions (Mayo et al., 2014). This warm-up program has been shown to reduce the risk of injury by 30% (Sadigursky et al., 2017).

Footballer injuries are especially relevant in Portugal because of the football industry's crucial role in the country's economy and society. In the 2022/23 season, professional football contributed EUR 667 million, representing 0.26 per cent of the country's total Gross Domestic Product (EY & Liga Portugal, 2024). This figure represents an increase of 8 per cent in the previous season. In addition to its direct economic impact, the sector generated EUR 228 million in taxes (a 6 per cent increase from the previous season) and generated 3,504 direct jobs with 74 per cent of the wage bill (EUR 364 million) going to the players (EY & Liga Portugal, 2024). Furthermore, the football transfer market in Portugal has established itself as an important source of revenue for national clubs, reflecting the country's ability to develop and value talent that attracts the interest of international teams. In the 2022/23 season, the transfer market recorded a positive balance of EUR 319 million, bringing the total surplus over the last six seasons to EUR 1.31 billion (EY & Liga Portugal, 2024). As an example, two Portuguese clubs - Sporting and Benfica - are among those that have trained the most footballers to play in the top five leagues over the last two decades (Observatory, 2024). In this context, injuries to professional footballers are a significant challenge for the football industry in Portugal, affecting not only sporting performance but also the financial sustainability of the clubs and the country's economy. Indeed, recent events highlight the severity and impact of injuries in Portuguese football. In September 2024, Boavista FC encountered an exceptional situation when both primary goalkeepers became injured (sustained anterior cruciate ligament ruptures) during the same training session, rendering them unavailable for the entire season. Beyond affecting the team's performance, this incident created substantial logistical and financial challenges, exacerbated by FIFA sanctions restricting player signings.

Given the significant impact of injuries on performance and long-term health in professional football players, research on their causes in Portugal is still limited. Notable

examples include (Martins et al., 2022). Regarding injury severity, few studies have assessed the underlying factors (Chomiak, J. et al., 2000), and to the best of the authors' knowledge, no such study has been conducted in Portugal. This study contributes to the literature by examining the predictors of injury severity using an artificial intelligence model - deep neural networks - focusing on all injured professional football players from the two top leagues over five consecutive seasons (2016/17–2020/21). The present study is the first to use such a large dataset, covering all injured professional players from the first and second divisions over multiple consecutive seasons.

### **3.2. The factors behind injury severity in professional football - an overview**

Injuries represent a significant challenge for professional football players. Injuries in football can be attributed to both intrinsic and extrinsic factors. Intrinsic risk factors include a player's age, previous injuries, days of rehabilitation, playing position, match exposure minutes, and physical and mental health conditions (Ekstrand et al., 2011; Svensson et al., 2016; Kwakye et al., 2023). For instance, a history of previous injuries significantly increases the risk of future injuries, with muscle re-injuries being particularly common (Rennie et al., 2016; Pérez-Gómez et al., 2022). Also, mental health disorders in athletes have been associated with an increased injury risk (Rogers et al., 2024). In football, the relationship between mental health and injuries can be bidirectional. There is empirical evidence showing that after a serious injury/surgery, a player's risk of developing mental health symptoms increases (Pillay et al., 2024). Extrinsic factors are elements linked to the playing environment, such as the type and condition of the surface, weather conditions, behaviour of the opponents, the level of competition, club affiliation, amount and quality of training, equipment (e.g. wearing shin guards), (Chomiak, J. et al., 2000; Zech & Wellmann, 2017; Chang et al., 2024).

The relationship between the overall number of injuries sustained by a player during a season and their severity is complex and influenced by multiple factors. Although some studies have reported the incidence and severity of football-related injuries (e.g., López-Valenciano et al., 2020) for a review), no study has predicted the severity of the injury based on intrinsic and extrinsic injury risk factors. The severity of injuries is categorised concerning the number of days of absence and cut points established for minimal, minor, moderate, and severe injuries (Nilsson et al., 2016; López-Valenciano et al., 2020). A brief literature review of potential predictors of injury severity is provided below.

### **3.2.1. Recurrence of Injuries**

There is evidence that recurrent injuries increase the risk of injuries, but this history doesn't automatically imply anything about the severity of injury in the future. For instance, studies have shown that the injury rate doesn't always predict how long a player will be out due to injury Sedeaud et al. (2020). Also, while the incidence of injury could differ throughout the season and between game periods, this is not necessarily reflective of a relationship with injury severity (Raya-González et al., 2018). The prevalence and incidence of group injury data among the team show that while numerous players are getting multiple injuries, the severity of the injuries does not always correlate with the number of injuries sustained (Lu et al., 2020; Toohey et al., 2022). Therefore, while players may sustain multiple injuries throughout a season, the severity of these injuries depends on various factors and is not directly correlated with their frequency. This highlights the importance of considering both injury frequency and severity when designing effective injury prevention programs (Sedeaud et al. 2020). Consequently, this leads to the formulation of the first research hypothesis:

H1: The total number of previous injuries and their severity determine the severity of future injuries.

### **3.2.2. Player Usage - Players' Matching Exposure**

Evidence that a substantial proportion of injuries occurred in players who routinely play more minutes per match, notably more than 75 minutes (Chang et al., 2024). Player loading throughout the season and the rate of injury severity are connected through several factors. First is that fatigue and chronic microtrauma accumulate throughout a season, increasing the rate of injuries, particularly during the latter portion of the season. Increased match intensity and unsolved injuries are thought to be responsible for the effect because they can cause greater new injury severity (Hoskins et al., 2006). Besides, players' physical fitness deteriorates as the season progresses, rendering them more vulnerable to injury due to accumulated fatigue (Kolodziej et al., 2021). Besides, the acute chronic workload ratio and injury severity relationship imply that higher workloads can result in more severe injuries, and therefore there is a requirement for careful workload management throughout the season (Sedeaud et al., 2020). The available evidence suggests that player usage during a season does influence the severity of the injury, with cumulative fatigue, open injury, and workload management playing critical roles in determining the extent of injury severity (Hoskins et al., 2006; Sedeaud et al., 2020; Kolodziej et al., 2021). Therefore:

H2: The more a player is used, i.e., with more match playing time, the more likely he is to suffer severe injuries.

### **3.2.3. Players Age**

According to most literature on the subject, the player's age is also an important factor in determining the injury severity. The reason for this is that age has a significant bearing on the types and mechanisms of injury sustained by players at varying developmental and professional stages. In the context of football in youth, adolescent growth spurt, particularly in the area of Peak Height Velocity, exposes the players to the risk of specific injuries such as apophyseal disorders and muscular imbalances, which cause strains and joint sprains (Gans et al., 2018; Johnson et al., 2020; Wik et al., 2021; O'Connor et al., 2024). Alongside, 19–30 age group professional players are confronted with rising physical demands, resulting in excess soft-tissue injuries, like hamstring and groin strains. Such injuries are precipitated by high-intensity training schedules and cumulative workload exposure (Pfirrmann et al., 2016; Ekstrand et al., 2021). With advancing age above 30 years, overuse-type injuries, like tendinopathy and cartilage wear and tear, become more frequent, with prolonged recovery times due to decreased tissue elasticity and healing capacity (Jiří Chomiak et al., 2000; Ekstrand et al., 2021). In the same vein, and according to Proctor and Cantu (2000), the risk of serious injuries, including head and spine injuries, generally increases with age due to the higher force of impact associated with greater weight and speed in older players. Furthermore, there have been several studies which have identified that players within the 35-44 years age bracket are 4.4 times more likely to sustain severe injuries than their youthful counterparts (Ross et al., 2022). The greater risk has been explained through various factors, including increased aggression, heightened competitiveness, and morphological changes resulting from growth spurts (Anderson et al., 2020).

Furthermore, higher physical attributes in older players, such as increased size, strength, speed, and aggressiveness, contribute to their higher risk of injury (Stuart et al., 2002). The evidence thus tends towards veteran footballers facing a higher risk of developing life-threatening injuries after the culmination of multiple factors involving their physiology and competition of matches. This emphasizes the necessity for developing injury prevention strategies tailored to specific age groups to effectively mitigate the identified risks. Consequently, the third research hypothesis is proposed as follows:

H3: The probability of players sustaining severe injuries rises with their age.

### **3.2.4. Players Tactical Position**

The player's tactical position has different characteristics and different physical requirements. Epidemiological studies have shown variations in injury incidence and severity depending on the player's role. Positions of left and right wingers, central midfielders, and side defenders are more prone to severe (Correa et al., 2012; Forsythe et al., 2025). This trend can be attributed to the high physical demands, frequent rotational movements, and extensive distance covered at submaximal speeds. In contrast, central defenders cover shorter distances and are subject to fewer accelerations and direction changes, making them less susceptible to injury (Douchet et al., 2023).

The relationship between player position and the risk of severe injury in professional football players is an issue that has yielded inconclusive results. For instance, Engström and Renström (1998) and Correa et al. (2012) found no variation in injury rates by player position, which showed an equal risk for all positions on the field. However, other research indicates that some positions are at greater risk of injury. For instance, goalkeepers and defenders have a greater have a greater shoulder injury rate than the rest of the players (Lima et al., 2024). In contrast, midfielders were observed to have a decreased injury rate in some research but not necessarily in all of them (Engström & Renström, 1998; Hollander et al., 2023). The risk heterogeneity of injury by position can be attributed to the varying physical requirements and mechanical work each position represents, which can lead to different physiological adaptations and susceptibility to injury (Escamilla-Martínez et al., 2023). While there is no consensus about whether the position in and of itself plays a role in significantly altering the risk of severe injury, it is evident that the physical demands and specific movements associated with each position can affect patterns of injury. More extensive and position-specific studies would be necessary to conclude. It is thus proposed that the fourth research hypothesis be formulated as follows:

H4: Players in tactical positions with more physical demands are more prone to serious injuries.

### **3.2.5. Player's Nationality**

Race and ethnicity are poorly reported and analysed in athlete-specific sports medicine literature (Sonnier et al., 2024). The few studies that conducted racial comparison concluded that white athletes had higher rates of sports specialisations mainly because they started competing at a younger age and spent more time training for their primary sport (Jayanthi et al., 2018). Regarding specific injuries, there is evidence that black athletes are twice as likely to rupture their Achilles tendons compared to white (Lemme et al., 2018).

Also, recovering from operative fixation of tibial plateau fractures was higher among white athletes (Kugelman et al., 2017). Among women's basketball associations, it was found that white players have a significantly higher likelihood of sustaining an anterior cruciate ligament tear than black players (Trojian & Collins, 2006) while another study found that black athletes had a significantly higher odds ratio of being lost to follow-up after anterior cruciate ligament reconstruction surgery (Ramkumar et al., 2019). A study explored athletes' mental health condition as an injury risk factor and concluded that athletes from racial and ethnic minority groups were significantly more likely to report preseason anxiety symptoms, depressive symptoms, and a combination of both compared to White athletes (Li et al., 2017). In this regard, other authors found that White athletes consistently had the highest vitamin D levels across all racial groups, while Black players exhibited the lowest average levels (Weber et al., 2021). Notwithstanding this evidence, the relationship between race and ethnicity and professional football risk of injury and their severity is lacking.

Further, the risk of injury in professional football varies significantly between countries (van Beijsterveldt et al., 2015). However, large amounts of geographical unavailability of data remain, particularly beyond Europe. A dearth of multi-season regional injury data for non-European continents compromises the ability to draw firm conclusions about trends in injury from across different geographic settings (Lu et al., 2020). This limitation of comprehensive data underlines the need for increased studies to examine the potential connections between a player's country of birth and susceptibility to injury. Thus, based on the aforementioned considerations, we propose the following hypothesis:

H5: The nationality of players may significantly impact the severity of injuries in professional football.

### **3.2.6. Top-Tier and Second-Tier Leagues Players**

A further injury risk factor is the level of the football league. Several studies found that lower-tier leagues report higher overall injury rates, whereas higher-tier leagues exhibit greater severity for specific injury types. As García-Fernandez et al. (2017) reported, the injury incidence is more significant in the lower leagues of Spanish football. The authors speculated that such greater incidence may be attributable to lower fitness levels or access to medical services. Likewise, Jiri Chomiak et al. (2000) found that traumatic injuries, i.e., ligament ruptures and fractures, were more common in elite athletes as a result of the heightened intensity and physicality of sports at this level. Several studies have determined

that match congestion and workload are among the factors that contribute to the risk of serious injury in first leagues.

Despite the insights gained from the available pool of literature, several inconsistencies remain. For example, Ekstrand and Tropp (1990) noted that the incidence of ankle injury was equal across the professional levels of play, thus challenging the assumption that injury severity increases in higher leagues. Also, Nitta et al. (2021) found a similar incidence of injury to the anterior cruciate ligament of the knee in professional football players in the first and second divisions of the Brazilian soccer championship between 2015 and 2019. In addition, Muaidi (2019) noted a preponderance of contact injuries in studying the Saudi Professional League. The findings suggest a multifaceted interaction between level of competition and serious injury, with elite leagues containing certain risk factors inherent in match intensity and workload and lower leagues containing greater injury rates potentially linked to differences in fitness and constraints of resources.

The bibliography offers supplementary insights that serve to deepen complexity. According to Engström and Renström (1998), players in elite leagues have an increased risk of injury for several reasons. They are exposed to higher intensities of training and more game participation than in lower divisions, thus exposing them to higher risks of injury. Players from top teams in the first division face higher competitive pressure as they participate in national and international competitions. This results in increased fatigue, fewer rest days, and, consequently, a higher risk of injury. Nevertheless, the first divisions provide better working conditions for players, particularly regarding resource quality, equipment, medical assistance, and technical support, which may reduce the risk of injury or, at the very least, its severity. In addition, economic and performance pressure in top-level professional leagues also contributes to the risk of injury. Clubs pay players much money, and injuries cost clubs significantly and affect the overall team performance (Page et al., 2022). The football league level has been demonstrated to play a crucial role in determining the risk and type of injuries sustained by professional players. These athletes face elevated risks due to increased exposure and elevated demands (Engström & Renström, 1998; Van Beijsterveldt et al., 2015; Page et al., 2022). Therefore, we may hypothesise that:

H6: Elite leagues tend to experience more severe injuries, while lower-level leagues generally report less severe injuries.

## 3.3. Materials and Methods

### 3.3.1. Study design

The present investigation employs a causal study design, utilizing artificial intelligence (AI) based on a deep-learning artificial neural network to examine the relationship between risk-injury factors and the severity of injuries sustained by athletes. Conventional statistical methodologies frequently encounter difficulties in adequately capturing non-linear interrelationships among contributing factors and the outcomes of injuries. AI emerges as a promising solution for addressing these complexities by accounting for direct and indirect causal pathways.

### 3.3.2. Data collection

Conducted throughout five seasons - 2016/2017 to 2020/2021, this causal study focused on the first and second leagues of professional men's football teams competing in Portugal. All players who suffered injuries during the five seasons were considered for analysis. We rely on secondary data collected from publicly available sources, including websites such as Transfermarkt (<https://www.transfermarkt.pt>), the Football Yearbook (Anuário do Futebol) for each season (e.g. <https://www.ligaportugal.pt/press-releases/289/anuario-do-futebol-profissional-portugues-2020-21>) and the official websites of the football clubs from the first and second league (e.g. <https://www.sporting.pt/pt/futebol/equipa-principal/plantel/franco-israel-wibmer>). A rigorous systematisation of all these data was required, which proved to be a complex and time-consuming task, as it involved collecting and cross-referencing player-level information from these multiple. A total of 1656 players had injuries during the five seasons, but after removing outliers, the total number of observations was adjusted downward to 1639.

The variable injury severity was categorized based on the number of days of absence according to medical practitioners and Nilsson et al. (2016), as follows: minimal, minor, moderate, major and severe. The injury risk factors considered in the analysis were players' age, nationality, tactical positions, matching exposure, number of injuries suffered, season and division played. A detailed description of the variables is summarized in Table 3.1.

Table 3.1. Definition of the variables employed in the study.

Variable	Description	Scale	Values
Season	The season when the injury occurred	Nominal	1,2,3,4, or 5
Injury severity *	Degree of severity of the player's last injury	Ordinal	1 = Minimal (1–3 days) 2 = Minor (4–7 days) 3 = Moderate (8–28 days) 4 = Major (28- 120 days) 5 = Severe (= > 120 days)
Number of Injuries	Number of injuries a player has suffered during the Season	Ratio	
Player Usage	Percentage of player utilization in all matches (used in more than % in all matches)	Ordinal	1 = used in more than 80% 2 = used between 50% and 79% 3 = used between 21% and 49% 4 = used in less than 20%
Age	Age of the player in the current season	Ratio	
Tactical Position	Player's position on the football field in the Season	Nominal	1 = Midfielder 2 = Defensive Midfielder 3 = Full-back 4 = Defender 5 = Winger 6 = Striker 7 = Second Striker/Supporting Forward 8 = Goalkeeper
Nationality	Player citizenship	Nominal	1 = Europe 2 = Southern Europe 3 = Africa 4 = North Africa 5 = America 6 = South America 7 = Asia 8 = Middle East
League	1st or 2nd leagues	Nominal	1 or 2
Total Injuries	Number of injuries suffered by the player before the current injury	Ratio	
Total days of recovery	Number of days the player was off	Ratio	

\* A framework consistent with the guidelines established by the FIFA Medical Assessment and Research Centre (F-MARC) was used to define injuries and the associated data collection procedures. These protocols have been meticulously designed to ensure uniformity and accuracy in the reporting and analysis of football injuries.

### 3.3.3. Data Analysis with AI

Deep neural networks (DNNs) are machine learning models with multiple layers of interconnected neurons, enabling hierarchical feature extraction through non-linear

processing (LeCun et al., 2015). They use activation functions, weight matrices, and biases to map complex input-output relationships, with deeper layers learning more abstract representations (Greff, 2017). DNNs employ backpropagation and gradient descent to adjust parameters during training, achieving high accuracy and showing potential for optimal classification performance (Sahoo & Karmakar, 2023). Theoretical studies have shown that intense networks can achieve Bayes optimality for classification tasks, providing insights into the benefits of depth in neural architectures (Radhakrishnan et al., 2022).

The proposed neural network architecture employs a multi-layer perceptron structure with additional attention mechanisms to weigh the relative importance of different input variables. It comprises an input layer that processes standardized variables, multiple hidden layers with Rectified Linear Unit (ReLU) activation functions, dropout layers for regularization, and an output layer that predicts injury severity on a continuous scale (Softmax function). Forward propagation in the hidden layers applies an affine transformation followed by a non-linearity:

$$\mathbf{h}^{(l)} = f\left(\mathbf{W}^{(l)} \mathbf{h}^{(l-1)} + \mathbf{b}^{(l)}\right), \quad l=1, \dots, L \quad (1)$$

where:

- $\mathbf{h}^{(0)} = \mathbf{x}$  represents the input layer
- $\mathbf{W}^{(l)} \in \mathbb{R}^{d_l \times d_{l-1}}$  are the weight matrices for layer  $l$
- $\mathbf{b}^{(l)} \in \mathbb{R}^{d_l}$  is the bias vector
- $f(\cdot)$  is the activation function (e.g., ReLU or tanh)
- $\mathbf{h}^{(l)}$  is the activation vector at layer  $l$

The final layer (output layer) generates a vector of logits:

$$\mathbf{z} = \mathbf{W}^{(L+1)} \mathbf{h}^{(L)} + \mathbf{b}^{(L+1)} \quad (2)$$

where  $\mathbf{z} \in \mathbb{R}^C$ , and  $C$  is the number of classes. The softmax function converts the logits into class probabilities:

$$\hat{y}_i = \frac{e^{z_i}}{\sum_{j=1}^C e^{z_j}}, \quad \text{for } i=1, \dots, C \quad (3)$$

where each  $\hat{y}_i$  represents the predicted probability for the class  $i$ , ensuring that the sum of  $\hat{y}_i$  is equal to one. The softmax is used in the output layer of neural networks to assign probabilities to the different classes. The value with the highest probability is often chosen as the model's prediction. Lastly, the model is trained by minimizing the cross-entropy loss function between the predicted distribution  $\hat{\mathbf{y}}$  and the actual distribution  $\mathbf{y}$ :

$$L = -\sum_{i=1}^C y_i \log \hat{y}_i \quad (4)$$

where  $y_i$  is a one-hot encoded indicator for the true class ( $y_i = 1$  if the observation belongs to the class  $i$ , otherwise  $y_i = 0$ ). The model performance can be evaluated by accuracy in severity classification, Mean Absolute Error (MAE) on the severity scale, and Area Under the ROC Curve.

The initialization of weights in DNN is crucial for practical training (He et al., 2015), with random initialization and proper scaling helps to address vanishing and exploding gradients during backpropagation (Glorot & Bengio, 2010). DNN learning relies on backpropagation for gradient calculation and parameter updates (LeCun et al., 2015), while momentum in Stochastic Gradient Descent (SGD) helps avoid local minima and speeds up convergence (Sutskever et al., 2013). Dividing data into training and test sets is fundamental in DNN development (Goodfellow, 2016), requiring a rigorous validation strategy to ensure generalisation and prevent overfitting (LeCun et al., 2015). The test set must remain separate from the training process to ensure an unbiased evaluation (Hastie, 2009), and cross-validation strengthens this by offering multiple train-test splits for more reliable performance estimates (Bishop & Bishop, 2023). The allocation size between training and test sets affects model performance, with larger training sets generally improving generalisation, if enough test data is retained (Zhang et al., 2021). Multiple runs are necessary for proper model evaluation (Wilson & Izmailov, 2020), as they allow for systematic assessment across different initializations and hyperparameters (Bouthillier et al., 2021), providing insights into stability and reproducibility (d'Ascoli et al., 2020).

We trained the DNN to identify the optimal setup for assessing how serious a football player's injury might be. Thus, the DNN was systematically trained to determine an optimized architecture capable of effectively addressing the classification of the severity (probability) of a football player's injury. The final architecture consists of four layers, with 99 input variables, providing a comprehensive data view. For optimization, the SGD was used, which is known for efficient and robust convergence. Additionally, ratio variables were standardized before training to avoid biases from differing scales. The inner layers, each with 12 units, used the ReLU activation function to address issues like the vanishing gradient problem and improve training speed. The output layer has five units for multi-class classification, with a softmax activation function to produce probabilistic outputs. Finally, the cross-entropy loss function was used to evaluate the model's performance by measuring the difference between predicted and actual classes.

### 3.4. Results

Thirty independent runs of DNN were carried out to ensure statistical robustness. Table A 3.1. in the appendix describes the runs (values are the arithmetic means), dividing the sample into learning and testing. The results show a near-even split between training (50.52%) and testing (47.53%) sets, indicating a robust experimental design. The excluded cases indicate classes with no simultaneous observations in the learning and test sets.

Table A 3.2. in the appendix presents the values for the empirical analysis of the DNN classification performance. The matrix provides a detailed assessment of DNN's classification performance across five distinct classes. It highlights variations in accuracy, showing that the model performs better with higher-numbered classes (3, 4, and 5), achieving accuracy between 86% and 94%. In contrast, lower-numbered classes (1 and 2) exhibit significantly lower accuracy, ranging from 0% to 20%, indicating difficulty distinguishing these classes. The performance metrics from the test set mirror those from the training set, with an overall accuracy of 76%. Classes 3, 4, and 5 perform well (77%-91%), while classes 1 and 2 maintain low accuracy (0%-10%). This misclassification suggests potential issues with feature representation in the DNN. Possible contributing factors include (1) similarities between lower-numbered classes, (2) insufficient distinguishing features for these classes, or (3) biases in the training dataset that limit the model's ability to learn effectively.

Table 3.2. summarizes each independent variable's weight and normalized weight relative to the dependent variable - injury severity. The weights represent the relative importance of each variable in predicting injury severity, while the normalized total weights provide a percentage contribution of each variable to the model's output.

Table 3.2. Total weight of the independent variable relative to the dependent variable.

	Weight	Normalized Weight
Total days of recovery	0.318	100.00%
Total Injuries	0.197	61.90%
Number of Injuries	0.16	50.30%
Nationality	0.113	35.60%
Tactical Position	0.075	23.50%
Season	0.041	13.00%
Age	0.04	12.60%
Player Usage	0.037	11.80%
League	0.019	6.10%

The total days of recovery emerge as the most significant predictor of injury severity, with a weight of 0.318 and a normalized total of 100.0%. The finding supported H1 indicates

that the duration of recovery is strongly correlated with the severity of the injury. Longer recovery times are typically associated with more severe injuries, which align with established medical and sports science principles. The second most influential variable is total injuries, with a weight of 0.197 and a normalized total of 61.9%. The result suggests that the cumulative number of injuries a player has sustained over their career plays a critical role in determining the severity of subsequent injuries. Players with a history of recurrence injuries may be more prone to severe injuries due to accumulated physical stress or underlying vulnerabilities. The number of injuries also demonstrates significant importance, with a weight of 0.160 and a normalized total of 50.3%. This finding confirms the impact of recent or frequent injuries on injury severity. Frequent injuries may indicate inadequate recovery, chronic issues, or heightened exposure to risk factors, all of which can contribute to more severe outcomes.

Players' nationality is another notable variable, with a weight of 0.113 and a normalized total of 35.6%. While its influence is moderate compared to the top three variables, it suggests that factors such as playing style, demographic and potentially physiological or even genetic predispositions associated with nationality may indirectly affect injury severity. The tactical players' position follows as another meaningful predictor, with a weight of 0.075 and a normalized total of 23.5%. Thus, the specific role/position the player occupies contributes meaningfully to injury severity prediction due to the unique physical demands and injury risks associated with different positions. Thus, hypotheses H4 and H5 are accepted.

In contrast, the season, players' age, and usage demonstrate a lower impact on the severity of injuries, ranging from 11.8% to 13.0%. League has the least influence, with a weight of 0.019 (6.1% normalized), indicating minimal variation in injury severity across leagues.

## **3.5. Discussion**

### **3.5.1. General Discussion**

The present study used AI to predict the severity of injuries among professional football players of the first and second Portuguese divisions during five consecutive seasons based on intrinsic and extrinsic risk-injury factors. Based on the application of a DNN, the results of this study offer significant insights into the determinants of injury severity and provide partial support for our hypotheses.

Our findings reveal that the number of recovery days and cumulative injury history (recurrence of injuries) strongly predict injury severity, thereby supporting H1. DNNs results

indicate that the summation of past injury burden and their respective severities – in terms of recovery time – demonstrates a strong association with future injury severity. The strong support for H1 aligns with existing literature demonstrating that previous injuries significantly increase the risk of future injuries, particularly for muscle re-injuries ( Rennie et al., 2016; Pérez-Gómez et al., 2022). The findings also corroborate the assertion that while injury patterns may fluctuate throughout a season, injury history remains a more critical determinant than temporal patterns (Raya-González et al., 2018). Moreover, the high weights assigned to the number of recovery days contradict previous research (Sedeaud et al., 2020), which found that the injury rate does not always predict how long a player will be out due to injury.

Contrary to our expectations, we only found a moderate influence of players matching exposure to injury severity, leading to rejecting H2. Although we support the directional relationship between both variables, the magnitude is less pronounced (only 11.8%) than we anticipated. Therefore, our findings are only moderately aligned with the existing literature that supported a strong relationship between players' usage and the risk of injuries (Hawkins et al., 2001; Raimondi & Taioli, 2007; Rennie et al., 2016; Zech & Wellmann, 2017; Bahdur et al., 2018). Likewise, H3 is not supported since players' age was found to have a minimal impact on injury severity (12.6%), despite the extensive body of literature indicating a heightened vulnerability to severe injuries with increasing age. Previous research indicates that older players have a significantly higher risk of severe injuries than younger ones (Liu et al., 2022), with injury rates rising with age (Wilke et al., 2023).

The findings regarding the relationship between a player's tactical position and the incidence of serious injuries confirm the acceptance of hypothesis H4. Accordingly, we found that the player's position on the pitch predicts almost one-quarter of the injury severity. This finding seems to conflict with findings reported elsewhere (Engström & Renström, 1998; Correa et al., 2012; Smpokos et al., 2019) indicating an absence of variation in injury rates according to player position. However, our findings align with studies reporting that some tactical positions are more physically demanding and have a more significant impact on injury patterns (Escamilla-Martínez et al., 2023; Rhini et al., 2024).

Similarly, H5 is accepted, as nationality is a relevant factor in predicting injury severity. The relevance of players' nationality to injury incidence remains underexplored, and existing findings are conflicting. While the acceptance of our H5 is supported by some studies (Kugelman et al., 2017; Lemme et al., 2018), others have found no significant relationship between both variables (Smpokos et al., 2019).

Lastly, playing in the first or second league did not predict injury severity, leading to the rejection of H6. This finding stands in contrast to the prevailing literature, which suggests that there are apparent differences in injury patterns between different levels of competition.

García-Fernandez et al. (2017) reported a higher incidence of injuries in lower leagues, while Jiri Chomiak et al. (2000) found traumatic injuries more prevalent among elite athletes. Nevertheless, our results are consistent with other studies in Portugal comparing muscle strength imbalances among professional football players from the first and second leagues found no clear association between competitive level and injury risk (Carvalho et al., 2016).

In sum, our findings confirm the multifaceted, multidimensional nature of football injury, thereby conforming to prior conceptualizations of injury aetiology (Sedeaud et al., 2020; Cardoso-Marinho et al., 2022; Bennett et al., 2024).

### **3.5.2. Theoretical Contributions and Implications**

This research contributes to the theoretical body of knowledge on the determinants of injury severity in professional football by providing empirical support for the primacy of individual injury history. Our study challenges dominant theoretical models that prioritise age as the leaden risk factor (Ross et al., 2022; Anderson et al., 2020; Liu et al., 2022) while supporting models that emphasise the importance of previous injury patterns (Pérez-Gómez et al., 2022; Rennie et al, 2016). Additionally, our findings regarding the impact of nationality contribute to ongoing debates about cultural and national variation in injury risk profiles [62,90], suggesting the need to reevaluate traditional injury-risk models to incorporate cross-cultural considerations better.

### **3.5.3. Practical Implications**

Our findings provide valuable insights into injury prevention and player management in professional football. By identifying key predictors of injury severity - recovery time, number of past injuries, tactical position, and nationality - teams can develop more effective risk assessment models and personalized training programs. Medical staff and coaches can use this information to tailor rehabilitation protocols, adjust workload based on injury history, and implement targeted preventive strategies for players in high-risk positions. However, the effectiveness of preventive measures relies on player cooperation, as evidence suggests that, despite recognizing their high injury risk and the benefits of preventive strategies, many players do not intend to follow them (Cardoso-Marinho et al., 2022). Thus, potential solutions include educational campaigns to raise players' awareness of the short and long-term consequences of injuries, financial penalties for non-compliance with prevention measures, and leveraging artificial intelligence to develop innovative tools that enhance player health management. Further, the predictive effect of player nationality on injury severity emphasises the need for preventive measures and training techniques

adapted to different cultural contexts and specific ethnic characteristics, rather than relying on universal approaches (Mayo et al., 2014).

Additionally, clubs may consider these injury severity risk factors in recruitment and squad management decisions to optimize player availability and long-term performance. Integrating these insights into practice can enhance player safety, improve overall team performance, and reduce the economic burden associated with injuries.

### **3.5.4. Limitations and further research**

Despite the valuable insights provided by this study, several limitations must be acknowledged. First, while our AI-based methodology identified key predictors of in-jury severity, the model relies on existing data, which may be subject to reporting biases or inconsistencies across different sources. Additionally, the study does not account for contextual factors such as training intensity, which could further influence injury outcomes. Another important limitation is the relatively analysis time frame, as the model was trained on data from only five seasons. Given that AI-based models typically require large datasets to enhance predictive accuracy and generalizability, the limited data scope may have constrained the model's performance. The DNN model yielded reduced classification accuracy for low-severity injuries, suggesting potential shortcomings in differentiating low-injury classes.

Future research should aim to refine predictive models by incorporating additional variables, such as biomechanical data, psychological factors, and real-time workload monitoring. Expanding the dataset to cover a longer period could improve model robustness and reliability. Longitudinal studies could provide deeper insights into how injury patterns evolve over a player's career. Furthermore, qualitative research exploring player attitudes toward injury prevention strategies could help bridge the gap between scientific recommendations and practical implementation. Finally, cross-cultural studies may offer a better understanding of how nationality influences injury severity, enabling the development of more tailored preventive measures.

## **3.6. Conclusions**

Using a deep neural network the present study explored the predictors of injury severity in Portuguese professional football (first and second) division over five consecutive seasons.

The DNN model results emphasise the key role of recovery time and injury history as predictors of the severity of the injury. Furthermore, playing position and players' nationality

showed a moderate predictive effect, while players' usage, age, and league level showed little effect. Study's results imply that an accumulation of the previous injuries of the individual significantly predicts the future risk of injury for a single player with secondary contributions made by other intrinsic and extrinsic factors.

Our results underscore the importance of tracking injury rates, monitoring individual injury histories, and assessing recovery times. This will help minimise the severity of injuries, increase player safety in professional football, and promote long-term health while improving club performance by reducing players' time away from competition. This study is original because, to the best of the authors' knowledge, no similar study has been conducted that includes all injured players over such an extended period. Recovery time and injury recurrence were the strongest predictors of injury severity, followed by players' nationality and tactical position on the field.



# CHAPTER 4 – REAL-WORLD INJURY PATTERNS IN PORTUGUESE PROFESSIONAL FOOTBALL: RISK PROFILES AND SOCIOECONOMIC CONCERNS

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## **Abstract**

Football is a high-intensity sport involving frequent contact and high physical demands, making injuries common. In Portugal, where football plays a major economic role, especially through player transfers, injuries carry both sporting and financial consequences. This study examines injury incidence and severity among professional players in the First and Second Leagues across five seasons (2016/17–2020/21), considering intrinsic (age, nationality) and extrinsic factors (tactical position, match participation, league, and environment). Using real-world data and quantitative methods, including descriptive, inferential statistics, and cluster analysis, findings show that injury incidence is associated with league level and nationality, while severity is influenced by league level and match participation. Although more injuries occurred in the First League, they were more severe in the Second League. Cluster analysis confirmed these patterns, revealing higher incidence among non-European players and greater severity among those with low match participation competing in the Second League.

**Keywords:** Football industry; Professional football; Injuries; Injury-risk intrinsic factors; Injury-risk extrinsic factors; Portugal.

## 4.1. Introduction

Football (soccer) is the world's most popular sport, with over 5 billion fans (FIFA, 2024) and origins dating back over 3,000 years. From ritualistic beginnings to a global industry, football now involves 265 million regular players, of whom few reach the professional level (Haugaasen & Jordet, 2012). The sport has become a multi-billion-euro sector with economic, social, and cultural significance, serving as a vehicle for national identity and soft power, especially in events like the World Cup ( Doidge et al., 2019; Toma & Catana, 2021; Guo et al., 2024; Yiapanas et al., 2024).

In Portugal, football is a major cultural and economic force, contributing over €662 million to GDP in 2023/24, with SADs in the top two leagues generating over €1 billion in turnover and creating more than 4,000 jobs (EY & Liga Portugal, 2024). The sector relies primarily on player transfers abroad, which accounted for 63% of First Division player movements and a positive transfer balance of €402 million (EY & Liga Portugal, 2024). Thus, injuries threaten not only sporting success but also economic value by affecting team performance and player market worth.

Player performance is central to club success, making injuries costly both athletically and economically. High-intensity demands have increased injury risks (Barnes et al., 2014; Carling et al., 2015) , with UEFA data showing about 50 injuries per top club per season, causing significant player absence (Ekstrand et al., 2021) and financial loss up to €500,000 per injury (Eliakim et al., 2020). These concerns have placed injury prevention and management at the centre of professional football strategy.

Despite investments in prevention, injury incidence remains stable (Ekstrand et al., 2021), and some injuries like hamstring strains are rising (Ekstrand et al., 2022). This persistence suggests that current prevention strategies may not sufficiently address key risk factors. Although many studies have explored injury rates and causes (López-Valenciano et al., 2020; Hoenig et al., 2022; Martins et al., 2022; Gurau et al., 2023; Chang et al., 2024), differences in methodology limit comparability, and several determinants remain underexplored. A better understanding of the complex drivers of injury risk is needed to inform more effective interventions.

This study examines injury incidence and severity in Portugal's First and Second Leagues over five seasons (2016–2021) using real-world data. It analyses trends and associations with age, ethnicity, position, exposure, and league level. This is the first study to assess all injuries across both divisions over multiple seasons. By profiling injury risk, it aims to support decision-makers in enhancing player welfare and team performance.

## **4.2. Current State of Research in Professional Football**

Over the past two decades, research on injury patterns in professional football has evolved from basic descriptive epidemiology (Hawkins et al., 2001) to exploring individual risk factors (Genovesi et al., 2025) and, more recently, complex interactions using advanced methods (Chang et al., 2024). Large-scale injury surveillance programs like the UEFA Elite Club Injury Study and FIFA Medical Assessment and Research Centre have produced valuable longitudinal data across leagues (Ekstrand et al., 2021). However, current understanding remains fragmented, with limited integration of intrinsic factors, such as age, ethnicity, and physiological traits, and extrinsic factors, which include environmental and contextual conditions influenced by team management or scheduling.

This study considers age and ethnicity as intrinsic risk factors, and tactical position, match participation, competition intensity, and environmental variables as extrinsic factors.

### **4.2.1. Intrinsic football player factors**

#### **4.2.1.1. Age-Related Injury Patterns**

Age is a key intrinsic factor influencing injury susceptibility in professional football. Longitudinal data suggest a 10% annual increase in injury risk with age among elite players (Ekstrand, 2011). Muscle-tendon injuries, particularly hamstring and calf strains, are notably more frequent in older athletes (Jones et al., 2022). Recent machine learning models also identify age as a critical predictor of injury, with players over 32 being especially vulnerable (Chang et al., 2024). These findings underscore the need for age-specific injury prevention and load management protocols.

#### **4.2.1.2. Ethnicity-Related Injury Patterns**

Despite extensive research on injury risk in professional football, the role of race or ethnicity remains underexplored. Studies often focus on age, position, training load, and injury history, rarely addressing ethnic background despite the multicultural nature of elite squads. Ethnic identity influences life experiences, socioeconomic status, health outcomes, and potentially injury risk.

Some research indicates ethnic differences in biomechanical factors that may affect injury patterns. For instance, Zengin et al. (2016) found Afro-Caribbean men have superior bone geometry and density compared to White and Asian men, with Asians showing thinner tibial cortices and lower bone strength. Hill et al. (2020) observed racial differences in gait

mechanics, and Song et al. (2018) reported foot structure disparities between Black and Asian individuals. In American football, racial differences in pain perception and tolerance have been documented (Edwards et al., 2023). Specifically, Latin American footballers in Europe differ significantly in body composition (height, weight, and fat percentage) compared to other groups (Conde-Pipo et al., 2023).

These findings highlight the need for further research into ethnic variations in injury risk. Given football's global diversity, injury prevention strategies must consider racial and ethnic differences to be effective.

## **4.2.2. Extrinsic football player contextual factors**

### **4.2.2.1. Tactical Position-Specific Injury Profiles**

Playing position significantly influences injury risk due to the distinct biomechanical and tactical demands of each role. Actions like tackling, sprinting, and ball distribution vary by position, creating specific injury patterns among defenders, midfielders, and forwards (Hall et al., 2022). Midfielders and wide defenders typically cover more high-speed distance and sprint more, while central defenders and midfielders focus more on passing (Sarmiento et al., 2024). Midfielders are particularly injury-prone due to high workloads and extensive pitch involvement. Ekstrand et al. (2011) reported that midfielders exhibit the highest injury rates, often linked to overuse from repeated high-intensity efforts. These leads to a 2.3-fold increased risk of adductor injuries (Larruskain et al., 2018; Oliveira et al., 2020). Their mental load may also heighten injury susceptibility (Iskra et al., 2025). Defenders often sustain contact injuries from aerial duels, whereas goalkeepers face acute injuries from explosive actions like diving and jumping, mainly affecting upper limbs (Bult et al., 2018). Though goalkeepers have fewer injuries overall, they experience more upper limb injuries and longer recovery times ( Carling et al., 2015; Bult et al., 2018). These results highlight the need for position-specific conditioning and prevention strategies (Brito et al., 2016).

### **4.2.2.2. Player match-participation injury incidence: Player participation tier**

Injury risk is closely linked to player load, especially with high match frequency and intense training. These demands cause physical and psychological stress, leading to post-match fatigue and performance drops that may take days to recover (Jones et al., 2017). Modern football's congested schedules and commercial pressures exacerbate this issue. Players now compete in more matches and perform more high-speed efforts than before (Jiang et al., 2022). Sudden spikes in high-intensity running increase non-contact injury risk (Anderson et al., 2016; Jaspers et al., 2018). European professionals often play 50–80

matches per season, with two games per week common (Carling et al., 2012). Such frequency raises injury risk by 22%, and recovery times under four days increase it by 69% (Bengtsson et al., 2018). Tactical evolutions involving more pressing and physical play further heighten risk (Barnes et al., 2014).

Fatigue is a major factor in non-contact injuries (McCall et al., 2014). A U-shaped relation exists between minutes played and injury risk, with over 75 minutes per game linked to more frequent and severe injuries (Carling et al., 2016; Ekstrand et al., 2019; Chang et al., 2024). These findings underscore the importance of load management and recovery strategies throughout the season.

#### **4.2.2.3. Competition Level – League injury incidence**

Research comparing injury patterns across football divisions is limited but reveals important differences. Some studies report similar overall injury rates between top and lower leagues (Arliani et al., 2018), though injury severity and type vary due to differences in match intensity, medical support, and prevention.

Top-tier leagues generally show higher injury rates, linked to greater physical and tactical demands (Waldén et al., 2016; López-Valenciano et al., 2019), with consistent findings across elite and lower-tier competitions (Jaspers et al., 2018). In Portugal, Second League players exhibit slightly lower strength ratios than First League players, possibly increasing muscle injury risk, such as hamstring strains (Carvalho et al., 2016). No significant differences were found in dynamic control or asymmetry, but physiological differences suggest potential vulnerabilities.

These results highlight the need for further comparative studies to better understand how league level affects injury incidence and severity.

#### **4.2.2.4. Environmental factors**

Environmental factors notably affect injury, incidence and severity in professional football. Extreme temperatures, rain, pollution, and altitude impact cardiovascular efficiency and performance, influencing injury risk and type (Ngota et al., 2024; Segreti et al., 2024). High temperatures can cause dehydration and fatigue, raising muscle strain and cramp risk (Taylor & Rollo, 2014), while wet, slippery surfaces increase traumatic lower-limb injuries (Ekstrand et al., 2011). Playing surface type also matters; artificial turf is linked to more ligament injuries compared to natural grass (Soligard et al., 2016). However, some studies report no significant correlation between environment and injury risk (Schwarz et al., 2025).

Environmental impacts may vary seasonally, underscoring the need for systematic monitoring to mitigate injury risk and protect player health.

Given the multifactorial nature of injury risk, encompassing both intrinsic and extrinsic variables, this study investigates how these elements are expressed within the context of Portuguese professional football. Building upon existing literature that emphasises the complexity and variability of injury patterns, the present study examines whether similar trends are evident in Portugal. Accordingly, this paper addresses the following research questions (RQ):

RQ1. Do injury incidence and severity differ between players in the first and second leagues?

RQ2. Do injury incidence and severity vary across different football seasons?

RQ3. Do injury incidence and severity differ according to players' intrinsic characteristics, such as age and nationality?

RQ4. Do injury incidence and severity differ based on extrinsic factors, such as playing position and minutes played?

## **4.3. Materials and Methods**

### **4.3.1. Dataset and definition of variables**

This study employed a retrospective observational design, allowing for the analysis of real-world data on injury patterns over time, thereby facilitating the identification of historical trends and potential risk factors. Data were collected from multiple sources, including official league reports, the transfermarkt.pt database, and club-maintained injury records. The data collection and systematisation process were both complex and time-intensive, requiring meticulous cross-referencing to ensure reliability. The initial dataset comprised 1656 professional football players who sustained at least one injury while competing in Portugal's First League (FL) or Second League (SL) across five consecutive seasons (2016/17 to 2020/21). Following the removal of outliers, the final sample included 1639 observations.

The dataset encompassed nine variables, classified into three categories:

- (1) Injury data: number of injuries and number of days lost (recovery time);
- (2) Intrinsic factors: player age and nationality;

(3) Extrinsic factors: tactical position and player workload (match participation).

Table A4.1, in the appendix, provides detailed descriptions of all variables and their respective measures. Player ages ranged from 17 to 39 years ( $M = 25.8$ ,  $SD = 4.3$ ). Most players were European (50.5%), with a predominance of athletes from Southern Europe (44.3%). South American players accounted for 30.6% of the sample, followed by African players (15.5%), of whom 7% originated from North Africa. Players from Asia (3%) and the Middle East (0.4%) were minimally represented.

The *number of injuries* per player ranged from one to four: 70.4% sustained a single injury, 20.6% sustained two, 6.6% sustained three, and 2.4% sustained four injuries.

*Injury severity* was defined using the time-loss criterion specifically, the number of days a player was unavailable for participation due to injury. Based on a slightly adapted version of the UEFA and FIFA consensus statements (Fuller et al., 2006), severity was classified into five categories: Minimal (2.3%), Minor (6.5%), Moderate (29.1%), Major (46.4%), and Severe (15.8%).

*Player participation tier* reflected the extent of match involvement throughout a season, calculated as the percentage of total matches played. Four categories were established: (A) >80% – Starter/Crucial player (6.4%), (B) 50–79% – Regular (Squad Rotation) player (27.5%), (C) 21–49% – Occasional player (33.8%), and (D) <20% – Residual player (32.4%).

*Tactical positions* were primarily determined by coaching staff, considering individual attributes such as dominant foot and tactical function. Central players are typically more physically robust, whereas wingers are generally characterised by greater speed and agility. This variable included eight specific positional roles. To enhance analytical depth, two derived variables were created:

*GDMF*: grouped players as Goalkeepers (7.3%), Defenders (35.8%), Midfielders (27.2%), or Forwards (29.7%);

*LCR*: categorised players based on typical positioning on the field-Left (16.8%), Centre (67.9%), or Right (15.3%).

### 4.3.2. Data Processing

This study employed a combined analytical approach integrating traditional statistical methods, both descriptive and inferential, with supervised Machine Learning techniques to explore the incidence and severity of injuries among professional football players. First, descriptive statistics were used to summarise central tendencies and variability within the dataset. After confirming non-normal distribution through the Shapiro-Wilk test and

assessing variance homogeneity using Levene's test, non-parametric methods - Mann-Whitney U test and Kruskal-Wallis H test, were employed for group comparisons. Post hoc pairwise comparisons were conducted using Dunn's test with Bonferroni correction to control for type I errors. Spearman's rank correlation was employed to examine associations between ordinal and continuous variables. Poisson regression was used to model count data (number of injuries per player), and in cases of overdispersion, Negative Binomial regression was adopted. Ordinal logistic regression was applied for ordinal outcomes such as injury severity. Second, to complement these analyses, a supervised Machine Learning algorithm - Classification Trees was implemented for cluster analysis. This method allowed for the identification of distinct injury risk profiles based on predictor variables and enabled the detection of complex interaction patterns not captured by traditional statistical models. All analyses were conducted at a 5% significance level ( $\alpha = 0.05$ ), and results were interpreted according to best practices in sports epidemiology and inferential modelling.

## **4.4. Results**

### **4.4.1. Descriptive Statistics and Group Comparisons**

#### **4.4.1.1. Injury Incidence**

Table 4.1. summarises the number of injuries, the total number of injured players, and the corresponding injury rates for each league and overall, across five consecutive seasons, highlighting clear differences in injury prevalence between the FL and the SL.

A total of 998 players in the FL and 641 in the SL sustained injuries over the five seasons. The FL recorded 1,479 injuries (avg. 296/season; SD = 52.15), affecting around 200 players annually (SD = 24.69) from an average pool of 1050 players (SD = 19.58). The proportion of injured players per season (PI/TP) was 19.4% (SD = 4.15%), and the injury event ratio (I/TP) was 28.8% (SD = 8.96%). In the SL, 833 injuries were reported (avg. 167/season; SD = 39.58), involving about 128 players annually (SD = 23.62) from a more variable pool of 476 (SD = 93.83). The PI/TP was 26.8% (SD = 1.48%), and the I/TP was 35% (SD = 3.78%).

Combined, the leagues averaged 462 injuries/year (SD = 88.83), affecting 328 players (SD = 47.57) from a total pool of 1,526 (SD = 102.07). The combined PI/TP was 21% (SD = 2.55%) and I/TP was 31% (SD = 5.40%).

The Mann-Whitney U and Welch's t-test confirmed significant differences in injury counts between leagues ( $p < 0.001$ ), with higher rates in the FL (Mean = 1.48) than in the SL (Mean = 1.30). Although both leagues showed a downward trend in injury occurrence over the five seasons, the Mann-Kendall test found it not statistically significant.

Table 4.1. Injury incidence, number of players injured, and injury rates in the FL, SL and both leagues across five seasons.

Season	First League (FL)					Second League (SL)					FL+SL				
	Injuries (I)	Players Injured (PI)	Total Players (TP)*	PI/TP	I/TP	Injuries (I)	Players Injured (PI)	Total Players (TP)*	PI/TP	I/TP	Injuries (I)	Players Injured (PI)	Total Players (TP)	PI/TP	I/TP
S1	339	218	924	24%	37%	205	157	517	30%	40%	544	375	1441	26%	38%
S2	362	227	943	24%	38%	195	148	528	28%	37%	557	375	1471	25%	38%
S3	279	203	1099	18%	25%	185	122	434	28%	43%	464	325	1533	21%	30%
S4	244	167	1129	15%	22%	121	101	442	23%	27%	365	268	1571	17%	23%
S5	255	183	1155	16%	22%	127	113	460	25%	28%	382	296	1615	18%	24%

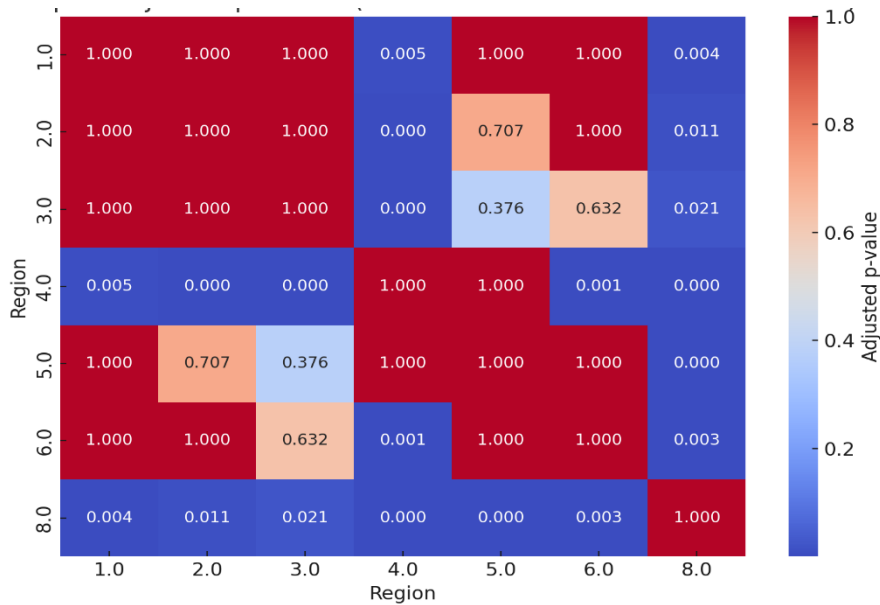
\* Total players (injured and non-injured) competing in the FL and SL by season

The Kruskal–Wallis test indicated significant differences in injury counts by match participation ( $H = 28.01$ ,  $p < 0.001$ ), but Dunn's post-hoc tests (Bonferroni-corrected) showed no significant pairwise differences. Poisson regression supported a significant overall model (LLR  $p = 0.0077$ ), yet no individual category significantly differed from the reference group (crucial players), reinforcing that match participation does not strongly predict injury frequency. Spearman's correlation showed a weak but significant relationship between age and injury count ( $\rho = 0.063$ ,  $p = 0.011$ ), though regression models (Poisson and Negative Binomial) found no statistical significance or explanatory power. Thus, age is not a meaningful predictor of injury frequency.

No significant differences in injury counts were found by tactical position, GDMF category, or LCR variable, according to Kruskal–Wallis and post-hoc tests, nor were any associations identified in Poisson or Negative Binomial regressions.

Ethnicity analysis via Kruskal-Wallis test revealed significant differences ( $H = 45.95$ ,  $p < 0.001$ ). Dunn's post-hoc tests showed North African and Asian players differed significantly from Europeans, while no other pairwise comparisons remained significant after correction. These differences are visualised in Figure 4.1., where darker heatmap cells highlight the most distinct regional contrasts.

Figure 4.1. Heatmap of adjusted p-values (Dunn Test with Bonferroni Correction)



#### 4.4.1.2. Injury Severity

This subsection presents the findings on injury severity. To avoid bias from recurrent injuries, the analysis was limited to players who sustained only one injury per season. Table 4.2. summarises injury severity across the FL, SL, and both leagues over the five seasons.

Table 4.2. Injury severity among players across FL, SL, and FL+SL for each of the five seasons

Season	FL						Total FL	SL					Total SL	Total FL + SL
	Injury Severity					Injury Severity								
	Minimal	Minor	Moderate	Major	Severe	Minimal		Minor	Moderate	Major	Severe			
S1	1	14	57	55	12	139	2	8	31	56	23	120	259	
S2	15	24	39	42	9	129	5	9	32	46	20	112	241	
S3	2	10	53	66	15	146	1	8	30	28	9	76	222	
S4	7	11	41	44	12	115	3	4	26	37	11	81	196	
S5	4	11	58	39	23	135	1	5	31	43	21	101	236	
<b>Total</b>	<b>29</b>	<b>70</b>	<b>248</b>	<b>246</b>	<b>71</b>	<b>664</b>	<b>12</b>	<b>34</b>	<b>150</b>	<b>210</b>	<b>84</b>	<b>490</b>	<b>1154</b>	

A total of 1,154 injuries were recorded over the five seasons, most (57.5%) in the FL. Moderate and major injuries were the most frequent in both leagues, but the SL had higher proportions of major (42.9%) and severe injuries (17%) compared to the FL (37% and

10.7%, respectively). Despite these differences, overall injury severity did not differ significantly between leagues (Mann-Whitney U = 138066, p = 0.99). However, seasonal analysis using the Kruskal–Wallis test showed significant differences in 2016/17 (H(1) = 7.55, p = 0.002) and 2017/18 (H(1) = 8.02, p = 0.001), with the SL exhibiting more major and severe injuries. No significant differences were found in other seasons, indicating comparable severity patterns across leagues in those years.

Table 4.3. summarises injury severity by match participation levels within both leagues. The analysis reveals that major and severe injuries are the most frequent across both leagues. Residual players (group D) had the highest injury counts, followed by occasional players (group C), while crucial players (group A) consistently showed the lowest injury rates. In the FL, residual players experienced the highest proportions of major (41.9%) and severe injuries (18.1%), a pattern also seen in the SL (46% and 24%, respectively). These results highlight an inverse relationship between match participation and injury severity, with less-exposed players suffering more severe injuries, particularly in the FL, a trend consistent across both leagues.

Table 4.3. Injury severity among player’s matches played across FL, SL, and FL+SL.

Players workload	FL						SL						Total injury FL + SL
	Injury Severity					Total injury FL	Injury Severity					Total injury SL	
	Minimal	Minor	Moderate	Major	Severe		Minimal	Minor	Mode rate	Major	Severe		
A - Crucial	3	10	22	5	1	41	1	10	19	10	1	41	82
B - Regular	9	27	76	57	6	175	6	8	36	55	18	123	298
C - Occasionally	11	17	81	89	23	221	2	8	51	61	21	143	364
D - Residual	6	16	69	95	41	227	3	8	44	84	44	183	410
<b>Total</b>	<b>29</b>	<b>70</b>	<b>248</b>	<b>246</b>	<b>71</b>	<b>664</b>	<b>12</b>	<b>34</b>	<b>150</b>	<b>210</b>	<b>84</b>	<b>490</b>	<b>1154</b>

The Kruskal-Wallis test confirmed significant differences in injury severity across the four player categories in the FL (H = 32.60, p < .001), the SL (H = 50.63, p < .001), and the combined dataset (H = 77.17, p < .001). Post hoc analyses (Tukey’s HSD as a proxy for Dunn’s test; see Table 4.4. showed that, in both the FL and the combined leagues, crucial players differed significantly from all other groups, and regular players differed from residual players. In the SL, significant differences were also found between crucial and residual players, and between regular players and both occasional and residual players.

Table 4.4. Correct pairwise comparisons of players match participation (in Rank order)

FL	Result*	SL	Result*	FL+SL	Result*
Rank A vs B ( $p = 0.0023$ )	True	Rank A vs B ( $p < 0.1217$ )	False	Rank A vs B ( $p = 0.0023$ )	True
Rank A vs C ( $p = 0.0004$ )	True	Rank A vs C ( $p < 0.1217$ )	False	Rank A vs C ( $p = 0.0004$ )	True
RankA vs D ( $p < 0.0001$ )	True	RankA vs D ( $p = 0.0002$ )	True	Rank A vs D ( $p < 0.0001$ )	True
Rank B vs C ( $p = 0.9505$ )	False	RankB> vs C ( $p < 0.0001$ )	True	RankB vs C ( $p = 0.9505$ )	False
Rank B vs D ( $p = 0.0331$ )	True	Ranking B vs D ( $p < 0.0001$ )	True	RankB vs D ( $p = 0.0331$ )	True
RankC vs D ( $p = 0.1083$ )	False	Rank C vs D ( $p < 0.0570$ )	False	Rank C vs D ( $p = 0.1083$ )	False

\* True = statistically significant –  $p \leq 0.05$

No significant associations were found between injury severity and age, tactical position (GDMF), playing side (LCR), or ethnicity. Spearman’s correlation and ordinal logistic regression confirmed that age does not influence injury severity. Similarly, Kruskal–Wallis tests showed no significant differences across positions, sides, or ethnic groups ( $H = 8.98$ ,  $p = .175$ ), indicating that these variables do not significantly affect injury severity.

#### 4.4.2. Cluster analysis

As the analysed factors did not fully explain the heterogeneity in injury incidence and severity, a supervised clustering algorithm was employed. Unlike unsupervised clustering, supervised clustering uses a known categorical variable to form homogeneous subgroups based on variation in a target outcome.

##### 4.4.2.1. Player Profiles According to Injury Incidence

To identify patterns in injury incidence, a Decision Tree-based clustering method was applied, using numerical (age) and categorical predictors (player workload, position, GDMF, LCR, ethnicity, league). Cross-validation defined four terminal nodes, producing four distinct clusters that reflect player profiles with different injury patterns (Table 4.5.).

Table 4.5. Decision Tree Clustering (4 Nodes) for injuries incidence: Cluster Profiles

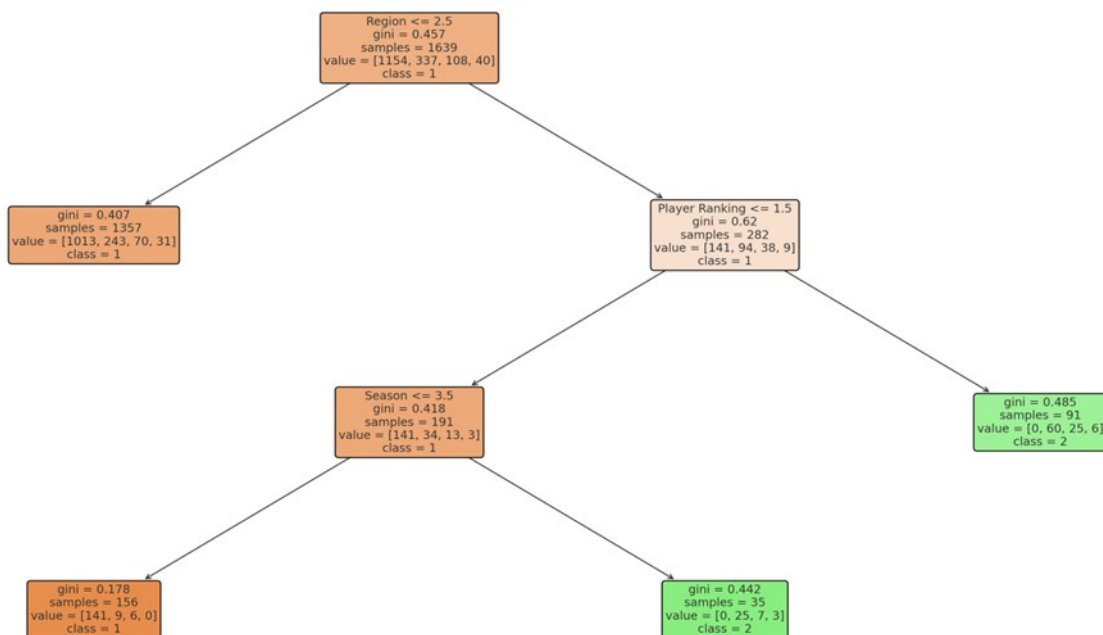
Cluster	Mean number Injuries	Min number Injuries	Max number Injuries	Number of Players	Mean Players' Age	Mean Season	Most Frequent match participation	Most Frequent GDMF	Most Frequent LCR	Most Frequent Ethnicity	Most Frequent League
1	1.35	1.00	4.00	1357	25.75	2.89	C	D	C	2	1
2	2.41	2.00	4.00	91	25.35	2.88	D	D	C	4	1
3	1.13	1.00	3.00	156	26.86	2.05	B	D	C	2	1
4	2.37	2.00	4.00	35	27.83	4.37	B	D	C	4	1

A summary of the cluster-level descriptive analysis is presented below:

- *Cluster 3* includes players with the lowest injury incidence (mean = 1.13), mostly older, regular-starting central defenders from Europe competing in the FL.
- *Cluster 1* the largest group, comprises European central defenders in the FL, averaging 25.8 years of age and typically used occasionally. They show a low-to-moderate injury burden (mean = 1.35) with little variation.
- *Cluster 4* represents a smaller group of older, regular-starting central defenders from North Africa in the FL, with a notably higher injury incidence (mean = 2.37).
- *Cluster 2* consists of residual players in the FL, also African central defenders, with the highest injury incidence (mean = 2.41). Despite similarities in age and position with Cluster 1, their elevated injury rates suggest underlying risk factors, possibly related to region and match participation.

Figure 4.2. displays the decision tree used to define the clusters. Each node represents a split based on key variables, ethnicity, match participation, and season. “Samples” indicates the number of players per node; “Value” shows the distribution of injury severity; “Class” identifies the most frequent severity category; and the “Gini” index reflects node heterogeneity.

Figure 4.2. Decision Tree for Injury Incidence



The decision tree model used to classify the number of injuries produced the following rules:

- Players with Ethnicity  $\leq 2.5$  (i.e., from Ethnicity 1 and 2) are directly assigned to Cluster 1.
- Among players with Ethnicity  $> 2.5$  (i.e., from Ethnicity 3 and above):
  - If Player match participation  $\leq 1.5$ :
    - And Season  $\leq 3.5$ , assigned to Cluster 3.
    - And Season  $> 3.5$ , assigned to Cluster 4.
  - If Player match participation  $> 1.5$ , assigned to Cluster 2.

The results show that ethnicity is the most influential variable, driving the primary and strongest split in the decision tree. Players from Regions 1 and 2 (Europe and Southern Europe) are directly classified into Cluster 1. For players of other ethnic backgrounds, further classification depends on match participation and season. Among these players (Ethnicity  $> 2.5$ ), those with lower match participation are further divided by season: those from earlier seasons are assigned to Cluster 3, while those from later seasons fall into Cluster 6. In contrast, residual players with high match participation are allocated to Cluster 2. Overall, the model underscores the central role of ethnicity and playing time in shaping injury incidence profiles.

#### 4.4.2.2. Player Profiles According to Injury Severity

To examine injury severity, a Decision Tree Classifier was applied using all available predictor variables, excluding injury severity itself. The tree was pruned to five terminal nodes, with the optimal structure selected through cross-validation (Table 4.6.).

Table 4.6. Decision Tree Clustering (5 Nodes) for Injury Severity: Cluster Profiles.

Cluster	Number of Players	Mean Injury Severity	Mean players' Age	Most Frequent match participation	Most Frequent GDMF	Most Frequent LCR	Most Frequent Ethnicity	Most Frequent League
1	82	2.89	28.23	A	D	C	2	1
24	449	3.71	25.29	D	D	C	2	2
35	175	3.14	26.48	B	D	C	2	1
47	295	3.54	22.99	D	F	C	2	1
58	153	3.57	30.08	C	D	C	2	1

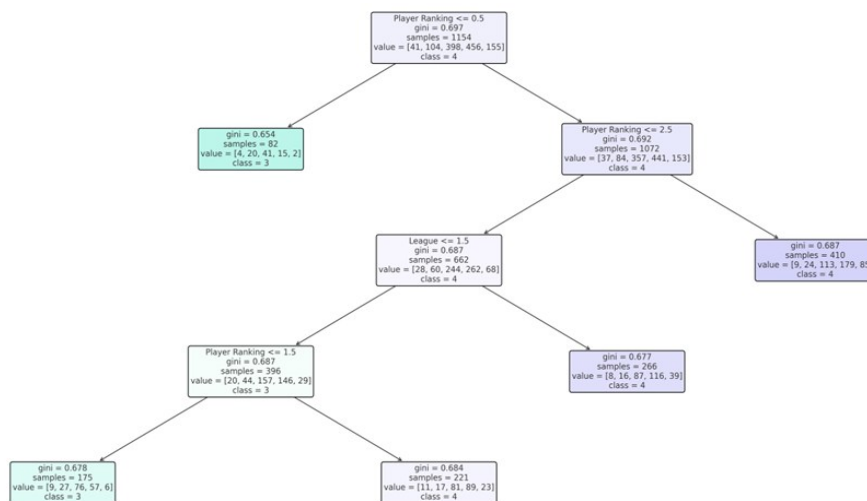
A summary of the descriptive cluster analysis is outlined below:

- *Cluster 1* includes with the lowest injury severity (mean = 2.89). These are generally older players (mean age: 28.2), primarily from Southern Europe, competing in the FL as starting or crucial central defenders.

- *Cluster 3* represents players with moderate injury severity (mean = 3.14), also predominantly from Southern Europe (mean age: 26.5). Most are regular central defenders competing in the FL.
- *Cluster 4* comprises the youngest players, predominantly central forwards with high injury severity (mean = 3.54). These players have residual match participation, play in the FL, and are mostly from Southern Europe. Their limited exposure, offensive role, and involvement in high-intensity actions may increase their susceptibility to injury.
- *Cluster 5* also shows high injury severity (mean = 3.57). It includes 153 players with the highest average age (30.1), from Southern Europe, who are mostly occasional central defenders in the FL. The combination of age, defensive roles, and infrequent participation may elevate injury risk due to reduced recovery and accumulated physical stress.
- *Cluster 2* exhibits the highest injury severity (mean = 3.71). This group includes 449 relatively young players (mean age: 25.3), mainly central defenders from Southern Europe, with residual match participation, competing largely in the SL.

Figure 4.3. illustrates the decision tree generated by the Classification algorithm, which classifies injury severity based on player characteristics.

Figure 4.3. Decision Tree for Injury Severity



The decision tree model developed to classify injury severity produced the following set of rules:

- Players with a match participation tier  $\leq 0.5$  (i.e., start matches) - Assign to cluster 1.

- Among players with a match participation tier > 0.5:
  - If match participation ≤ 2.5 (i.e., regulars or occasional players):
    - If League < 1.5 then:
      - If match participation ≤ 1.5 – Assign to cluster 3
      - If match participation > 1.5 – Assign to cluster 5
    - If League > 1.5 – Assign to cluster 4
  - If match participation > 2.5 (i.e., residual players) – Assign to cluster 2

The results show that the most influential variable in the model was match participation. Players who consistently started matches were directly assigned to Cluster 1, which is associated with the lowest injury severity. For players with a match participation tier between 0.5 and 2.5, league level became a key determinant: In the FL, players with more regular involvement were placed in Cluster 3, while those with less frequent participation were classified into Cluster 5, indicating higher injury severity. Players from this group competing in the SL were allocated to Cluster 7, which also correlates with high injury severity. Lastly, players with very limited match participation (tier > 2.5), identified as residual or marginal squad members, were consistently assigned to Cluster 2, a group marked by high injury severity.

Thus, the model underscores a protective effect of consistent match participation on injury severity and highlights the interaction between league level and player usage patterns. The clusters reflect significant distinctions in injury risk profiles across different player roles and contexts.

## **4.4. Discussion**

### **4.4.1. General Discussion**

This study offers novel insights into injury incidence and severity among professional footballers in Portugal over five seasons, using a combination of descriptive, inferential, and cluster analysis to identify player profiles linked to different risk levels.

This has economic implications, as injuries in the FL accounted for 13,088.8 lost days and an estimated €42.3 million over five seasons, based on average annual player spending.

Our findings provide partial answers to our research questions. Addressing RQ1 - whether injury incidence and severity differ between FL and SL players, we found that injury incidence was significantly higher in the FL, contrasting with international evidence of similar rates across divisions (Arliani et al., 2018; Jaspers et al., 2018), but consistent with research linking top-tier competition to greater physical demands (López-Valenciano et al., 2019;

Waldén et al., 2016). This has economic implications, as injuries in the FL accounted for 13,088.8 lost days and an estimated €42.3 million over five seasons, based on average annual player spending (€236,500).

As for severity, SL players sustained proportionally more severe injuries, though statistically significant differences were found only in 2016/17 and 2017/18, mainly in the “major” and “severe” categories which aligns with findings from other professional contexts (Carvalho et al., 2016; Gabbett, 2016). These patterns likely reflect structural disparities, lower-tier clubs often face limitations in pitch quality, medical infrastructure, and preventive resources, which have been linked to increased injury risk (Drawer & Fuller, 2002; Bahr & Krosshaug, 2005).

In relation to RQ2 - injury variation across seasons, the overall incidence and severity remained stable, in line with some studies (Ekstrand et al., 2011). This stability may reflect consistent training methods, fixture scheduling, and medical practices. Unlike periods affected by external shocks, such as COVID-19 (Seshadri et al., 2021), the five seasons analysed appear to have been relatively stable.

Concerning RQ3 - intrinsic factors, age showed no significant effect on injury incidence or severity. This contrasts with earlier studies suggesting increased injury risk with advancing age, particularly for chronic or overload-related injuries (Gabbett, 2016; Jones et al., 2022; Martins et al., 2022; Kwakye et al., 2023), but aligns with more recent findings suggesting that effective load management may mitigate such risks (Malone et al., 2018). Nationality, however, was significantly associated with injury incidence. North African players (Maghrebian, Algerian, Moroccan) exhibited higher injury rates, while Asian players had the lowest. These results support international evidence relating regional differences in injury risk to physiological and cultural factors (Song et al., 2018). For example, Ramadan observance may affect training, sleep, and diet, potentially impairing recovery and increasing injury risk (Maughan et al., 2012; Osman et al., 2020). Physiological predispositions, such as a predominance of fast-twitch muscle fibres among North African players, may also contribute to higher muscular injury susceptibility (Mujika et al., 2004). In contrast, lower injury rates among Asian players may reflect disciplined routines in diet, sleep, and training. While comparative data are limited, some evidence supports this view, noting lower body fat, reduced physical fitness, but high technical skill, resilience, and strong work ethic among East Asian players (Luo et al., 2025). However, findings remain mixed: some report higher injury rates among Asian players (Yoon et al., 2004), while others find similar rates compared to Europeans (Tabben et al., 2022). Despite its effect on incidence, nationality did not significantly influence injury severity, suggesting comparable clinical outcomes across groups.

Regarding RQ4 - extrinsic factors, no significant differences in injury incidence or severity were found across tactical positions, challenging prior studies that identified defenders and midfielders as more injury-prone (Hägglund et al., 2013, Brito et al., 2016; Bult et al., 2018; López-Valenciano et al., 2020; Jones et al., 2022). This inconsistency may stem from team-specific tactical or workload variations. In contrast, match participation significantly influenced injury severity: players with greater exposure sustained less severe injuries, supporting evidence of a protective effect from regular competition (Hulin et al., 2016; Windt et al., 2017; Kwakye et al., 2023).

Finally, the cluster analysis supported and expanded previous findings by identifying specific player profiles linked to injury incidence and severity. Ethnicity and match participation were key for injury incidence: European players had lower injury rates, and players with limited match exposure were more injury-prone, findings consistent with prior evidence on cultural and physiological adaptation (Hulin et al., 2016; Tranaeus et al., 2024). For injury severity, regular participation was again protective, while sporadically involved players were more often associated with severe injury clusters as stated elsewhere (Gabbett, 2016; Malone et al., 2018). Severity patterns also varied by league and season, with SL players and earlier seasons more frequently linked to severe injuries, likely due to differences in resources and medical support (Ekstrand et al., 2020).

Overall, these results highlight the importance of considering both intrinsic and extrinsic factors, and their interplay when assessing injury risk and developing preventive strategies.

#### **4.4.2. Practical Implications**

This study offers evidence-based guidance for injury prevention in Portuguese professional football, a sector of significant economic relevance due to the player transfer market. Findings highlight the need to consider both intrinsic and extrinsic factors, particularly for players with low match exposure and those from diverse cultural backgrounds. Optimising training load and adopting culturally sensitive approaches may enhance prevention strategies. Moreover, addressing structural disparities between leagues through targeted investment in medical and training infrastructure, especially in lower-tier clubs, could reduce injury risk and improve team performance.

#### **4.4.3. Limitations and directions for future research**

Despite its strengths, namely the use of comprehensive real-world data from five consecutive seasons and the combined use of descriptive, inferential, and cluster analyses

this study has limitations. It is restricted to a single national context, which may limit generalisability. Key variables such as training load, psychological factors, and club-level infrastructure were not included. Furthermore, the reliance on routinely collected data may introduce reporting inconsistencies across clubs. Future research should consider multi-country comparisons, integrate more detailed workload and recovery metrics, and adopt longitudinal designs to enhance predictive accuracy. Combining machine learning with traditional methods may also reveal deeper patterns to inform injury prevention strategies.

## **4.5. Conclusions**

Given the substantial sporting and economic impact of injuries, especially in Portugal, where player transfers drive much of the football economy understanding injury patterns is essential for protecting player health and ensuring the industry's sustainability. Our analyses showed that injury incidence is associated with league level and nationality, while severity is influenced by league level and match participation. Although injury numbers were higher in the FL, injuries were more severe in the SL, particularly in earlier seasons. Cluster analysis reinforced these patterns, identifying higher incidence among non-European players and greater severity among those with low match exposure and in the SL.

Overall, this study confirms that injury risk is multifactorial, with competition level, match participation, and nationality outweighing age or tactical position. Structural inequalities and underexposure, rather than age or role, are the key risk factors. These findings call for tailored, context-sensitive prevention strategies and challenge the overreliance on age- or position-based assumptions. By drawing on real-world data from five seasons of the Portuguese FL and SL, this research offers robust, ecologically valid insights for injury prevention in elite football.



# CHAPTER 5 – OCCUPATIONAL SAFETY AND INJURY RISK IN PROFESSIONAL FOOTBALL: THE PORTUGUESE LEGAL FRAMEWORK IN COMPARATIVE PERSPECTIVE

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## **Abstract**

Professional football players face considerable occupational hazards, with injuries posing serious challenges to player safety, club performance, and regulatory oversight. This descriptive study examines the multifaceted implications of Portugal's Laws No. 48/2023, which formally recognises professional football as a high-risk occupation and strengthens the mandatory insurance regime through a major regulatory update. Adopting a qualitative approach, the analysis focuses on Portugal, where the professional football business model heavily relies on player commercialisation, while drawing comparisons with regulatory frameworks in Spain, Germany, England, Italy, France, and Brazil. Findings indicate that Portugal's legal framework enhances player safety by ensuring comprehensive coverage and improved disability protections, yet also introduces financial pressures on clubs, particularly those with lower economic capacity. These pressures are exacerbated by limited market competition and high insurance concentration, increasing premium costs. Cross-country comparisons reveal persistent disparities in legal standards, insurance scope, and institutional coordination, which complicate risk allocation in an increasingly globalised football market. While full harmonisation remains challenging, the study identifies key principles to guide policy reform and international cooperation. Overall, the findings advance understanding of occupational risk regulation in sport and offer practical insights for designing effective, equitable, and safety-oriented protection systems for professional athletes.

**Keywords:** Athletes safety; Sports law; professional football; Football players injuries; Occupational insurance; High-risk profession; Insurance regulation; Comparative legal analysis

## 5.1. Introduction

Professional football represents one of the most economically significant and culturally pervasive sporting activities globally, with the European market alone generating €26.8 billion in 2023 (Yiapanas, 2025). However, this global industry is underpinned by a stark occupational reality: professional footballers face injury rates that far exceed those of traditionally high-risk professions (Ekstrand et al., 2021; López-Valenciano et al., 2023). These injuries generate legal, economic, and social consequences, affecting players' health and welfare, clubs' financial sustainability, and broader regulatory frameworks (Carmichael et al., 2017; Eliakim et al., 2020). In countries such as Portugal, where the buying and selling of players constitutes a crucial source of revenue for clubs, the physical condition of athletes represents a fundamental economic asset. Within this context, injuries emerge not only as a sporting challenge but also as an economic, labour, and social issue, directly impacting team performance and the market value of players.

The economic dimension of football injuries is particularly significant. Injuries impose both direct costs, such as medical expenses and player salaries during recovery, and indirect costs, including productivity loss and decreased team performance, which together represent a substantial financial burden (Vidoni et al., 2018; Cardoso-Marinho et al., 2022). Clubs may face up to 15 muscle injuries per season, particularly hamstring injuries, which often entail longer recovery times and elevated recurrence-related expenses (Raya-González et al., 2018). At the macro level, leagues and national associations also incur heavy losses (Krist et al., 2013). These injuries not only affect athletic performance but also reduce revenue from broadcasting and other income streams (Nieto Torrejón et al., 2024), reinforcing the need for injury prevention strategies and robust insurance markets tailored to the high-risk profile of the profession (Saltzman et al., 2023).

Despite the high exposure to physical risk, professional footballers do not always benefit from a legal framework fully adapted to the nature of their activity. The recurrence and severity of specific injuries raise concerns regarding the adequacy of existing social protection, particularly concerning mandatory occupational accident insurance coverage and the potential classification of professional football as a “wear-and-tear” or “fast-depreciation” profession. These issues become especially relevant considering the relatively short average career span and the possibility of early retirement due to disability. Within this context, Portugal's Law No. 48/2023 establishes a dedicated legal regime for compensating work-related injuries among professional athletes, recognising the heightened occupational risks inherent in elite sport. Repealing the earlier Law No. 27/2011, this legislation introduces enhanced protections specifically tailored to the realities of athletic performance. It mandates that football clubs provide compulsory workplace accident

insurance, calibrated to the elevated injury risks of professional football. Crucially, it reinforces players' rights to compensation, rehabilitation, and long-term support in cases of temporary or permanent incapacity, aligning legal safeguards with the distinctive demands of the profession. Law No. 48/2023 represents a significant refinement of the previous framework, a landmark development in the evolution of sports labour law, with potentially far-reaching implications for the governance, financial sustainability, and insurance architecture of football in Portugal. The law reflects a growing recognition of the sports' hazard profile, which has been compared to that of mining and emergency services (Dennis & Finch, 2008). Empirical evidence supports this classification: elite players experience injury rates nearly a thousand times higher than those in other dangerous industries (Gouttebauge et al., 2018), and, for instance, the prevalence of knee osteoarthritis in retired male footballers is two to three times higher than in the general male population (Fernandes et al., 2018). These health consequences extend beyond retirement. Former professional footballers who sustained multiple severe injuries during their careers reported poorer physical quality of life after retirement (Teixeira et al., 2025).

Despite extensive health research documenting injury patterns, rehabilitation protocols, and prevention strategies (Ekstrand et al., 2021; López-Valenciano et al., 2023), the legal classification of these injuries as occupational risks and the resulting economic and insurance implications remain underexplored in a comparative context (Weatherill, 2014, 2017). The works of Liu et al. (2022) on legal accountability and Ross et al. (2022) and Krutsch et al. (2021) on insurance are examples of these discrete strands of inquiry that illuminate complementary facets of the same phenomenon. However, a synthesised framework that intertwines legal obligations, their economic effects, and insurance practice remains conspicuously absent as regulatory and insurance responses continue to diverge across countries due to varying legal, cultural, and economic rationales (Chadwick et al., 2019; Greenhow & Wolohan, 2025). An integrated research agenda is therefore essential if scholars and practitioners are to devise holistic strategies for the prevention and management of football injuries. This gap is particularly concerning considering the growing globalisation of the football industry, which intensifies player mobility and exposes professionals to heterogeneous legal and insurance regimes. In the era of globalisation, professional football increasingly operates as a transnational labour market marked by intensified player mobility and complex legal challenges. Following the Bosman ruling, which eliminated intra-European Union transfer restrictions, the proportion of foreign players in European clubs increased substantially (Sever et al., 2023), driving greater contractual liberalisation and competitive recruitment (Vasilakis, 2017). However, this mobility exposes players to heterogeneous legal regimes, fragmented social security systems, employment insecurity, and disparities in insurance coverage across jurisdictions (Liang, 2019). While

globalisation expands career opportunities, it simultaneously multiplies structural vulnerabilities, underscoring the need for interdisciplinary analyses that highlight the need for a comprehensive research agenda synthesising legal, economic, and insurance dimensions of football injuries to inform holistic prevention and governance strategies, especially regarding the inequities created by fragmented regulatory environments. Indeed, this research gap is of particular significance since the absence of harmonised approaches creates potential inequities in player protection, competitive imbalances between clubs operating under different regulatory regimes, and complex challenges for insurance markets attempting to price and manage these risks.

Accordingly, this study aims to address these gaps through an interdisciplinary analysis of the legal, economic, and insurance implications of classifying football as a high-risk profession, focusing particularly on Portugal's law as a comparative case study. The objectives include: (i) analysing the legal foundations and implementation mechanisms of the mandatory Portuguese insurance Law and assessing its economic effects on stakeholders such as clubs, players and insurers, (ii) conducting a systematic comparative analysis of legal frameworks and insurance requirements across seven jurisdictions (Portugal, Spain, Germany, England, Italy, France, and Brazil) and (iii) proposing evidence-based policy recommendations balancing player protection, financial sustainability, and competitive equity.

The present paper is organised as follows: Section 2 reviews the literature on legal and insurance aspects of football injuries. Section 3 analyses the Portuguese case, outlining the legal framework governing workers' compensation insurance for professional football players in Portugal. Section 5 broadens the analysis to six additional leagues, comparing their regulatory approaches to insurance coverage for professional football players. Section 6 concludes and presents practical implications and future research directions.

## **5.2. Literature Review**

### **5.2.1 Legal Frameworks for Professional Athletes**

The legal status of professional athletes remains a complex and evolving issue, marked by substantial variation across jurisdictions. Traditional labour laws often fail to capture the particularities of sports careers, leading to the emergence of specialised frameworks. This section explores four core dimensions that structure legal debates in this area: employment status, occupational risk classification, regulatory protection, and legal traditions.

### **5.2.1.1 Employment Status of Professional Athletes**

Professional athletes face distinctive employment challenges that differentiate them from workers in conventional labour markets. In many European jurisdictions, professional footballers are predominantly classified as employees, thereby entitled to standard labour protections, including occupational health and safety regulations, social security benefits, and collective bargaining rights (O’Leary et al., 2024). Nonetheless, the practical implementation of these protections exhibits considerable variation, with certain countries adopting sport-specific exceptions or adaptations to the general employment framework (Parrish, 2003). Professional athletes often face short, injury-prone careers that may end involuntarily, making post-retirement transitions to related roles, such as coaching or media, essential for leveraging their specialised skills and human capital (Frick & Moser, 2020). O’Leary et al. (2024) highlight that exclusion from standard employee status across European jurisdictions creates notable gaps in social and employment protections, especially concerning injury-related risks without sufficient social security or compensation. Conversely, European professional footballers benefit from sport-specific legal frameworks that offer advantages unavailable to typical employees, such as access to specialist arbitration via the Court of Arbitration for Sport and regulatory autonomy granted to bodies like FIFA and UEFA (Parrish, 2003; Duval, 2016). These frameworks have shaped a differentiated labour governance system in sport, which, while protective in certain respects, is unevenly applied and may exacerbate disparities between elite and lower-tier athletes. Outside Europe, employment governance tends to be more fragmented or sport specific. International federations such as FIFA exert considerable regulatory authority through contractual mechanisms that override national labour laws, forming a “chain of contracts” among clubs, players, and governing bodies (Freeburn, 2018). This arrangement, while offering some protections, may also undermine local labour standards. According to Kohe & Purdy (Kohe & Purdy, 2025) professional athletes occupy a unique socio-legal category of “sport workers,” governed by normative and contractual regimes that confer privileges while reproducing precarity, particularly amid career instability and employer dominance.

### **5.2.1.2. Legal Classification of Occupational Risk in Sports**

Occupational risks in sports are distinct due to the specific nature of athletic activities and are generally classified as occupational accidents or diseases, both legally defined and statistically monitored (Cuny & Lejeune, 2003). The classification system used significantly influences how such risks are understood and measured. However, traditional frameworks were primarily designed for industrial contexts and often fail to capture the unique features of sport-related risks (Beloff et al., 2012). Risk categories, typically based on accident

frequency, harm severity, and preventability, manifest differently in sports settings compared to conventional workplaces (Siekmann, 2012; Soek & Siekmann, 2023). Weatherill (2017) identifies three main legal approaches to classifying occupational risk in professional sports: (1) inclusion within standard frameworks with sport-specific adaptations; (2) creation of specialised classification systems; and (3) exclusion from formal frameworks, relying instead on private contracts and insurance. Portugal's Law No. 48/2023 exemplifies the first model, formally recognising professional football as a high-risk occupation within its general occupational injury regime.

### **5.2.1.3. Regulatory Approaches to Athlete Protection**

Athlete protection is increasingly recognised as a systemic, rights-based issue requiring cultural change. However, current safeguarding practices often reflect majority-centric views, limiting their applicability across diverse contexts (Tuakli-Wosornu & Kirby, 2022). Regulatory approaches vary widely across jurisdictions. Parrish (2003) identifies a spectrum ranging from strong state regulation to primarily private governance via sporting federations and collective agreements. These differences reflect broader regulatory philosophies - some jurisdictions favour direct state involvement, while others rely on industry self-regulation with variable state oversight (Foster, 2019).

In Europe, the EU has become a key actor in athlete protection, shaping national systems through direct legislation, especially in areas like free movement and anti-discrimination, and indirect harmonisation of standards (Duval, 2016; Weatherill, 2017). Outside Europe, the divergence is even more pronounced. While North America relies heavily on private mechanisms such as collective bargaining and league rules, South America and parts of Asia tend toward more state-driven models (Freeburn, 2018). These disparities pose significant challenges for international governance, particularly in globalised sports like football (Foster, 2019).

### **5.2.1.4. Comparative Legal Traditions in Sports Law**

Comparative law, by analysing different legal traditions and systems, provides valuable insights for legislative development and reform, including in sports law (Siekmann, 2012). Legal traditions, shaped by institutions of lawmaking and adjudication, significantly influence how jurisdictions regulate sports (Guerriero, 2016). Civil law countries tend to codify athlete protections more comprehensively, whereas standard law systems rely on case law and private ordering (Soek & Siekmann, 2023). These differences affect how occupational risks in football are defined, regulated, and compensated.

Many jurisdictions operate under a dual regulatory model where general employment, health, and tort laws intersect with sport-specific rules, often creating legal uncertainty (Beloff et al., 2012; Weatherill, 2014). Historical developments also matter: legal traditions have evolved differently in response to the professionalisation of football, with path dependencies (Parrish, 2003), colonial legacies, and legal transplants shaping hybrid legal systems (Foster, 2019).

Despite these divergences, recent comparative research highlights growing convergence in key areas. Duval (2016) notes increased recognition of athletes' employment rights, while (Colucci & Vermeer, 2023) identifies emerging international standards for injury compensation and insurance. Still, significant legal fragmentation remains, posing challenges for stakeholders operating across jurisdictions (Exner et al., 2025).

## **5.2.2 Insurance Systems for Professional Athletes**

Insurance systems for professional athletes have evolved significantly, reflecting broader differences between public and private health coverage models. Public insurance systems, prevalent in countries with robust welfare states, are characterised by mandatory subscription, comprehensive coverage, and substantial government funding. These systems ensure that all citizens, including athletes, have access to necessary medical services (Lee et al., 2008; Torvaldsson et al., 2023).

Professional athletes benefit from the broad scope of public insurance, which typically includes full access to medical examinations, medication, and laboratory analyses (Salti et al., 2010). In contrast, private insurance, whether employer-based or individually purchased, may offer more customised plans, but often with partial or selective coverage (Salti et al., 2010). Regulatory structures also differ in public systems, general practitioners frequently serve as gatekeepers, directing access to specialised care and controlling costs (Bongers et al., 1997). Fundamentally, public insurance prioritises social equity and universal access, while private models are driven by market efficiency and profit motives, potentially influencing the scope and quality of coverage for athletes (OECD, 2004).

At the international level, sport governance frequently operates under self-regulatory models, where private organisations such as leagues and federations establish their own rules, bylaws, and enforcement mechanisms. These macro-regulatory systems govern relationships between clubs, athletes, and governing bodies with minimal external legal oversight, and frequently include revenue-sharing mechanisms to promote financial stability (Dowling et al., 2018; Hu & Shu, 2024). However, significant challenges arise in the context of player transfers, particularly in globalised sports such as football, by involving complex financial operations and multiple stakeholders. The fast-paced nature of transfer

negotiations raises ethical concerns about medical confidentiality, especially regarding the ownership, access, and disclosure of medical data. The cancelled transfer of Ruud van Nistelrooy, following the disclosure of medical concerns, remains a high-profile example of these tensions (Malcolm, 2016). Insurance systems must also contend with logistical barriers to transnational coverage, including the difficulty of coordinating follow-up care and long-term medical support after international transfers (van Hooff et al., 2023). These gaps are particularly problematic given the short, high-risk careers of professional athletes and the potential for long-term disability or career-ending injuries. While insurance systems provide a framework for financial and medical security, the challenges in player transfers, including confidentiality issues and logistical constraints, require ongoing attention and improvement to support the well-being and career development of professional athletes.

### **5.3. The Portuguese Legal Framework**

Portugal's legal framework governing professional sports has progressively evolved, with the recent enactment of Law 48/2023 of 22 August (República, 2023) providing a significant refinement of previous legislation. This law aims to modernize and streamline the regulation of professional sports activities, building on the foundations already established. This section examines the context, development, key provisions, implementation mechanisms, and drawbacks of this legislative framework, providing the foundation for subsequent comparative analysis.

#### **5.3.1 The Legal Treatment of Sports Injuries in Portugal: An Evolutionary Perspective**

Portugal's regulatory framework for professional sport began to take shape with Law No. 28/1998 of 26 June (República, 1998), which recognised the distinctive nature of sports employment. Replacing Decree-Law No. 305/95, this legislation established a dedicated regime for employment and training contracts in professional sport, acknowledging its specificities relative to general labour law. However, Law No. 28/1998 did not adequately address work-related accidents, a critical issue given the elevated injury risks and short career spans typical of professional athletes. In response, Law No. 8/2003 (República, 2003) introduced provisions for compensating injuries in sport, but it was regarded as an incomplete solution. A more targeted legal framework emerged with Law No. 27/2011 (República, 2011), which repealed Law No. 8/2003 (República, 2003) and created a specific regime for compensating occupational accidents among professional athletes. It established mandatory sports insurance and clarified rules for calculating indemnities and

pensions, reflecting the unique physical demands and vulnerabilities of sports professionals.

However, the continued commercialisation and complexity of professional sport revealed the limitations of this framework. As a result, Law No. 48/2023, in force since 22 August 2023, introduced a comprehensive overhaul of the legal regime for occupational accidents in sport. Replacing Law No. 27/2011, the new legislation responds to the specific needs of athletes by enhancing protection mechanisms and legal clarity. Key innovations include mandatory informed consent for the sharing of medical data between insurers and employers, structured rehabilitation processes, conflict-resolution procedures involving federation-appointed medical experts, and updated rules for compensation and disability pensions. The law also explicitly covers medical travel and accommodation expenses.

This reform acknowledges the accelerated physical wear and shorter career spans of professional athletes, especially footballers. It represents a significant step forward in adapting Portuguese occupational injury law to the realities of modern professional sport. Under the new framework, football clubs are required to contract workplace accident insurance policies that are tailored to the heightened injury risks associated with professional football.

One of the most innovative aspects of Law No. 48/2023 is its formal recognition of the risks associated with professional football. The law introduces a dedicated compensation table that reflects the elevated incidence and severity of injuries within the sport. Indeed, while Law 48/2023 does not explicitly designate professional football players as high-risk professionals, the disability schedule contained within the law provides clear evidence that professional football constitutes a high-risk occupation.

The reform also strengthened the insurance architecture underpinning athlete protection. In conjunction with Law No. 54/2017 (República, 2017) (governing the sports employment contract), Law No. 98/2009 (República, 2009) (which regulates occupational accident compensation), and the collective bargaining agreement between Liga Portugal and the Union of Professional Football Players, Law No. 48/2023 requires clubs to maintain insurance policies that provide coverage for temporary incapacity, permanent disability, and long-term medical care. Clubs must provide proof of such insurance as a condition for licensing and participation in official competitions (Liga Portugal, 2025). At the same time, the Labour Inspectorate and the Insurance Supervisory Authority are empowered to monitor compliance and apply sanctions in cases of breach. Insurance exclusions are tightly regulated. Only objectively verified pre-existing conditions or narrowly defined cases of gross negligence are permitted as grounds for exemption.

Despite recent legal advancements, disputes between players and insurers over disability classifications have intensified. Between the 2017/2018 and 2021/2022 seasons,

the proportion of claims involving medical board assessments rose from 2.3% to 6%, while litigation rates nearly doubled from 10.7% to 19.3%. Although the average disability ratings have remained stable, the rising number of cases brought to court suggests increasing reliance on legal and medico-technical mechanisms, highlighting the judicialisation of the insurance process and raising concerns about the effectiveness and transparency of current dispute-resolution frameworks.

Despite these improvements, legal disputes between players and insurers over disability classifications have intensified. Between the 2017/2018 and 2021/2022 seasons, the proportion of claims involving medical board assessments rose from 2.3% to 6%, peaking at 8% in 2020/2021, while litigation rates nearly doubled from 10.7% to 19.3% (IGFEG). Although the average disability ratings assigned by these boards have remained stable, the rising number of cases brought to court suggests increasing reliance on legal and medico-technical mechanisms, highlighting the judicialisation of the insurance process and raising concerns about the effectiveness and transparency of current dispute-resolution frameworks.

This legislative progress aligns with broader European and international trends in athlete protection. The European Commission's 2024 implementation report on the EU Work Plan for Sport 2021–2024 identified health, safety, and social protection as key priorities for EU sport policy, encouraging Member States to reinforce their regulatory frameworks in this area (Commission, 2024). At the international level, FIFA's 2021 re-vision of the Club Protection Programme modestly expanded insurance coverage for temporary total disablement during international duty. However, it continued to exclude permanent disability and long-term medical costs (FIFA, 2023). Concurrently, FIFPro's 2022-2023 Player Workload Monitoring reports revealed that congested match calendars were increasing injury risks and long-term health burdens for elite footballers (FIFPro, 2023), fuelling calls for stronger domestic protections, of which the Portuguese reform is a notable example.

### **5.3.2. Economic Drawbacks of the New Legal Framework**

While Law No. 48/2023 represents a significant step forward in safeguarding the rights and health of professional athletes, it also introduces substantial economic burdens, particularly for smaller football clubs with limited financial resilience. Since the legislation mandates compulsory occupational accident insurance, clubs are legally required to secure coverage from private insurance providers.

From the insurer's perspective, the high risk and mandatory nature of this market may lead to concentration, as only a limited number of companies are willing to underwrite such

policies, a pattern evident in the Portuguese context, where the market remains highly concentrated. Moreover, since professional compensation insurance is compulsory, insurers are aware that football clubs are legally obliged to purchase coverage. Together, these two dynamics - limited competition and inelastic demand - contribute to inflating insurance premiums. Thus, it reinforces the need for active regulatory oversight to safeguard market efficiency and contain cost escalation.

These insurance policies are not offered at fixed rates but are negotiated individually, with premiums calculated as a proportion of the insured players' total wage bill. Although insurers must operate within regulatory parameters that forbid discrimination based on nationality or union affiliation, they may differentiate based on objective risk factors, most notably, the players' age and salary levels. Consequently, clubs with older or higher-paid players are likely to face proportionally higher insurance costs.

While premiums can be substantial, they represent a strategic investment for clubs. By transferring the financial risk of injury to insurers, clubs are relieved from the obligation of paying injured players' wages, especially relevant in cases of long-term absence or high salaries. In the long run, additional benefits may include reduced healthcare expenses and improved performance due to lower injury-related anxiety. Though difficult to quantify, simulation models suggest that avoided earnings losses may offset insurance costs, especially when effective prevention strategies reduce the frequency of severe injuries (Al Attar et al., 2016).

Even with risk transferred to insurers, clubs retain incentives to invest in prevention, improve medical infrastructure, and ensure compliance with rehabilitation protocols. These efforts not only mitigate injury risk but can also lead to lower premiums. However, these measures require financial resources that many clubs lack (Gregson et al., 2022). In this context, FIFA-mandated compensatory mechanisms for training clubs can help absorb some of these costs, particularly in lower leagues.

Insurance premiums may also restrict clubs' ability to offer competitive wages, invest in player acquisitions, or support youth development, factors that influence team performance and revenue streams. Since the absence of star players affects audience engagement, improved injury protection could help stabilise revenues from tickets and broadcasting (Wills et al., 2022). Still, the impact varies according to each club's financial structure and existing risk management practices (Dallmeyer et al., 2025).

Finally, a further economic drawback of the framework may be its vulnerability to moral hazard, a classic issue in insurance economics (Pauly, 1968), where insured individuals take greater risks or reduce precaution because they do not bear the full cost of their actions. In football, this could translate into strategic behaviour by players, particularly older or injury-prone internationals, who may choose Portugal as a final career destination due to

the generous coverage. This dynamic raises the risk of adverse selection, potentially increasing claims and premiums. Although no empirical evidence confirms this trend in Portugal, similar effects have been documented in other generous insurance contexts (Cutler & Zeckhauser, 1998). Long-term sustainability may therefore depend on complementary safeguards such as stricter medical evaluations, differentiated premium structures, and enhanced regulatory monitoring, to ensure that the protective benefits do not inadvertently encourage opportunistic or moral hazard behaviours.

## **5.4. Comparative Analysis of International Frameworks**

This descriptive analysis focuses on legal classification, insurance design, and implementation dynamics among seven professional football leagues: Portugal, Spain, Germany, England, Italy, France, and Brazil. These jurisdictions were selected based on several criteria identified as methodologically significant in comparative legal research (Zweigert et al., 1998):

1. **Legal tradition diversity:** The selected jurisdictions represent different legal traditions, including civil law (Portugal, Spain, Germany, Italy, France, Brazil) and common law (England) systems, enabling analysis of how these broader traditions influence sports-specific regulations.
2. **Football significance:** All selected jurisdictions have well-established professional football leagues with significant economic activity and international prominence, ensuring relevance to the global football ecosystem.
3. **Regulatory approach variation:** The jurisdictions demonstrate significant variations in their approaches to occupational risk classification and insurance requirements for professional athletes, providing valuable comparative insights.
4. **Data availability:** Sufficient legal, economic, and insurance data are available for all selected jurisdictions, enabling robust comparative analysis.
5. **International transfer connections:** The selected jurisdictions represent major markets in terms of transfer fee volume, underscoring the practical importance of cross-jurisdictional regulatory coordination (Poli et al., 2023).

This research draws on multiple data sources to ensure comprehensive coverage and methodological triangulation. The data on Legal and Regulatory Sources includes national legislation governing occupational risk classification, employment status, and insurance requirements for professional athletes; regulatory frameworks established by national football associations and leagues; international regulations issued by FIFA and UEFA concerning player protection and insurance. Collective bargaining agreements between player associations and clubs or leagues; judicial decisions addressing football injury compensation and insurance disputes. These documents were accessed through official government databases, archives of sports governing bodies, legal databases (including LexisNexis, Westlaw, and EUR-Lex), and direct requests to relevant institutions. Additional sources include the Deloitte Annual Review of Football Finance, UEFA Club Licensing Benchmarking Report, EY Portuguese Professional Football Yearbook, and KPMG Football Benchmark.

Table 5.1 presents the main features of international frameworks and includes Portugal as a benchmark for direct comparison.

Table 5.1. Comparative analysis of international occupational insurance frameworks

<i>Jurisdiction</i>	<i>Risk-classification approach</i>	<i>Insurance architecture</i>	<i>Principal legal/regulatory instruments</i>	<i>Distinctive features &amp; innovations</i>	<i>Principal challenges</i>
<i>Portugal</i>	Statutory designation of professional football as a high-risk occupation under the Law. 48/2023, Law 54/2017 and Law 98/2009. recognised as a rapid-wear profession under Labour Code.	Mandatory private occupational-accident insurance funded by clubs; limited coverage by social security	Law 48/2023; Law 54/2017 and Law 98/2009; CBA between LP and SJPF (Liga-Portugal, 2022) ASF and Liga Portugal supervisory rules (Liga-Portugal, 2025)	Lifetime medical care and financial compensation for permanent disability; reassessment rights; supervisory oversight by ASF; club licensing linked to proof of insurance	Sharp premium increases for small clubs; need for sustained supervisory capacity; uneven enforcement outside top divisions
<i>Spain</i>	No explicit high-risk statute; coverage shaped by Royal Decree 1006/1985 and LaLiga-AFE collective bargaining	Mixed model: public social-security foundation with collectively bargained private top-ups	RD 1006/ (Spain, 1985); LaLiga-AFE CBA (Liga, 2022)	Flexible, negotiable benefit levels aligned with economic cycles	Variable protection across divisions; limited standardisation of long-term care
<i>Germany</i>	Sectoral actuarial classification within	Mandatory public GUV	SGB VII (Germany, 1996); GUV/VBG statutes	Prevention incentives via	Cost volatility for injury-prone

	the statutory accident insurance Gemeinde Unfallversicherungen (GUVVBG); no sport-specific statute	funded by employer contributions with experience-rating; optional private supplements	(Verwaltungs-Berufsgenossenschaft, 2023) Bundesliga & DFB regulations (DFL, 2023)	risk-weighted premiums; concussion research funding	clubs; statutory caps for high earners; limited adaptation for sports-specific risk
<i>England</i>	No legislative high-risk status; insurance duties are embedded in Premier League/EFL rules and the Standard Player Contract	Near-total reliance on private market cover mandated by league rules, backed by PFA schemes. Employer-paid liability insurance; NHS covers medical needs; limited private top-ups	Employment Rights Act (Parliament, 1996); Employers' Liability (Compulsory Insurance) Act (UK Parliament, 1996); FA & Premier League rule (League, 2025)	Product innovation (loss-of-value, key-player cover); strong club-level risk-management incentives	High premiums tied to squad value; uneven protection outside top divisions; gaps in post-career support; unclear private-public coordination
<i>Italy</i>	Implicit high-risk recognition via elevated INAIL contribution classes; no dedicated statute	Public INAIL occupational-accident insurance supplemented by collectively bargained private policies	Law 91/1981 (Italy, 1981); INAIL (INAIL, 2025); FIGC regulations	Public risk-pooling plus negotiated flexibility; experience-rated contributions	Administrative complexity; benefit ceilings for very high salaries; coordination issues between insurers
<i>France</i>	High injury risk addressed through integration into the general CPAM regime; no separate high-risk statute	Robust public social-security base with mandatory private top-ups and CFPF benefits	Code du Travail & Sécurité Sociale (France, 2025a) CPAM (France, 2025b) FFF/LFP/UNFP agreements (Professionnel, 2025)	Emphasis on career-long health monitoring and transition support; recognition of psychological injury	High contribution rates; multi-layered administrative complexity; high contribution rates; limited club autonomy
<i>Brazil</i>	Mandatory accident insurance under the Pelé Law without formal high-risk classification; heavy reliance on the private sector	Predominantly private club-funded insurance layered on basic INSS social security	Pelé Law 9.615/1998; CBF standards (Brazil, 1998)	Coverage scaled to contract value; intensified compliance monitoring	Inconsistent implementation; weak public backstop; limited long-term care provision

Note: CBA – Collective Bargaining Agreement; LP- Liga Portugal (Professional Portuguese Football League) ; SJPF – Sindicato dos Jogadores Profissionais de Futebol (Portuguese Professional Footballer’s Union); AFE – Asociación de Futbolistas Españoles (Spanish Footballers’ Association); GUV – Gesetzliche Unfallversicherung (German public entity linked to the statutory accident insurance system); DFB – Deutscher Fußball-Bund (German Football Federation); EFL – English Football League; NHS – National Health Service; INAIL – Istituto Nazionale per l’Assicurazione contro gli Infortuni sul Lavoro (Italian National Institute for Insurance against Accidents at Work); FIGC – Federazione Italiana Giuoco Calcio (Italian Football Federation); CPAM – Caisse Primaire d’Assurance Maladie (Primary Health Insurance Fund); FF – Fédération Française de

Football (French Football Federation); LFP – Ligue de Football Professionnel (French Professional Football League); UNFP – union Nationale des Footballeurs Professionnels (French National Union of Professional Footballers); CBF – Confederação Brasileira de Futebol (Brazilian Football Confederation).

### **5.4.1. Country-Level Approaches to Risk Protection in Professional Football**

Based on the comparative data in Table 1, this section examines how seven countries structure their professional football injury protection systems across five key dimensions: risk classification, insurance architecture, legal instruments, distinctive innovations, and main challenges.

#### **5.4.1.1. Risk Classification Approach**

Jurisdictions vary markedly in how they conceptualise and classify the occupational risks associated with professional football. Portugal stands out as the only country to legally define professional football as a high-risk activity within its national legislation (Law No. 48/2023). This designation carries significant regulatory and insurance implications. This formal recognition aligns legal doctrine with empirical evidence on injury prevalence, thereby reinforcing the legitimacy of compulsory insurance mandates. Evidence from other high-demand contexts also supports this approach: in the military, for example, soccer accounts for the highest share of sport-related injuries, often exceeding rugby and other contact sports in both frequency and severity (Orr et al., 2020). By contrast, countries such as Germany, Italy, and France adopt more integrated approaches, embedding football within broader sectoral or occupational categories under their public accident insurance systems. These frameworks implicitly acknowledge elevated risk levels but do not isolate football as a distinct category, relying instead on general classifications for sports, entertainment, or performing arts sectors. While this facilitates administrative consistency, it may limit sport-specific tailoring of risk-based contributions or prevention measures. In England and Spain, the classification of foot-ball-related risk is not codified through public legislation. Instead, it is shaped through collective bargaining agreements and general labour law. The absence of statutory classification places greater weight on contractual negotiation and may lead to heterogeneous standards across clubs and leagues. Brazil occupies a hybrid position: federal legislation (notably the Pelé Law) mandates accident insurance for professional athletes, implicitly recognising heightened risk, though without a formal classification within occupational safety law. This normative ambiguity can complicate enforcement and limit the design of risk-adjusted premiums or incentives.

Overall, while all jurisdictions acknowledge the inherently hazardous nature of professional football, only Portugal has formalised this recognition into a specific legal classification. The remaining systems rely on indirect or implicit approaches, which may generate inconsistencies in coverage adequacy, actuarial accuracy, and injury prevention strategies.

#### **5.4.1.2. Insurance Architecture**

The insurance architecture across jurisdictions reflects a spectrum from fully public to fully private systems, with several hybrid models in between. Portugal employs a hybrid model: while insurance is purchased from private providers, it operates under strict public regulation. This structure ensures compulsory coverage and benefit uniformity, but the reliance on private underwriting may heighten premium costs for clubs, particularly in lower divisions. Germany and Italy represent public-centred models. Both integrate professional football within national statutory accident insurance schemes (GUV/BGV in Germany; INAIL in Italy), financed through employer contributions. These systems offer standardised coverage and administrative stability, with Germany notably incorporating an experience-rating mechanism to incentivise injury prevention. France also relies heavily on public financing through social security, but supplements this with tailored sectoral agreements between football federations and unions. The resulting architecture delivers both baseline protection and additional services, such as career transition programmes and mental health support. In contrast, England and Brazil follow market-driven models where insurance is arranged privately. England's decentralised approach allows for bespoke contracts but results in uneven protection, especially among lower-tier or academy-level players. Brazil mandates private insurance by law, but in practice, weak enforcement and financial instability among clubs often lead to gaps in coverage. Spain occupies an intermediate position. Insurance arrangements are shaped through collective bargaining, which can ensure robust benefits in top leagues but may lack consistency and enforcement strength across all tiers.

Across systems, the main trade-off lies between coverage universality (better ensured in public or hybrid models) and contractual flexibility (favoured in private systems). Hybrid regimes such as those in Portugal and France appear best positioned to reconcile these competing demands.

### **5.4.1.3. Legal and Regulatory Instruments**

Legal and regulatory instruments governing insurance for professional footballers vary significantly in terms of formality, centralisation, and enforceability, reflecting each country's broader legal culture and institutional architecture. Portugal stands out with a dedicated legal framework: Law No. 48/2023 formally classifies professional football as high-risk work and mandates compulsory insurance under public supervision. This statute is complemented by earlier legislation (Laws No. 54/2017 and 98/2009), collectively ensuring legal certainty and regulatory coherence. Germany and Italy embed football within broader national accident insurance statutes. In Germany, the Social Code VII and the GUV/BGV framework provide binding public-law coverage. Similarly, Italy's Decree 38/2000 and subsequent administrative guidance from INAIL standardise coverage for professional athletes under general occupational injury rules. France adopts a layered model: the Labour Code establishes the legal foundation, which is then customised through sector-specific collective agreements between football bodies (FFF/LFP) and unions. These agreements offer both regulatory detail and adaptability, notably in areas such as career transition and psychosocial care. England relies primarily on general labour law and civil liability principles. There is no football-specific statute mandating insurance; instead, coverage arises from employment contracts and private negotiation. This legal flexibility enables bespoke arrangements for elite players but risks under protection in less regulated tiers. Spain uses collective bargaining agreements to define insurance responsibilities and benefits. These are recognised in law but function as semi-formal instruments whose effectiveness depends on enforcement at the club level and the strength of the players' union. Brazil is governed by federal sports legislation, particularly the Pelé Law (Law No. 9.615/1998), which mandates private insurance for athletes. However, legal mandates are often undermined by weak enforcement mechanisms, especially among financially precarious clubs.

Overall, Portugal and Germany exemplify statutorily grounded models with strong public oversight. France and Spain rely more heavily on contractual instruments negotiated within the sector, while England and Brazil operate under general legal norms with variable implementation. The level of legal formalisation directly influences coverage consistency, players' legal recourse, and compliance across club tiers.

### **5.4.1.4 Distinctive Features and Innovations**

While insurance structures differ markedly across jurisdictions, several systems incorporate distinctive innovations that aim to enhance protection, reduce injury risk, and improve long-term player welfare. Portugal stands out for its comprehensive statutory regime, which mandates insurance coverage for all professional players. While legally

robust, it lacks mechanisms to reward injury prevention. Germany incorporates experience-rating into its public system, financially rewarding clubs with lower injury rates, an uncommon yet effective preventive strategy. France offers holistic support through the CFPF, addressing both career transition and psychological risks, alongside detailed collective agreements. Spain relies on collective bargaining to integrate injury coverage into broader employment protections, though implementation can vary by club and region. England enables bespoke insurance contracts, especially for elite players, offering flexibility but resulting in unequal coverage across tiers. Brazil links premiums to player earnings, a value-based model that suits club diversity but suffers from weak enforcement and non-compliance risks.

These features reflect divergent priorities: legal certainty in Portugal, institutional innovation in Germany and France, and contractual flexibility in Spain, England, and Brazil, with varying levels of equity and effectiveness.

#### **5.4.1.5. Principal Challenges**

Despite varied structural designs, all systems face significant challenges in balancing athlete protection with financial sustainability and administrative feasibility. Portugal's mandatory insurance regime ensures uniform coverage but imposes high financial burdens on clubs, especially in lower divisions, and may create moral hazard by reducing incentives for injury prevention. Germany's actuarial approach promotes efficiency through experience-rating, but coverage caps may inadequately protect high-earning players. France offers extensive benefits, but the high cost of contributions can exacerbate inequalities between clubs with different financial capacities. Spain's dependence on collective agreements introduces inconsistencies, with the scope and quality of coverage varying by club and negotiation strength. Long-term care provisions also remain weak. England's market-driven system creates fragmented coverage, especially for lower-tier and academy players, who often lack access to robust protection. Finally, Brazil faces systemic enforcement issues: clubs may default on premiums due to financial instability, leaving players effectively uninsured despite legal mandates.

These challenges underline the tension between ensuring adequate protection and maintaining economic viability, particularly for clubs outside the elite strata.

## **5.4.2. Strategic Outlook: Best Practices, Coordination, and Reform**

The findings summarised in Section 5.1 reveal not only systemic diversity but also converging trends that inform strategic development. This sub-section distils those patterns and identifies forward-looking institutional strategies.

The comparative analysis highlights four core elements that consistently underpin the most resilient insurance frameworks. First, hybrid financing models, which blend broad public pooling with risk-sensitive private contributions, offer a pragmatic balance between equity and efficiency. Second, phased implementation aligned with club financial capacity, as observed in Portugal, facilitates political feasibility without compromising player protection. Third, formalised prevention incentives, such as experience rating or conditional premium rebates, are associated with measurable reductions in injury incidence. Fourth, the presence of specialised institutions (e.g., France's CPFP) enhances long-term player welfare by supporting career transitions and addressing psychosocial risks.

However, structural challenges persist at the transnational level. The coexistence of divergent national systems, FIFA's limited jurisdiction, and pronounced economic disparities among clubs and leagues hinder the development of cohesive standards. These asymmetries generate competitive imbalances and complicate cross-border injury claims. While some progress has been made through bilateral agreements and league-mandated documentation, harmonisation remains partial. A feasible path forward lies in the adoption of adaptable international minimum standards that respect legal diversity while guaranteeing essential protections (Parrish, 2003; Commission, 2024).

## **5.5. Conclusion**

This study has examined the legal, economic, and insurance implications of classifying professional football as a high-risk profession, with Portugal as a focal case. Through an interdisciplinary lens, the analysis addressed three core objectives: understanding the specific impacts of the Portuguese insurance framework; identifying cross-country regulatory and insurance differences; and formulating policy proposals that promote both player protection and systemic sustainability.

Portugal's mandatory insurance regime improved in 2023, standing out with a legal model of occupational accident insurance, ensuring robust and uniform protection for athletes, which represents a significant advancement in valuing player welfare. This high-risk classification positions Portugal as a pioneering jurisdiction in athlete protection, offering a replicable model for other countries. Player protection is especially critical in contexts such as Portugal, where the professional football business model fundamentally

relies on the player transfer market. Severe or prolonged injuries can directly affect players' market value and the financial sustainability of clubs, making it imperative to establish a regime that combines comprehensive coverage with mechanisms promoting equity and economic stability within the sector. While the framework improves legal certainty and enhances access to compensation, it also presents challenges related to premium inflation and financial strain on smaller clubs, highlighting the importance of regulatory oversight and adaptive cost-sharing mechanisms.

The comparative analysis confirmed the fragmented nature of legal and insurance regimes across Europe and Brazil, revealing inconsistencies in coverage scope, funding models, and institutional coordination. Portugal's statutory high-risk regime contrasts with the implicit sectoral recognition seen in Germany, Italy, and France, with collectively bargained insurance schemes in Spain, and England, and with the Brazilian law that integrates insurance, labour, and contractual protections within a unified national law. This diversity highlights the challenges of harmonisation in a globalised labour market, where regulatory disparities may create competitive imbalances and vulnerabilities for players, particularly for players operating across borders. Despite regulatory disparities, FIFA's Club Protection Programme offers a minimal layer of harmonisation by insuring players during major international competitions, particularly benefiting those without equivalent club-level coverage. Still, regulatory diversity enables legal innovation and offers opportunities for mutual learning, mainly when supported by international soft-law mechanisms.

Ultimately, this research contributes to a growing interdisciplinary agenda that seeks to reconcile player welfare with financial sustainability and competitive fairness in professional football. By documenting legal and institutional differences and analysing the implications of Portugal's high-risk classification, the study provides a foundation for evidence-based policy and future regulatory convergence.

### **5.5.1. Practical Implications**

The findings of this study offer several practical implications for stakeholders engaged in regulating, managing, and participating in professional football. First, the Portuguese approach illustrates how a mandatory high-risk classification can form a robust legal basis for athlete protection. This model demonstrates the feasibility of enforcing comprehensive coverage through binding legal provisions, offering lessons for jurisdictions seeking to strengthen player welfare. Second, four guiding principles emerge as critical to designing sustainable and fair insurance frameworks across professional football: (i) comprehensive and career-long protection, ensuring that players are covered throughout the whole span of their professional lives, including long-term disability and post-career consequences; (ii)

balanced cost distribution among stakeholders (clubs, insurers, federations), mitigating financial pressures particularly on smaller clubs; (iii) incentives for injury prevention, such as differentiated premiums based on safety records or investment in medical support infrastructure; and (iv) flexible but coordinated international frameworks, which allow national systems to retain autonomy while aligning on minimum standards for cross-border protection, especially regarding transfer transitions and international duty. Broader coordination remains necessary, particularly as players move across jurisdictions with varying regulatory standards. This is especially pertinent for countries like Portugal, where the professional football business model relies heavily on the international transfer of players. In such contexts, ensuring consistent and adequate protection is not only a matter of player welfare but also an essential element for preserving the long-term value of clubs' most important assets.

### **5.5.2. Limitations and Future Research**

While this study offers a comprehensive descriptive overview of the Portuguese insurance framework for professional footballers and its broader regulatory context, several limitations must be acknowledged. First, the analysis is primarily qualitative and descriptive. Although it draws upon existing legislation, insurance structures, and secondary data, it does not empirically measure the effectiveness of the Portuguese model in reducing injury rates, improving rehabilitation outcomes, or enhancing long-term player welfare. These dimensions warrant further investigation using quantitative or mixed-method approaches. Second, the cross-country comparison is necessarily selective and focused on illustrative contrasts rather than exhaustive benchmarking. Legal heterogeneity, differences in labour law, and the varying roles of collective bargaining across countries make comprehensive comparisons methodologically challenging. Moreover, access to detailed and comparable insurance data across jurisdictions remains limited, hindering broader empirical generalisation.

Future research could address these gaps by evaluating the outcomes of mandatory insurance policies through longitudinal injury databases, player health surveys, or claims records. Comparative studies could examine how different regulatory approaches affect cost efficiency, litigation rates, and player satisfaction. Furthermore, interdisciplinary collaboration, including sports medicine, economics, and legal studies, could provide more holistic assessments of risk allocation and welfare protection in professional sport. Finally, the growing commercialisation of football, alongside increasing player mobility, reinforces the need to explore international coordination mechanisms in greater depth. Future work

could analyse the feasibility and impact of supranational regulatory standards or transnational insurance pools to address persistent disparities and enhance.

## CHAPTER 6 - CONCLUSION

This doctoral dissertation set out to investigate the multidimensional role of professional football in Portugal, adopting an integrated economic, management, medical, and legal perspective. The research explores the intertwined relationship between the economic and sporting value of professional football players and the risks, impacts, and governance of injuries within the specific context of Portuguese professional football. In Portugal, where the football industry holds a prominent position in the national sports economy and exerts measurable influence on GDP, employment, and - most significantly - the capital balance, players's economic and sporting rights are the foremost intangible assets in club portfolios. Their transfer market value, driven by Portugal's role as a net exporter of football talent, constitutes a structural pillar of both club-level financial sustainability and the country's positive capital account. At the same time, players' on-field performance is central to competitive success, league standing, and the generation of revenues from broadcasting rights, sponsorship contracts, and matchday income. Injury events, therefore, represent more than clinical setbacks: they are critical incidents capable of depreciating asset value, undermining sporting performance, and triggering financial instability.

Against this backdrop, the dissertation pursued four interrelated objectives. The first was to analyse the economic and managerial structure of Portuguese professional football, with particular emphasis on the strategic role of players' economic and sporting rights as intangible assets within a transfer-driven business model, and to assess the financial, managerial, and macroeconomic vulnerabilities associated with clubs' reliance on player development and transfer revenues. The second was to identify and evaluate the main predictors of injury severity among professional football players, developing predictive models based on real-world data to inform medical decision-making, injury prevention, and risk management strategies. The third was to examine the incidence and severity of injuries across the First and Second Leagues, considering both intrinsic and extrinsic factors, and to identify patterns with implications for prevention, resource allocation, and strategic planning at the club level. Finally, the fourth objective intends to critically assess the legal and regulatory framework governing occupational risk and insurance in Portuguese professional football, with a particular focus on Law No. 48/2023, situating it within a comparative international context.

The studies presented in Chapters 2 to 5 provide the foundations for the conclusions drawn here. This research shows that professional football clubs cannot sustain economic viability without actively managing injury risk. In addition, to ensuring effective injury

governance, clubs should implement clinical protocols, develop data-driven prediction systems, manage their assets, develop sporting performance strategies, and implement regulatory innovations.

Finally, this thesis demonstrates that safeguarding the economic viability and competitive future of Portuguese professional football requires viewing injury management as a key part of strategic management, rather than just of medical concern. Building on this integrated perspective, the following section summarises the main empirical findings, which together support and refine this overarching conclusion.

## **6.1. Summary of Findings**

The findings of this doctoral thesis emphasise the central role that professional football players hold within the Portuguese football system, showing their importance both as assets and key drivers of clubs' financial stability. The second chapter examined the economic structure of Portuguese professional football and confirmed that the industry relies heavily on developing and transferring players. The analysis revealed that Portuguese sports societies mainly follow a producer-driven model, focusing on developing local talent for sale in international markets. These revenues often determine the sport societies financial survival and affect larger economic indicators like Portugal's Gross Domestic Product, employment, and capital account. This model was found to be highly vulnerable to external shocks: events such as player injuries can seriously undermine both on-field performance and financial stability, underlining the need for sustained investment in player health and welfare.

The third chapter examined what drives the severity of injuries among Portuguese professional football players, using a deep neural network to analyse data from all injured players in the First and Second Leagues over five consecutive seasons. The results showed that a player's prior injuries and recovery time are the most important predictors of how severe future injuries are, with nationality and tactical position also playing a moderate role. In contrast, factors such as age, match participation, and league level had little impact. The study highlights the value of carefully tracking injury histories and recovery, providing a foundation for tailored medical care and data-driven risk management strategies that protect players as key assets while reducing both financial losses and competitive setbacks for clubs.

The fourth chapter extended this analysis by examining injury incidence and severity in relation to intrinsic and extrinsic factors. Descriptive, inferential, and cluster analyses revealed that league level, match participation, and structural factors such as underexposure or nationality are stronger determinants of injury risk than age or tactical

position. Injuries were more frequent in the First League but more severe in the Second League, particularly among non-European players and those with limited match exposure. These results provide critical insights for the design of context-sensitive prevention programs and the optimisation of player management, aligning sporting objectives with economic imperatives.

The fifth chapter explored the legal and insurance frameworks that govern occupational risk in Portuguese professional football, with a focus on Law No. 48/2023. The study confirmed that the law, by mandating occupational accident insurance for professional athletes, significantly enhances player protection and establishes Portugal as a pioneer in athlete welfare. However, it also generates financial pressures for clubs, particularly smaller ones, due to premium costs and risk-sharing requirements. Comparative analysis with other countries highlighted persistent regulatory disparities in insurance coverage, institutional coordination, and legal recognition of occupational risk, demonstrating both the challenges and opportunities for policy innovation and international learning. The research emphasised that effective risk governance requires not only legal protection but also integration with club-level management practices, injury prevention strategies, and asset valuation.

## **6.2. Integrated Contributions**

Taken together, the four studies (chapters 2 - 5) demonstrate the interdependent nature of economics, management, medical practice, and legal regulation in Portuguese professional football. Players emerge as both the most valuable and most vulnerable assets, whose performance, health, and market value directly influence club sustainability, league competitiveness, and the broader national economy. By combining macroeconomic and microeconomic analyses (chapter 2), predictive modelling of injuries (chapter 3), epidemiological evidence (chapter 4), and legal-economic assessment (chapter 5), this doctoral research provides a comprehensive, evidence-based framework for understanding the dynamics of injury risk, asset management, and regulatory protection in a globalised football market.

## **6.3. Research Implications**

### **6.3.1 Theoretical implications**

Taken together, the four studies advance theoretical understanding across sports economics, management, and law by elucidating the interdependent nature of professional football as both a sporting and economic system. The present research confirms that

football players represent the most important assets within the Portuguese transfer-driven business model, influencing both club sustainability, and macroeconomic outcomes (Rohde & Breuer, 2017). By situating players at the intersection of sporting performance, financial valuation, and legal protection, the thesis bridges micro-level management practices with macro-level economic implications, highlighting the strategic significance of youth players development systems as sources of competitive advantage for countries with smaller domestic markets (EY & Liga Portugal, 2025).

The studies also contribute to theoretical knowledge on injury risk in professional football. The work demonstrates that injury severity is primarily predicted by individual injury history and recovery time, with secondary contributions from players' nationality and tactical position (Ekstrand et al., 2021; López-Valenciano et al., 2023). Structural factors such as league level and match participation further shape injury patterns, while age and position play a less central role than traditionally assumed (Nieto Torrejón et al., 2024). These findings challenge prevailing theoretical models that overemphasize age or physical characteristics, emphasizing the need for context-sensitive approaches and the integration of epidemiological and predictive data into conceptual frameworks of sports risk management.

Finally, the present thesis extends the theoretical discussion to a legal and regulatory dimension by analysing Portugal's Law No. 48/2023 in a comparative perspective. It highlights how formal recognition of football as a high-risk profession, combined with mandatory occupational accident insurance, interacts with economic and managerial priorities to protect strategic assets – players, while ensuring the financial sustainability of clubs (Memari et al., 2021; Gregson et al., 2022; Zhang et al., 2024). Cross-country comparisons further demonstrate the diversity of regulatory approaches, offering insights into harmonisation challenges and the role of law as a mechanism for systemic risk governance in a globalised labour market.

### **6.3.2 Practical implications**

From a practical standpoint, this research provides actionable guidance for clubs, policymakers, and insurers. By recognising the economic relevance of players as strategic assets, the thesis underscores the need for balanced management strategies that integrate talent development, financial prudence, and risk mitigation practices (FBG, 2024; EY & Liga Portugal, 2025). The heavy reliance on the player transfer market amplifies the importance of injury prevention and rehabilitation strategies to safeguard both sporting performance and market value. Using artificial intelligence and machine learning networks would be important tools for sports societies to estimate injury severity, tailor individualized recovery

programs, and optimise squad management, while accounting for cross-cultural variations in player profiles.

The research also highlights the importance of targeted, context-sensitive prevention strategies, particularly for players with low match exposure, non-European nationalities, or competing in lower-tier leagues. Addressing structural disparities through investment in medical infrastructure and culturally informed training practices can reduce injury risk and improve team performance (Ekstrand et al., 2021; López-Valenciano et al., 2023).

Lastly, the analysis of Portugal's occupational accident insurance framework provides practical insights for policy and governance. Mandatory coverage improves legal certainty, protects player health and welfare, and offers a replicable model for other jurisdictions, while also highlighting economic pressures on smaller clubs (Memari et al., 2021; Gregson et al., 2022). This research brings together legal, economic, and management perspectives to support policies that protect players while ensuring financial sustainability and competitive balance, providing a roadmap for more resilient and evidence-based governance in professional football.

## **6.4. Research Limitations**

As with any rigorous scientific investigation, this doctoral thesis is not exempt from limitations. Acknowledging and discussing them openly show a commitment to intellectual honesty and helps place the findings in the right context.

The first article (Chapter 2) is primarily based on aggregated financial data and publicly available reports, which, while robust, may not fully capture the nuances of individual sports societies' strategies or private contractual arrangements. Moreover, the analysis focuses on macroeconomic and sector-wide patterns, without a detailed microeconomic exploration of individual transfer transactions or the valuation methodologies applied to players. The second article (Chapter 3), which developed predictive models of injury severity using deep neural networks, also presents limitations. The artificial intelligent based approach relies on historical injury data that may contain reporting biases or inconsistencies across clubs and seasons. Contextual factors such as training intensity, player workload, or club-specific rehabilitation protocols were not included, potentially constraining the model's predictive accuracy. Additionally, the model was trained on five consecutive seasons, limiting the dataset's size and, consequently, the generalisability of predictions. Notably, the model exhibited lower classification performance for low-severity injuries, highlighting challenges in distinguishing between minor injury categories. The third article (Chapter 4), draw on comprehensive real-world data and apply advanced statistical analyses, including descriptive, inferential, and cluster methods. The

study focuses specifically on Portuguese professional football, which may limit its generalisability to other leagues or international contexts. It does not capture certain key variables, such as psychological factors, training load, or club-level medical infrastructure, and the reliance on routinely collected data may introduce inconsistencies in reporting across teams. Finally, the fourth article (Chapter 5), analysing the legal and insurance framework of Portuguese professional football, faces limitations inherent to qualitative and descriptive research. While the study provides an in-depth evaluation of Law No. 48/2023 and cross-country comparisons, it does not empirically assess the effectiveness of Portugal's mandatory occupational accident insurance in reducing injury rates, improving rehabilitation outcomes, or enhancing long-term player welfare. The cross-country analysis is illustrative rather than exhaustive, constrained by legal heterogeneity, differences in labour law, and the limited availability of comparable insurance data across jurisdictions.

These limitations highlight the complexity of integrating economic, medical, and legal perspectives in professional football research. While they do not diminish the contributions of this thesis, they underscore areas where future investigations could expand the empirical scope, incorporate additional variables, and explore broader international contexts to enhance understanding and applicability.

## **6.5. Future Research Directions**

Although this doctoral thesis offers a broad analysis of the economic, medical, and legal dimensions of Portuguese professional football, there is still much to be explored. Drawing on the findings and limitations of the four studies, this research points to several directions for future work that can both enrich our understanding and improve the way professional football is managed in Portugal and internationally. First, the economic dimension warrants further exploration. Future studies could assess the long-term sustainability of Portugal's transfer-driven football model, considering the growing financial polarisation in European football, the evolving regulatory landscape, and the resilience of sports societies to global economic shocks. Investigating the indirect economic impact of the football industry on the broader national economy, alongside the role of player mental health and welfare and insurance policies in safeguarding asset value, would provide valuable insights for both scholars and practitioners.

For predictive injury modelling (Article 2), future work should refine deep learning frameworks by incorporating additional variables such as biomechanical data, psychological factors, and real-time monitoring of workload. Expanding datasets to cover longer periods could enhance model robustness, while longitudinal studies could illuminate the evolution of injury patterns across players' careers. Qualitative research examining

player attitudes toward prevention strategies may bridge the gap between evidence-based recommendations and practical implementation. Furthermore, cross-cultural investigations could provide insights into how nationality influences injury severity, enabling more tailored prevention measures.

Second, regarding injury prevention and management, particularly regarding predictive injury modelling, future studies should aim to refine deep learning approaches by bringing in additional variables such as biomechanical measures, psychological aspects, and real-time workload monitoring. Using larger datasets that span more extended periods would make models more reliable, while longitudinal research could provide insights into how injury patterns develop over the course of a player's career. At the same time, qualitative studies that capture players' perspectives on prevention strategies could help close the gap between scientific recommendations and their day-to-day application in practice. Furthermore, cross-cultural investigations could provide insights into how nationality influences injury severity, enabling more tailored prevention measures. Furthermore, the analysis of injury incidence and severity patterns could benefit from multi-country comparative research, integrating detailed workload, recovery metrics, and longitudinal designs to enhance predictive accuracy. Combining machine learning with traditional statistical methods may reveal deeper patterns, supporting more effective injury prevention strategies across competitive contexts.

Third, in the legal and regulatory domain, future research could quantitatively evaluate the outcomes of mandatory insurance policies, using injury databases, player health surveys, or claims records to assess effectiveness in reducing injuries, improving rehabilitation outcomes, and promoting long-term player welfare. Comparative studies examining different regulatory approaches help understand their impact on cost efficiency, litigation rates, and player satisfaction. The growing internationalisation and commercialisation of football highlight the need to examine the feasibility and impact of supranational regulatory standards or transnational insurance pools to address persistent disparities and enhance cross-border coordination. Indeed, the effects of international player mobility and globalisation on injury patterns, risk management, and regulatory harmonisation represent critical areas for further exploration. Interdisciplinary approaches involving economics, management, sports medicine, and legal studies could provide more holistic assessments of risk allocation and welfare protection.

In addition to the specific contributions of the four articles, this research also opens space for further exploration. Future work could look more closely at the economic impact of injuries, not only for individual players but also at the club and league level, linking time lost on the pitch to revenues, market value, and transfer outcomes. It would also be valuable to examine inequalities between clubs, especially how differences in resources shape their

capacity to prevent injuries and remain competitive over time. Exploring the role of investment in medical and training infrastructures could shed light on ways to reduce these gaps and support a more balanced and sustainable football industry.

These future research paths highlight the need to bring together economic, medical, and legal perspectives. Doing so can support evidence-based policies, improve player health and performance, and help secure the sustainable growth of professional football.

## 6.6. Scientific Dissemination and Publication Status

The four studies that constitute the core of this doctoral thesis have been submitted to peer-reviewed scientific journals, reflecting the scholarly rigor and relevance of the research. Table 6.1. summarises the journals, submission dates, and status of each manuscript, highlighting the scholarly impact and dissemination pathway of the research findings.

Table 6.1. Submission overview of thesis articles

Chapter/Article	Journal / submission data / status	Clarivate Analytics Impact factor (2024)	Scopus Quartil
Chapter 2: 'Players as Strategic Assets in Portuguese Professional Football: Micro and Macroeconomic Perspectives of a Transfer-Driven Industry'	<i>Sport, Business, Management: An International Journal</i> / 21 July 2025 / 'under review'	1.7	Q2
Chapter 3: 'Predicting Injury Severity in Portuguese Professional Football: An AI-Driven Analysis Using Deep Neural Networks'	<i>BMC Sports Science, Medicine and Rehabilitation</i> / 17 April 2025 / 'under review'	2.8	Q1
Chapter 4: 'Real-World Injury Patterns in Portuguese Professional Football: Risk Profiles and Socioeconomic Concerns'	<i>European Journal for Sport and Society</i> / 16 May 2025 / 'under review'	1.0	Q1
Chapter 5: 'Occupational Safety and Injury Risk in Professional Football: The Portuguese Legal Framework in Comparative Perspective'	<i>Safety</i> / 12 August 2025 / 'under review'	1.7	Q2

The submission of these articles to high-quality, peer-reviewed journals underscores the originality, robustness, and practical significance of this research, highlighting its

contribution to the advancement of knowledge in sports economics, management, and policy, and reinforcing the value of evidence-based approaches to player welfare, injury risk management, and the sustainable governance of professional football.



## REFERENCES

- Al Attar, W. S. A., Soomro, N., Pappas, E., Sinclair, P. J., & Sanders, R. H. (2016). How Effective are F-MARC Injury Prevention Programs for Soccer Players? A Systematic Review and Meta-Analysis. *Sports Medicine*, 46(2), 205–217. <https://doi.org/10.1007/s40279-015-0404-x>
- Amand, M., Chéron, A., Pelgrin, F. and Terriau, A. (2023), “Soccer labour market equilibrium and efficient training of players”, *European Economic Review*, Vol. 156, <https://doi.org/10.1016/j.euroecorev.2023.104461>
- Anderson, B. L., Gittelman, M. A., Mann, J. K., Cyriac, R. L., & Pomerantz, W. J. (2016). High school football players' knowledge and attitudes about concussions. *Clinical journal of sport medicine*, 26(3), 206–209. <https://doi.org/10.1097/JSM.0000000000000214>
- Anderson, D. S., Cathcart, J., Wilson, I., Hides, J., Leung, F., & Kerr, D. (2020). Lower limb MSK injuries among school-aged rugby and football players: a systematic review. *BMJ Open Sport Exerc Med*, 6(1), e000806. <https://doi.org/10.1136/bmjsem-2020-000806>
- Andreff, W. and Szymanski, S. (2009). *Handbook on the economics of sport*, Edward Elgar Publishing. Available at: <https://www.e-elgar.com/shop/gbp/handbook-on-the-economics-of-sport-9781848443518.html>
- Arliani, G. G., Lara, P. H. S., Astur, D. C., Pedrinelli, A., Pagura, J. R., & Cohen, M. (2018). Orthopaedics injuries in male professional football players in Brazil: a prospective comparison between two divisions. *Muscles Ligaments Tendons J*, 7(3), 524–531. <https://doi.org/10.11138/mltj/2017.7.3.524>
- Armitage, M., McErlain-Naylor, S. A., Devereux, G., Beato, M., & Buckthorpe, M. (2022). On-field rehabilitation in football: Current knowledge, applications and future directions. *Frontiers in Sports and Active Living*, 4. <https://doi.org/10.3389/fspor.2022.970152>
- Armstrong, G. and Giulianotti, R. (2001). *Fear and Loathing in World Football*, Berg Publishers, Oxford. Available at: <http://ndl.ethernet.edu.et/bitstream/123456789/36927/1/GaryArmstrong.pdf>
- Ascari, G., & Gagnepain, P. (2007). Evaluating rent dissipation in the Spanish football industry. *Journal of Sports Economics*, 8(5), 468–490. <https://doi.org/10.1177/1527002506292582>

- Ati, A., Bouchet, P. and Jeddou, R. (2024). Using multi-criteria decision-making and machine learning for football player selection and performance prediction: a systematic review, *Data Science and Management*, Vol. 7 No. 2, pp. 79-88. <https://doi.org/10.1016/j.dsm.2023.11.001>
- Bahdur, K., Pruna, R., Erasmus, H., & Pedret, C. (2018). Does cognition play a role in injury prevention and return to play in the elite football player? A perspective from the field. *Apunts. Medicina de l'Esport*, 53. <https://doi.org/10.1016/j.apunts.2018.05.001>
- Bahr, R., & Krosshaug, T. (2005). Understanding injury mechanisms: a key component of preventing injuries in sport. *Br J Sports Med*, 39(6), 324–329. <https://doi.org/10.1136/bjism.2005.018341>
- Banco de Portugal (n.d.). “Balança Capital: saldo (2016-2021)”. Available at: <https://bpstat.bportugal.pt/serie/12512248>
- Barnes, C., Archer, D. T., Hogg, B., Bush, M., & Bradley, P. (2014). The evolution of physical and technical performance parameters in the English Premier League. *International journal of sports medicine*, 35(13), 1095–1100. <https://doi.org/10.1055/s-0034-1375695>
- Barros, C. & Ibrahímo, M. (2002). *Transatlantic Sport*, Edward Elgar Publishing, Cheltenham, UK. Available at: <https://www.elgaronline.com/view/9781840649475.xml>
- Barros, C. & Leach, S. (2006). Performance evaluation of the English Premier Football League with data envelopment analysis, *Applied Economics*, Vol. 38 No. 12, pp. 1449-1458. <https://doi.org/10.1080/00036840500396574>
- Behravan, I. & Razavi, S. (2021). A novel machine learning method for estimating football players' value in the transfer market, *Soft Computing*, Vol. 25, pp. 2499-2511. <https://doi.org/10.1007/s00500-020-05319-3>
- Beloff, M., Kerr, T., Demetriou, M., & Beloff, R. (2012). *Sports Law*. Bloomsbury Publishing.
- Bengtsson, H., Ekstrand, J., Waldén, M., & Hägglund, M. (2018). Muscle injury rate in professional football is higher in matches played within 5 days since the previous match: a 14-year prospective study with more than 130 000 match observations. *British journal of sports medicine*, 52(17), 1116–1122.
- Bennett, H., Fuller, J., Debenedictis, T., & Chalmers, S. (2024). Ankle sprain, concussion, and anterior cruciate ligament injuries are common and burdensome in sub-elite

- female Australian football players. *Journal of Science and Medicine in Sport*, 27. <https://doi.org/10.1016/j.jsams.2024.05.008>
- Bishop, C. M., & Bishop, H. (2023). *Deep learning: Foundations and concepts*. Springer Nature.
- Blachowicz, J. (2009). How Science Textbooks Treat Scientific Method: A Philosopher's Perspective. *British Journal for the Philosophy of Science*, 60(2), 303-344. <https://doi.org/10.1093/bjps/axp011>
- Bongers, I. M. B., Van Der Meer, J. B. W., Van Den Bos, J., & Mackenbach, J. P. (1997). Socio-economic differences in general practitioner and outpatient specialist care in the Netherlands: A matter of health insurance? *Social Science & Medicine*, 44. [https://doi.org/10.1016/S0277-9536\(96\)00262-6](https://doi.org/10.1016/S0277-9536(96)00262-6)
- Bouthillier, X., Delaunay, P., Bronzi, M., Trofimov, A., Nichyporuk, B., Szeto, J., Mohammadi Sepahvand, N., Raff, E., Madan, K., & Voleti, V. (2021). Accounting for variance in machine learning benchmarks. *Proceedings of Machine Learning and Systems*, 3, 747–769.
- Bradfield, J. (2016). Use-Trace Epistemology and the Logic of Inference. *Lithic Technology*, 41(4), 293-303. <https://doi.org/10.1080/01977261.2016.1254360>
- Brazil. (1998). Law No. 9.615/1998 (Lei Pelé), of March 24, regulating professional sports and athletes' rights. Retrieved 01/08/2025 from [https://www.planalto.gov.br/ccivil\\_03/leis/l9615consol.htm](https://www.planalto.gov.br/ccivil_03/leis/l9615consol.htm)
- Brewer, B. (2017), "The commercial transformation of world football and the North–South divide: A global value chain analysis", *International Review for the Sociology of Sport*, Vol. 54 No. 4, pp. 410-430, <https://doi.org/10.1177/1012690217721176>
- Brito, J., Hertzog, M., & Nassis, G. P. (2016). Do match-related contextual variables influence training load in highly trained soccer players? *Journal of Strength and Conditioning Research*, 30(2), 393–399. <https://doi.org/10.1519/JSC.0000000000001096>
- Bult, H. J., Barendrecht, M., & Tak, I. J. R. (2018). Injury risk and injury burden are related to age group and peak height velocity among talented male youth soccer players. *Orthopaedic journal of sports medicine*, 6(12), 2325967118811042.
- Cardoso-Marinho, B., Barbosa, A., Bolling, C., Marques, J. P., Figueiredo, P., & Brito, J. (2022). The perception of injury risk and prevention among football players: A

- systematic review. *Frontiers in Sports and Active Living*, 4. <https://doi.org/10.3389/fspor.2022.1018752>
- Carling, C., Le Gall, F., & Dupont, G. (2012). Are physical performance and injury risk in a professional soccer team in match-play affected over a prolonged period of fixture congestion? *Int J Sports Med*, 33(1), 36–42. <https://doi.org/10.1055/s-0031-1283190>
- Carling, C., McCall, A., Le Gall, F., & Dupont, G. (2015). What is the extent of exposure to periods of match congestion in professional soccer players? *Journal of sports sciences*, 33(20), 2116–2124.
- Carling, C., McCall, A., Le Gall, F., & Dupont, G. (2016). The impact of short periods of match congestion on injury risk and patterns in an elite football club. *British journal of sports medicine*, 50(12), 764–768.
- Carmichael, F., Rossi, G., & Thomas, D. (2017). Production, Efficiency, and Corruption in Italian Serie A Football. *Journal of Sports Economics*, 18(1), 34–57. <https://doi.org/10.1177/1527002514551802>
- Carvalho, A., Brown, S., & Abade, E. (2016). Evaluating injury risk in first and second league professional Portuguese soccer: muscular strength and asymmetry. *J Hum Kinet*, 51, 19–26. <https://doi.org/10.1515/hukin-2015-0166>
- Cerdin, J.L. & Selmer, J. (2013). Who is a self-initiated expatriate? Towards conceptual clarity of a common notion. *The International Journal of Human Resource Management*, Vol. 25 No. 9, pp. 1281-1301. <https://doi.org/10.1080/09585192.2013.863793>
- Chadwick, S., Parnell, D., Widdop, P., & Anagnostopoulos, C. (2019). *Routledge handbook of football business and management*. Routledge London. <https://doi.org/https://doi.org/10.1080/16184742.2022.2032251>
- Chang, C., Chen, Y. & Juan, C. (2024). Predicting sports performance of elite female football players through smart wearable measurement platform. *Progress in Brain Research*, Vol. 286, <https://doi.org/10.1016/bs.pbr.2024.04.002> Deloitte (2023). Home Truths: Annual Review of Football Finance. 2023. Available at: <https://www.deloitte.com/global/en/Industries/tmt/research/gx-annual-review-of-football-finance.html>
- Chang, V., Sajeev, S., Xu, Q. A., Tan, M., & Wang, H. (2024). Football Analytics: Assessing the Correlation between Workload, Injury and Performance of Football Players in the English Premier League. *Applied Sciences*, 14(16), 7217.

- Chomiak, J., Junge, A., Peterson, L., & Dvorak, J. (2000). Severe injuries in football players. Influencing factors. *The American journal of sports medicine*, 28(5\_suppl), 58–68. [https://doi.org/10.1177/28.suppl\\_5.s-58](https://doi.org/10.1177/28.suppl_5.s-58)
- CIES Football Observatory, (2023), Transfer revenue streams: A global mapping (Monthly Report n°92). International Centre for Sports Studies (CIES). Available at: <https://football-observatory.com/IMG/sites/mr/mr92/en/>
- Colucci, M., & Vermeer, R. (2023). The status and role of players in the football industry. In *Research Handbook on the Law of Professional Football Clubs* (pp. 258–273). Edward Elgar Publishing.
- Commission, E. (2024). Report on the implementation and relevance of the European Union Work Plan for Sport 2021–2024 (COM(2024) 73 final). <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52024DC0073>
- Conde-Pipo, J., Latorre, J. A., Gimenez-Blasi, N., Olea-Serrano, F., Requena, B., & Mariscal-Arcas, M. (2023). Comparative Analysis of Body Composition Profiles among Latin American Elite Football Players Competing in Europe. *Applied Sciences*, 13(11), 6778.
- Correa, M. B., Knabach, C. B., Collares, K., Hallal, P. C., & Demarco, F. F. (2012). Video analysis of craniofacial soccer incidents: A prospective study. *Journal of Science and Medicine in Sport*, 15. <https://doi.org/10.1016/j.jsams.2011.07.011>
- Cuny, X., & Lejeune, M. (2003). Statistical modelling and risk assessment. *Safety Science*, 41. [https://doi.org/10.1016/S0925-7535\(01\)00056-X](https://doi.org/10.1016/S0925-7535(01)00056-X)
- Cutler, D. M., & Zeckhauser, R. J. (1998). Adverse selection in health insurance. *Forum for Health Economics & Policy*.
- Dada, Paweł, Pawlik, Paweł and Zaroda, Przemysław. The Most Common Injuries in Soccer: An Analytical Review. *Quality in Sport*. Online. 11 July 2024. Vol. 16, p. 52836. <https://doi.org/10.12775/QS.2024.16.52836>.
- D’Ascoli, S., Refinetti, M., Biroli, G., & Krzakala, F. (2020). Double trouble in double descent: Bias and variance (s) in the lazy regime. *International Conference on Machine Learning*,
- Dallmeyer, S., Steinfeldt, H., Hübers, T., Pietzonka, M., & Breuer, C. (2025). Monetising misfortune: the financial consequences of injuries in professional football teams. *BMJ Open Sport & Exercise Medicine*, 11(2), e002437. <https://doi.org/10.1136/bmjsem-2024-002437>

- Deloitte (2023). Home Truths: Annual Review of Football Finance. Available at: <https://www.deloitte.com/global/en/Industries/tmt/research/gx-annual-review-of-football-finance.html>
- Deloitte (2025). Deloitte Sports Business Group. *Annual Review of Football Finance 2025: European football market revenue increased 8% in 2023–24 to a record €38 billion*. Deloitte UK. Available at: <https://www.deloitte.com/uk/en/services/consulting/research/annual-review-of-football-finance-europe.html>
- Dennis, R., & Finch, C. (2008). Sports Injuries. *International Encyclopedia of Public Health*. <https://doi.org/10.1016/B978-012373960-5.00062-9>
- DFL. (2023). DFL-Spielordnung. Retrieved 01/08/2025 from <https://media.dfl.de/sites/2/2023/03/Lizenzierungsordnung-LO-2023-03-04-Stand.pdf>
- Dieles, T., Mattsson, C. & Takes, F. (2024), "Identifying successful football teams in the European player transfer network", *Applied Network Science*, Vol. 9, p. 65, <https://doi.org/10.1007/s41109-024-00675-7>
- Doidge, M., Robert, C., Jonas, G., Richard, I., Peter, M., & and Silvério, J. (2019). The impact of international football events on local, national and transnational fan cultures: a critical overview. *Soccer & Society*, 20(5), 711–720. <https://doi.org/10.1080/14660970.2019.1616264>
- Dolles, H. & Egilsson, B. (2017). Sports expatriates. McNulty, Y. and Selmer, J. (Eds), *Research Handbook of Expatriates*, Edward Elgar, Cheltenham, pp. 350-367.
- Douchet, T., Paizis, C., Carling, C., Cometti, C., & Babault, N. (2023). Typical weekly physical periodization in French academy soccer teams: a survey [journal article]. *Biology of Sport*, 40(3), 731–740. <https://doi.org/10.5114/biolSport.2023.119988>
- Dowling, M., Leopkey, B., & Smith, L. (2018). Governance in Sport: A Scoping Review. *Journal of Sport Management*, 32(5), 438–451. <https://doi.org/10.1123/jsm.2018-0032>
- Drawer, S., & Fuller, C. W. (2002). Evaluating the level of injury in English professional football using a risk-based assessment process. *Br J Sports Med*, 36(6), 446–451. <https://doi.org/10.1136/bjism.36.6.446>

- Duval, A. (2016). The FIFA regulations on the status and transfer of players: transnational law-making in the shadow of Bosman. In *The Legacy of Bosman: Revisiting the Relationship between EU Law and Sport* (pp. 81–116). Springer.
- Edwards, R. R., Tan, C. O., Dairi, I., Whittington, A. J., Thomas, J. D., Campbell, C. M., Ross, E., Taylor, H. A., Jr., Weisskopf, M., Baggish, A. L., Zafonte, R., & Grashow, R. (2023). Race differences in pain and pain-related risk factors among former professional American-style football players. *Pain*, 164(10), 2370–2379. <https://doi.org/10.1097/j.pain.0000000000002948>
- Ekstrand, J. (2011). Injury incidence and injury patterns in professional football: the UEFA injury study. *British journal of sports medicine*, 45(7), 553–558. <https://doi.org/10.1136/bjsm.2009.060582>
- Ekstrand, J., & Tropp, H. (1990). The Incidence of Ankle Sprains in Soccer. *Foot & Ankle*, 11(1), 41–44. <https://doi.org/10.1177/107110079001100108>
- Ekstrand, J., Bengtsson, H., Waldén, M., Davison, M., Khan, K. M., & Hägglund, M. (2022). Hamstring injury rates have increased during recent seasons and now constitute 24% of all injuries in men's professional football: the UEFA Elite Club Injury Study from 2001/02 to 2021/22. *Br J Sports Med*, 57(5), 292–298. <https://doi.org/10.1136/bjsports-2021-105407>
- Ekstrand, J., Hägglund, M., & Fuller, C. W. (2011). Comparison of injuries sustained on artificial turf and grass by male and female elite football players. *Scand J Med Sci Sports*, 21(6), 824–832. <https://doi.org/10.1111/j.1600-0838.2010.01118.x>
- Ekstrand, J., Hägglund, M., & Waldén, M. (2011) (2). Epidemiology of muscle injuries in professional football (soccer). *Am J Sports Med*, 39(6), 1226–1232. <https://doi.org/10.1177/0363546510395879>
- Ekstrand, J., Krutsch, W., Spreco, A., van Zoest, W., Roberts, C., Meyer, T., & Bengtsson, H. (2020). Time before return to play for the most common injuries in professional football: a 16-year follow-up of the UEFA Elite Club Injury Study. *British journal of sports medicine*, 54(7), 421–426. <https://doi.org/10.1136/bjsports-2019-100666>
- Ekstrand, J., Spreco, A., & Davison, M. (2019). Elite football teams that do not have a winter break lose on average 303 player-days more per season to injuries than those teams that do: a comparison among 35 professional European teams. *Br J Sports Med*, 53(19), 1231–1235. <https://doi.org/10.1136/bjsports-2018-099506>
- Ekstrand, J., Spreco, A., Bengtsson, H., & Bahr, R. (2021). Injury rates decreased in men's professional football: an 18-year prospective cohort study of almost 12 000 injuries

- sustained during 1.8 million hours of play. *British journal of sports medicine*, 55(19), 1084–1092. <https://doi.org/10.1136/bjsports-2020-103159>
- Eliakim, E., Morgulev, E., Lidor, R., & Meckel, Y. (2020). Estimation of injury costs: financial damage of English Premier League teams' underachievement due to injuries. *BMJ Open Sport & Exercise Medicine*, 6(1).
- Engström, B. K. O., & Renström, P. A. F. H. (1998). How can injuries be prevented in the world cup soccer athlete? *Clinics in Sports Medicine*, 17. [https://doi.org/10.1016/S0278-5919\(05\)70116-2](https://doi.org/10.1016/S0278-5919(05)70116-2)
- Escamilla-Martínez, E., Sánchez Martín, F., Ramos-Ortega, J., González-García, P., Cortés-Vega, M.-D., & Fernández-Seguín, L. M. (2023). Age related changes in the Q angle of non-professional football players. *Heliyon*, 9. <https://doi.org/10.1016/j.heliyon.2023.e16781>
- Exner, J., Weatherill, S., & Zglinski, J. (2025). The European Sports Act: a proposal to improve sports governance through EU legislation.
- EY & Liga Portugal (2018), Portuguese Professional Football Yearbook, 1st ed. Available at: <https://issuu.com/ligapfp/docs/ey>
- EY & Liga Portugal (2019), Portuguese Professional Football Yearbook, 2nd ed. Available at: [https://issuu.com/ligapfp/docs/ey\\_reportligaclubes2017\\_digital](https://issuu.com/ligapfp/docs/ey_reportligaclubes2017_digital)
- EY & Liga Portugal (2020), Portuguese Professional Football Yearbook, 3rd ed. Available at: <https://www.ligaportugal.pt/press-releases/260/anuario-do-futebol-profissional-portugues-epoca-2018-19>
- EY & Liga Portugal (2021), Portuguese Professional Football Yearbook, 4th ed. Available at: <https://www.ligaportugal.pt/press-releases/279/anuario-do-futebol-profissional-portugues-2019-20>
- EY & Liga Portugal (2022), Portuguese Professional Football Yearbook, 5th ed. Available at: <https://www.ligaportugal.pt/press-releases/289/anuario-do-futebol-profissional-portugues-2020-21>
- EY. & Liga Portugal (2024). Anuário do Futebol Profissional Português. (7<sup>a</sup> ed.). Retrieved 24/02/2025, available at: <https://www.ligaportugal.pt/press-releases/335/anuario-do-futebol-profissional-portugues-epoca-2022-23>
- EY & Liga Portugal (2025). Anuário do Futebol Profissional Português. (8<sup>a</sup> ed.) [https://www.ey.com/content/dam/ey-unified-site/ey-com/pt-pt/newsroom/2025/03/document/ey\\_anuarioligaportugal2023\\_24\\_af.pdf](https://www.ey.com/content/dam/ey-unified-site/ey-com/pt-pt/newsroom/2025/03/document/ey_anuarioligaportugal2023_24_af.pdf)

- Fan, M., Liu, F., Huang, D. & Zhang, H. (2023), "Determinants of international football performance: Empirical evidence from the 1994–2022 FIFA World Cup", *Heliyon*, vol. 9. <https://doi.org/10.1016/j.heliyon.2023.e20252>
- FBG (2024) The business of football academies: How clubs create value from youth development? Available at: [https://footballbenchmark.com/w/football-clubs-valuation-the-european-elite-2024?utm\\_source=chatgpt.com](https://footballbenchmark.com/w/football-clubs-valuation-the-european-elite-2024?utm_source=chatgpt.com)
- FBG (2025) Investing in Portuguese Football. A Prime Spot for Multi-Club Ownership? Available at: <https://footballbenchmark.com/w/investing-in-portuguese-football-a-prime-spot-for-multi-club-ownership-#:~:text=Portugal%20has%20built%20a%20global%20reputation%20as,Europe's%20top%20leagues%20for%20substantial%20transfer%20fees>
- Fernandes, G. S., Parekh, S. M., Moses, J., Fuller, C., Scammell, B., Batt, M. E., Zhang, W., & Doherty, M. (2018). Prevalence of knee pain, radiographic osteoarthritis and arthroplasty in retired professional footballers compared with men in the general population: a cross-sectional study. *Br J Sports Med*, 52(10), 678–683. <https://doi.org/10.1136/bjsports-2017-097503>
- FIFA (2022) Regulations on the Status and Transfer of Players, October 2022 edition. Available at: <https://digitalhub.fifa.com/m/620d0240c40944ed/original/Regulations-on-the-Status-and-Transfer-of-Players-October-2022-edition.pdf>
- FIFA (2024a) Regulations. On the status and transfer of players. Available at: <https://digitalhub.fifa.com/m/69b5c4c7121b58d2/original/Regulations-on-the-Status-and-Transfer-of-Players-June-2024-edition.pdf>
- FIFA (2024b) FIFA Global Transfer Report. Available at: <https://inside.fifa.com/transfer-system/global-transfer-report>
- FIFA (2025) FIFA Global Transfer Report 2024. Available at: <https://digitalhub.fifa.com/m/142077cfbb75c2b0/original/Global-Transfer-Report-2024.pdf>
- FIFA TMS (2021) International transfer market snapshot: A ten-year overview (2011–2020), Fédération Internationale de Football Association, available at: <https://inside.fifa.com/legal/media-releases/fifa-publishes-report-on-ten-years-of-international-transfers>
- FIFA. (2023). FIFA Club Protection Programme 2023–2026 – Technical Bulletin. Retrieved 01/08/2025 from

- <https://hns.family/files/documents/29604/Technical%20Bulletin%20-%20FIFA%20Club%20Protection%20Programme%202023%20-%202026.pdf>
- FIFA. (2024). Professional Football Report Men's Football <https://doi.org/https://digitalhub.fifa.com/m/2a5dc95026d9cf8a/original/FIFA-Professional-Football-Report-2023.pdf>
- FIFPro. (2023). Annual Player Workload Monitoring Report 2022–2023. . Retrieved 01/08/2025 from [https://fifpro.org/media/qa5pkwep/fifpro\\_pwm2023\\_final.pdf](https://fifpro.org/media/qa5pkwep/fifpro_pwm2023_final.pdf)
- Forsythe, B., Knapik, D. M., Khazi-Syed, D., Chang, J., Bohn, C., Hand, C., Korrapati, A., Lavoie-Gagne, O., Chiampas, G., Mandelbaum, B. R., & Chahla, J. (2025). Analysis of Injury Epidemiology in Soccer Players in the 2019 Confederation of North, Central America and Caribbean Association Football Gold Cup as Reported by Team Physicians. *Arthroscopy, Sports Medicine, and Rehabilitation*. <https://doi.org/10.1016/j.asmr.2024.101074>
- Foster, K. (2019). Global Sports Law Revisited. *Entertainment and Sports Law Journal*, 17(1), 4. <https://doi.org/10.16997/eslj.228>
- FPF (2020) Federação Portuguesa de Futebol. Portuguese Football Federation. *Regulation of B teams and satellite clubs* [PDF]. Available at: <https://www.fpf.pt/DownloadDocument.ashx?id=18804>
- FPF (2024a) Federação Portuguesa de Futebol. Portuguese Football Federation. FPF closes 2023/24 season with a new record of nearly 243,000 registered players. Available at: <https://www.fpf.pt/pt/News/Todas-as-not%C3%ADcias/Not%C3%ADcia/news/45527>
- FPF (2024b) Federação Portuguesa de Futebol. Portuguese Football Federation. Youth football participation grows by 11% in the under-7 category. Available at: <https://www.fpf.pt/pt/News/Todas-as-not%C3%ADcias/Not%C3%ADcia/news/48083>
- FPF (2024c) Federação Portuguesa de Futebol. Portuguese Football Federation. *Regulations for the Liga Revelação and Taça Revelação (Under-23 National Championship)*. Available at: <https://www.fpf.pt/DownloadDocument.ashx?id=26801>
- France. (2025a). Code du travail [Labour Code]. Retrieved 01/08/2025 from <https://www.legifrance.gouv.fr/codes/id/LEGITEXT000006072050/>

- France. (2025b). CPAM (Caisse Primaire d'Assurance Maladie): Accidents du travail et maladies professionnelles (AT/MP). Retrieved 01/08/2025 from <https://www.ameli.fr>
- Franck, E. (2014) "Financial Fair Play in European Club Football - What is it All About?", University of Zurich, Department of Business Administration, UZH Business Working Paper No. 328, available at: <http://dx.doi.org/10.2139/ssrn.2284615>
- Fraser, D., & Burrows, J. (2022). The 2021/22 European Football Injury Index-Mid Season Update. Howden Insurance Brokers Limited. Retrieved 24/02/2025 from <https://view.publitas.com/howden-uk-group/howden-sport-and-entertainment-feeling-the-strain-interim-injury-report-2022/>
- Freeburn, L. (2018). Regulating international sport: Power, authority and legitimacy. Brill.
- Frick, B. (2007). The football players' labor market: Empirical evidence from the major European leagues. *Scottish Journal of Political Economy*, 54(3), 422–446. <https://doi.org/10.1111/j.1467-9485.2007.00423.x>
- Frick, B., & Moser, K. (2020). Are Women Really Less Competitive Than Men? Career Duration in Nordic and Alpine Skiing. *Frontiers in Sociology*, 5. <https://doi.org/10.3389/fsoc.2020.539766>
- Fuller, C. W., Ekstrand, J., Junge, A., Andersen, T. E., Bahr, R., Dvorak, J., Hagglund, M., McCrory, P., & Meeuwisse, W. H. (2006). Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries. *Br J Sports Med*, 40(3), 193–201. <https://doi.org/10.1136/bjism.2005.025270>
- Gabbett, T. J. (2016). The training-injury prevention paradox: should athletes be training smarter and harder? *British journal of sports medicine*, 50(5), 273–280. <https://doi.org/10.1136/bjsports-2015-095788>
- Gabinete de Estratégia e Estudos. (2019). *Sector da cortiça em Portugal* (Em Análise, BMEP N° 01|2019). Ministério da Economia, Portugal. Retirado de dados do Sistema de Contas Integradas das Empresas (SCIE) e Contas Nacionais (INE). Available at: <https://www.gee.gov.pt/pt/documentos/estudos-e-seminarios/artigos/8479-analise-02-19/file>
- Gans, I., Retzky, J. S., Jones, L. C., & Tanaka, M. J. (2018). Epidemiology of recurrent anterior cruciate ligament injuries in National Collegiate Athletic Association sports: the Injury Surveillance Program, 2004-2014. *Orthopaedic journal of sports medicine*, 6(6), 2325967118777823.

- García-Fernandez, P., Guodemar Perez, J., Ruiz Lopez, M., López Rodríguez, E., & Hervás-Pérez, J. (2017). Injury Rate in Professional Soccer Players within the Community of Madrid: A Comparative, Epidemiological Cohort Study among the First, Second and Second B Divisions. *Journal of Physiotherapy & Physical Rehabilitation*, 2(4).
- Genovesi, F., Tabone, M., Nuara, S., Pasquali, E., Rossi, A., Perali, A., & Bongiovanni, T. (2025). Injury risk profile for soccer players: identification of the risk factors for soccer-related injuries - an umbrella review. *Res Sports Med*, 1–27. <https://doi.org/10.1080/15438627.2025.2467867>
- Germany. (1996). Sozialgesetzbuch VII – Gesetzliche Unfallversicherung (SGB VII) [Social Code Book VII – Statutory Accident Insurance]. Retrieved 01/08/2025 from [https://www.gesetze-im-internet.de/sgb\\_7/](https://www.gesetze-im-internet.de/sgb_7/)
- Glorot, X., & Bengio, Y. (2010). Understanding the difficulty of training deep feedforward neural networks. Proceedings of the thirteenth international conference on artificial intelligence and statistics,
- Goddard, J., Sloane, P. & Wilson, J. (2012), 'The Bosman Ruling and Labor Mobility in Football (Soccer)', in Kahane, L.H. & Shmanske, S. (eds), *The Oxford Handbook of Sports Economics: The Economics of Sports*, Vol. 1, Oxford Handbooks. <https://doi.org/10.1093/oxfordhb/9780195387773.013.0014>
- Goggins, L., Peirce, N., Stokes, K., & Williams, S. (2021). Negative association between injuries and team success in professional cricket: A 9-year prospective cohort analysis. *Journal of Science and Medicine in Sport*, 24. <https://doi.org/10.1016/j.jsams.2020.07.007>
- Goodfellow, I. (2016). *Deep learning* (Vol. 196). MIT press.
- Gouttebauge, V., Aoki, H., & Kerkhoffs, G. M. M. J. (2018). Knee osteoarthritis in professional football is related to severe knee injury and knee surgery. *Injury Epidemiology*, 5. <https://doi.org/10.1186/s40621-018-0157-8>
- Gouveia, C. & Pereira, R. (2020), 'Professional football in Portugal: preparing to resume after the COVID-19 pandemic', *Soccer & Society*, vol. 22, no. 1–2, pp. 103–114. <https://doi.org/10.1080/14660970.2020.1796653>
- Gouveia, C. G. (2022). An intercultural sporting event as part of soft power strategy: The Lusofonia Games in Macau. *Soccer & Society*, 24(6), 823–837. <https://doi.org/10.1080/19406940.2022.2137554>

- Greenhow, A., & Wolohan, J. (2025). *The Routledge Handbook on Sports Law and Governance*. Taylor & Francis.
- Greff, K.; Srivastava, R.K.; Koutník, J.; Steunebrink, B.R.; Schmidhuber, J. LSTM: A Search Space Odyssey (2027). *IEEE Transactions on Neural Networks and Learning Systems* 2017, 28, 2222-2232. <https://doi.org/10.1109/TNNLS.2016.2582924>
- Gregson, W., Carling, C., Gualtieri, A., O'Brien, J., Reilly, P., Tavares, F., Bonanno, D., Lopez, E., Marques, J., Lolli, L., & Salvo, V. D. (2022). A survey of organizational structure and operational practices of elite youth football academies and national federations from around the world: A performance and medical perspective [Original Research]. *Frontiers in Sports and Active Living*, Volume 4 - 2022. <https://doi.org/10.3389/fspor.2022.1031721>
- Grix, J. & Houlihan, B. (2013), 'Sports Mega-Events as Part of a Nation's Soft Power Strategy: The Cases of Germany (2006) and the UK (2012)', *The British Journal of Politics and International Relations*, vol. 16, no. 4, pp. 572-596. <https://doi.org/10.1111/1467-856X.12017>
- Guerriero, C. (2016). Endogenous legal traditions. *International Review of Law and Economics*, 46. <https://doi.org/10.1016/j.irl.2016.02.001>
- Guo, J., Yang, H., & Zhang, X. (2024). How watching sports events empowers people's sense of wellbeing? The role of chain mediation in social interaction and emotional experience. *Front Psychol*, 15, 1471658. <https://doi.org/10.3389/fpsyg.2024.1471658>
- Gurau, T. V., Gurau, G., Musat, C. L., Voinescu, D. C., Anghel, L., Onose, G., Munteanu, C., Onu, I., & Iordan, D. A. (2023). Epidemiology of Injuries in Professional and Amateur Football Men (Part II). *J Clin Med*, 12(19). <https://doi.org/10.3390/jcm12196293>
- Haig, B. D. (2005). An abductive theory of scientific method. *Psychol Methods*, 10(4), 371-388. <https://doi.org/10.1037/1082-989X.10.4.371>
- Hall, E. C. R., Larruskain, J., Gil, S. M., Lekue, J. A., Baumert, P., Rienzi, E., Moreno, S., Tannure, M., Murtagh, C. F., Ade, J. D., Squires, P., Orme, P., Anderson, L., Whitworth-Turner, C. M., Morton, J. P., Drust, B., Williams, A. G., & Erskine, R. M. (2022). Playing Position and the Injury Incidence Rate in Male Academy Soccer Players. *J Athl Train*, 57(7), 696–703. <https://doi.org/10.4085/1062-6050-0346.21>
- Hammerschmidt, J., Durst, S., Kraus, S. & Puumalainen, K. (2021), 'Professional football clubs and empirical evidence from the COVID-19 crisis: Time for sport

- entrepreneurship?', *Technological Forecasting and Social Change*, vol. 165. <https://doi.org/10.1016/j.techfore.2021.120572>
- Hastie, T. (2009). *The elements of statistical learning: data mining, inference, and prediction*. In: Springer.
- Haugaasen, M., & and Jordet, G. (2012). Developing football expertise: a football-specific research review. *International Review of Sport and Exercise Psychology*, 5(2), 177–201. <https://doi.org/10.1080/1750984X.2012.677951>
- Havran, Z. & András, K. (2014), 'Regional Export Efficiency in the Market of Football Players', *Theory Methodology Practice (TMP)*, Faculty of Economics, University of Miskolc, vol. 10, no. 2, pp. 3-15
- Hawkins, R. D., Hulse, M., Wilkinson, C., Hodson, A., & Gibson, M. (2001). The association football medical research programme: an audit of injuries in professional football. *British journal of sports medicine*, 35(1), 43–47.
- He, K., Zhang, X., Ren, S., & Sun, J. (2015). Delving deep into rectifiers: Surpassing human-level performance on imagenet classification. *Proceedings of the IEEE international conference on computer vision*.
- Herm, S., et al. (2014). When the crowd evaluates soccer players' market values: Accuracy and evaluation attributes of an online community. *Sport Management Review*, 17(4), 484–492. <https://doi.org/10.1016/j.smr.2013.12.006>
- Herman, M. (2024). Injuries cost top leagues 732 million euros last season, Bundesliga worst hit. Retrieved 24/02/2025 from <https://www.reuters.com/sports/soccer/injuries-cost-top-leagues-732-million-euros-last-season-bundesliga-worst-hit-2024-10-15/>
- Hill, C. N., Reed, W., Schmitt, D., Sands, L. P., & Queen, R. M. (2020). Racial differences in gait mechanics. *J Biomech*, 112, 110070. <https://doi.org/10.1016/j.jbiomech.2020.110070>
- Hoening, T., Edouard, P., Krause, M., Malhan, D., Relógio, A., Junge, A., & Hollander, K. (2022). Analysis of more than 20,000 injuries in European professional football by using a citizen science-based approach: An opportunity for epidemiological research? *J Sci Med Sport*, 25(4), 300–305. <https://doi.org/10.1016/j.jsams.2021.11.038>
- Hollander, K., Mason, J., Zech, A., Okoth, C., & Häner, M. (2023). Field hockey. <https://doi.org/10.1016/B978-0-323-99992-2.00051-7>

- Hoskins, W., Pollard, H., Hough, K., & Tully, C. (2006). Injury in rugby league. *Journal of Science and Medicine in Sport*, 9. <https://doi.org/10.1016/j.jsams.2006.03.013>
- Hu, Y., & Shu, S. (2024). Exploring the dynamics of governance: An examination of traditional governance and governance innovation in the United States professional sports leagues. *Heliyon*, 10(13). <https://doi.org/10.1016/j.heliyon.2024.e32883>
- Hulin, B. T., Gabbett, T. J., Lawson, D. W., Caputi, P., & Sampson, J. A. (2016). The acute:chronic workload ratio predicts injury: high chronic workload may decrease injury risk in elite rugby league players. *Br J Sports Med*, 50(4), 231–236. <https://doi.org/10.1136/bjsports-2015-094817>
- Ichniowski, C. & Preston, A. (2014), 'Do star performers produce more stars? Peer effects and learning in elite teams', NBER Working Paper, no. 20478.
- IFPI (2024). International Federation of the Phonographic Industry. *IFPI Global Music Report 2024: Global recorded music revenues grew 10.2% to US\$ 28.6 billion*. Available at: [https://www.ifpi.org/wp-content/uploads/2024/04/GMR\\_2024\\_State\\_of\\_the\\_Industry.pdf](https://www.ifpi.org/wp-content/uploads/2024/04/GMR_2024_State_of_the_Industry.pdf)
- IGFEG. ((nd)). Instituto de Gestão Financeira e Equipamentos da Justiça, IP. Retrieved 01/08/2025 from <https://www.dgsi.pt/>
- INAIL. (2025). Institutional documents on insurance coverage. Professional athletes and fundamental principles and rights at work (Technical Brief)
- INE (2021), Contas Nacionais. Séries Longas para a Economia Portuguesa. Available at: [https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine\\_destaques&DESTAQUES\\_dest\\_boui=535669495&DESTAQUESmodo=2](https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_destaques&DESTAQUES_dest_boui=535669495&DESTAQUESmodo=2)
- Ishac, W. (2024) 'Examining sport tourism role in fostering social sustainability: Qatar youth perceptions', *Frontiers in Sports and Active Living*, vol. 6, p. 1388123. <https://doi.org/10.3389/fspor.2024.1388123>
- Iskra, M., Voigt, L., & Raab, M. (2025). Accounting for dynamic cognition–action interaction in decision-making tasks in sports: A scoping review. *Sport, Exercise, and Performance Psychology*, 14(1), 193–213. <https://doi.org/10.1037/spy0000361>
- Italy. (1981). Law 91/1981, March, 23. Professional Sport Law. *Gazzeta ufficiale*, anno 122, 86. Retrieved 01/05/2025 from <https://www.gazzettaufficiale.it/eli/gu/1981/03/27/86/sg/pdf>

- Jaspers, A., De Beéck, T. O., Brink, M. S., Frencken, W. G., Staes, F., Davis, J. J., & Helsen, W. F. (2018). Relationships between the external and internal training load in professional soccer: what can we learn from machine learning? *International journal of sports physiology and performance*, 13(5), 625–630.
- Jayanthi, N. A., Holt, D. B., Jr., LaBella, C. R., & Dugas, L. R. (2018). Socioeconomic Factors for Sports Specialization and Injury in Youth Athletes. *Sports Health*, 10(4), 303–310. <https://doi.org/10.1177/1941738118778510>
- Jiang, J., Ge, H., Du, L., Gomez, M. A., Gong, B., & Cui, Y. (2022). Impact of Match Type and Match Halves on Referees' Physical Performance and Decision-Making Distance in Chinese Football Super League. *Front Psychol*, 13, 864957. <https://doi.org/10.3389/fpsyg.2022.864957>
- Johnson, C. F. (1996). Deductive versus inductive reasoning: A closer look at economics. *Social Science Journal*, 33(3), 287-299. [https://doi.org/10.1016/S0362-3319\(96\)90024-5](https://doi.org/10.1016/S0362-3319(96)90024-5)
- Johnson, D. M., Williams, S., Bradley, B., Sayer, S., Murray Fisher, J., & Cumming, S. (2020). Growing pains: Maturity associated variation in injury risk in academy football. *European Journal of Sport Science*, 20(4), 544–552. <https://doi.org/https://doi.org/10.1080/17461391.2019.1633416>
- Jones, C. M., Griffiths, P. C., & Mellalieu, S. D. (2017). Training Load and Fatigue Marker Associations with Injury and Illness: A Systematic Review of Longitudinal Studies. *Sports Med*, 47(5), 943–974. <https://doi.org/10.1007/s40279-016-0619-5>
- Jones, S., Almqvist, F., & Ekstrand, J. (2022). Injury incidence and position-specific injury patterns in professional football: a 10-year study. *Scandinavian journal of medicine & science in sports*, 32(4), 744–752. <https://doi.org/10.1111/sms.14073>
- Kohe, G. Z., & Purdy, L. G. (2025). Conceptualising the notion of the 'sport worker' and 'sport/s work': a commentary. *Sport in Society*, 28(3), 473–487.
- Kolodziej, M., Nolte, K., Schmidt, M., Alt, T., & Jaitner, T. (2021). Identification of Neuromuscular Performance Parameters as Risk Factors of Non-contact Injuries in Male Elite Youth Soccer Players: A Preliminary Study on 62 Players With 25 Non-contact Injuries. *Frontiers in Sports and Active Living*, 3. <https://doi.org/10.3389/fspor.2021.615330>
- Kowalski, W. (2022), 'Entrepreneurship in sport: sport in business, using professional football as an example', *Studia Historiae Oeconomicae*, vol. 40, no. 2, pp. 21–52. Adam Mickiewicz University.

- Krist, M. R., van Beijsterveldt, A. M. C., Backx, F. J. G., & Ardine de Wit, G. (2013). Preventive exercises reduced injury-related costs among adult male amateur soccer players: a cluster-randomised trial. *Journal of Physiotherapy*, 59. [https://doi.org/10.1016/S1836-9553\(13\)70142-5](https://doi.org/10.1016/S1836-9553(13)70142-5)
- Krutsch, V., Krutsch, W., Härtl, J., Bloch, H., Alt, V., Klein, C., Reinsberger, C., Seiffert, R., Huber, L., & Weber, J. (2021). Head injuries in professional football (soccer): Results of video analysis verified by an accident insurance registry. *PLoS ONE*, 16. <https://doi.org/10.1371/journal.pone.0255695>
- Kugelman, D. N., Qatu, A. M., Haglin, J. M., Konda, S. R., & Egol, K. A. (2017). Participation in Recreational Athletics After Operative Fixation of Tibial Plateau Fractures: Predictors and Functional Outcomes of Those Getting Back in the Game. *Orthop J Sports Med*, 5(12), 2325967117743916. <https://doi.org/10.1177/2325967117743916>
- Kumar, M. & Bhalla, S. (2021). Global sports market today: An overview. *International Journal of Physical Education, Sports and Health* 2021; 8(4): 223-225. Available at: <https://www.kheljournal.com/archives/2021/vol8issue4/PartD/8-4-44-846.pdf>
- Kwakye, S. K., Mostert, K., Garnett, D., & Masenge, A. (2023). Risk factors associated with football injury among male players from a specific academy in Ghana: a pilot study. *Scientific Reports*, 13(1), 8070. <https://doi.org/10.1038/s41598-023-34826-0>
- Lago, U., Simmons, R. & Szymanski, S. (2006), 'The financial crisis in European football: an introduction', *Journal of Sports Economics*, vol. 7, no. 1, pp. 3–12. <https://doi.org/10.1177/1527002505282871>
- Larruskain, J., Lekue, J. A., Diaz, N., Odriozola, A., & Gil, S. M. (2018). A comparison of injuries in elite male and female football players: A five-season prospective study. *Scandinavian journal of medicine & science in sports*, 28(1), 237–245.
- Law no. 1/90, of January 13 (1990), Framework Law of the Sports System, *Diário da República*, 1st Series, no. 11, pp. 180–186.
- Law no. 10/2013, of January 25 (2013), Legal framework of sports companies, *Diário da República*, 1st Series, no. 17, pp. 626–637.
- Law no. 19/96, of June 25 (1996), Revision of the Framework Law of the Sports System, *Diário da República*, 1st Series-A, no. 145, pp. 2022–2023.
- Law No. 27/2011 of 16 June, (2011). <https://diariodarepublica.pt/dr/detalhe/lei/27-2011-669999>

- Law No. 28/1998 of 26 June, (1998). <https://diariodarepublica.pt/dr/detalhe/lei/28-1998-479416>
- Law No. 48/2023 of 22 August, (2023). <https://diariodarepublica.pt/dr/detalhe/lei/48-2023-220172306>
- Law no. 48/2023, of August 22 (2023), Establishes the specific legal framework for the compensation of damages arising from work-related accidents involving professional athletes and repeals Law No. 27/2011, of 16 June, Diário da República, 1st Series-A, no. 162, pp. 2–7.
- Law no. 5/2007, of January 16 (2007), Framework Law on Physical Activity and Sport, Diário da República, 1st Series, no. 11, pp. 372–383.
- Law No. 54/2017 of July 14, (2017). <https://diariodarepublica.pt/dr/detalhe/lei/54-2017-107692694>
- Law No. 8/2003 of 12 May, (2003). <https://diariodarepublica.pt/dr/detalhe/lei/8-2003-581670>
- Law No. 98/2009 of 4 September, (2009). [https://www.pgdlisboa.pt/leis/lei\\_mostra\\_articulado.php?nid=1156&tabela=lei](https://www.pgdlisboa.pt/leis/lei_mostra_articulado.php?nid=1156&tabela=lei)
- League, F. P. (2025). The FA Handbook. Retrieved 01/08/2025 from <https://www.thefa.com/football-rules-governance/lawsandrules/fa-handbook>
- LeCun, Y., Bengio, Y., & Hinton, G. (2015). Deep learning. *Nature*, 521(7553), 436–444. <https://doi.org/10.1038/nature14539>
- Lee, S.-Y., Chun, C.-B., Lee, Y.-G., & Seo, N. K. (2008). The National Health Insurance system as one type of new typology: The case of South Korea and Taiwan. *Health Policy*, 85. <https://doi.org/10.1016/j.healthpol.2007.07.006>
- Lemme, N. J., Li, N. Y., DeFroda, S. F., Kleiner, J., & Owens, B. D. (2018). Epidemiology of Achilles Tendon Ruptures in the United States: Athletic and Nonathletic Injuries From 2012 to 2016. *Orthop J Sports Med*, 6(11), 2325967118808238. <https://doi.org/10.1177/2325967118808238>
- Li, H., Moreland, J. J., Peek-Asa, C., & Yang, J. (2017). Preseason Anxiety and Depressive Symptoms and Prospective Injury Risk in Collegiate Athletes. *Am J Sports Med*, 45(9), 2148–2155. <https://doi.org/10.1177/0363546517702847>
- Liang, Y. (2019). The emerging labour market and transformation from state amateurs to professional athletes. *Communist and Post-Communist Studies*, 52. <https://doi.org/10.1016/j.postcomstud.2019.10.005>

- Liga, L. (2022). LaLiga Impulso: Acuerdo estratégico con CVC para acelerar el crecimiento global de LaLiga y sus clubes. Retrieved 01/08/2025 from <https://www.laliga.com/es-GB/noticias/laliga-impulso-acuerdo-estrategico-con-cvc-para-acelerar-el-crecimiento-global-de-laliga-y-sus-clubes>
- Liga-Portugal. (2022). Collective Bargaining Agreement for Professional Football Players. Retrieved 01/08/2025 from [https://ligaportugalstorage.blob.core.windows.net/backoffice/assets/cct\\_jogadores\\_profissionais\\_a165864e2a.pdf](https://ligaportugalstorage.blob.core.windows.net/backoffice/assets/cct_jogadores_profissionais_a165864e2a.pdf)
- Liga-Portugal. (2025). Regulations of Competitions Organized by Liga Portugal (2025/26 Season). Article 85: Documentary Requirements. Retrieved 01/08/2025 from <https://www.ligaportugal.pt/news/24879/regulamentos-de-competicoes-e-disciplinar>
- Lima, E. B. d. S., Belangero, P. S., Lara, P. H. S., Ribeiro, L. M., de Figueiredo, E. A., Andreoli, C. V., Pochini, A. d. C., Ejnisman, B., Pagura, J. R., Cohen, M., & Arliani, G. G. (2024). Shoulder injuries in Brazilian professional football players: epidemiological analysis of 3828 games. *Journal of ISAKOS*, 9. <https://doi.org/10.1016/j.jisako.2024.01.012>
- Limba, F. & Sapulette, S. (2021), 'European football player transfer scheme according to IFRS and IAS: case study on Juventus Football Club S.p.A.', *Budapest International Research and Critics Institute-Journal (BIRCI-Journal)*, vol. 4, no. 4, pp. 12355–12365. <http://dx.doi.org/10.33258/birci.v4i4.3299>
- Liu, H., Huang, S., Bu, T., Jiang, W., Fu, T., & Zhao, L. (2022). Epidemiology of Campus Football Injuries in Ningxia, China: Occurrence, Causes, and Management. *Frontiers in Public Health*, 10. <https://doi.org/10.3389/fpubh.2022.893541>
- Liu, X., Liu, Y., Lu, X., Wang, Q. & Wang, T. (2016), 'The anatomy of the global football player transfer network: club functionalities versus network properties', *PLoS ONE*, vol. 11. <https://doi.org/10.1371/journal.pone.0156504>
- López-Valenciano, A., Ayala, F., Vera-García, F. J., De Ste Croix, M. B., Hernández-Sánchez, S., Ruiz-Pérez, I., Cejudo, A., & Santonja, F. (2019). Comprehensive profile of hip, knee and ankle ranges of motion in professional football players. *Journal of Sports Medicine and Physical Fitness*, 59(1), 102–109.
- López-Valenciano, A., Moreno-Perez, V., López-Del Campo, R., Resta, R., & Del Coso, J. (2023). The five-substitution option enhances Teams' running performance at high speed in football. *International Journal of Sports Medicine*, 44(05), 344–351.

- López-Valenciano, A., Ruiz-Perez, I., Garcia-Gomez, A., Vera-Garcia, F. J., De Ste Croix, M., Myer, G. D., & Ayala, F. (2020). Epidemiology of injuries in professional football: a systematic review and meta-analysis. *Br J Sports Med*, 54(12), 711–718. <https://doi.org/10.1136/bjsports-2018-099577>
- Lu, D., McCall, A., Jones, M., Kovalchik, S., Steinweg, J., Gelis, L., & Duffield, R. (2020). Injury epidemiology in Australian male professional soccer. *Journal of Science and Medicine in Sport*, 23. <https://doi.org/10.1016/j.jsams.2020.01.006>
- Luo, L., Tang, Y., Li, X., Sun, G., Guo, E., & Xu, H. (2025). East Asian expatriate football players and national team success: Chinese, Japanese, and South Korean players in Europe (2000–2024). *Scientific Reports*, 15(1), 3707. <https://doi.org/10.1038/s41598-024-80953-7>
- Magee, J. & Sugden, J. (2002), 'The world at their feet': professional football and international labor migration', *Journal of Sport and Social Issues*, vol. 26, no. 4, pp. 421–437. <https://doi.org/10.1177/0193732502238257>
- Maguire, J. & Stead, D. (1998), 'Border crossing: soccer labour migration and the European Union', *International Review for the Sociology of Sport*, vol. 33, no. 1, pp. 59–73. <https://doi.org/10.1177/101269098033001005>
- Mahootian, F., & Eastman, T. E. (2009). Complementary frameworks of scientific inquiry: Hypothetico-deductive, hypothetico-inductive, and observational-inductive. *World Futures*, 65(1), 61-75. <https://doi.org/10.1080/02604020701845624>
- Malcolm, D. (2016). Confidentiality in Sports Medicine. *Clinics in Sports Medicine*, 35. <https://doi.org/10.1016/j.csm.2015.10.006>
- Malone, S., Owen, A., Mendes, B., Hughes, B., Collins, K., & Gabbett, T. J. (2018). High-speed running and sprinting as an injury risk factor in soccer: Can well-developed physical qualities reduce the risk? *J Sci Med Sport*, 21(3), 257–262. <https://doi.org/10.1016/j.jsams.2017.05.016>
- Martins, F., França, C., Marques, A., Iglésias, B., Sarmiento, H., Henriques, R., Ihle, A., Lopes, H., Ornelas, R. T., & Gouveia, É. R. (2022). Sports Injuries of a Portuguese Professional Football Team during Three Consecutive Seasons. *International journal of environmental research and public health*, 19(19), 12582.
- Maughan, R. J., Zerguini, Y., Chalabi, H., & Dvorak, J. (2012). Achieving optimum sports performance during Ramadan: some practical recommendations. *J Sports Sci*, 30 Suppl 1, S109–117. <https://doi.org/10.1080/02640414.2012.696205>

- Mayo, M., Seijas, R., & Álvarez, P. (2014). Structured neuromuscular warm-up for injury prevention in young elite football players. *Revista Española de Cirugía Ortopédica y Traumatología (English Edition)*, 58. <https://doi.org/10.1016/j.recote.2014.09.004>
- McCall, A., Carling, C., Nedelec, M., Davison, M., Le Gall, F., Berthoin, S., & Dupont, G. (2014). Risk factors, testing and preventative strategies for non-contact injuries in professional football: current perceptions and practices of 44 teams from various premier leagues. *Br J Sports Med*, 48(18), 1352–1357. <https://doi.org/10.1136/bjsports-2014-093439>
- McGovern, P. (2002), 'Globalization or internationalization? foreign footballers in the English league, 1946–95', *Sociology*, vol. 36, no. 1, pp. 23–42. <https://doi.org/10.1177/0038038502036001002>
- McLean, S., Read, G., Hulme, A., Dodd, K., Gorman, A., Solomon, C. & Salmon, P. (2019), 'Beyond the tip of the iceberg: using systems archetypes to understand common and recurring issues in sports coaching', *Frontiers in Sports and Active Living*, vol. 1. <https://doi.org/10.3389/fspor.2019.00049>
- Memari, Z., Rezaei Pandari, A., Ehsani, M. & Mahmudi, S. (2021). Business management in the football industry from a supply chain management perspective, *International Journal of Sports Marketing and Sponsorship*, vol. 22, no. 4, pp. 737–763. <https://doi.org/10.1108/IJSMS-02-2020-0025>
- Mendoza, R. (2017) Football and economy relations at the international level, Universitat de Barcelona. Available at: [https://www.ub.edu/school-economics/recent\\_thesis/football-economy-relations-international-level/](https://www.ub.edu/school-economics/recent_thesis/football-economy-relations-international-level/)
- Millward, P. (2011). *The global football league: Transnational networks, social movements and sport in the new media age*. Palgrave Macmillan
- Minchuk, Y. (2024) 'The transfer market for sports players - a contest theory approach', *Sports Economics Review*, vol. 6, 100035. <https://doi.org/10.1016/j.serev.2024.100035>
- Moreau, N., Roy, M., Wilson, A. & Atlani, L. (2020) 'Life is more important than football: comparative analysis of Tweets and Facebook comments regarding the cancellation of the 2015 African Cup of Nations in Morocco', *International Review for the Sociology of Sport*, vol. 56, no. 2, pp. 252–275. <https://doi.org/10.1177/1012690219899610>
- Morrow, S. (2003) *The people's game? football, finance and society*, Palgrave Macmillan, Basingstoke.

- Muaidi, Q. I. (2019). Saudi professional league: A prospective study of the injuries and illnesses sustained by professional soccer players during the 2015-2016 season. *Asian Journal of Sports Medicine*, 10(1).
- Mujika, I., Padilla, S., Pyne, D., & Busso, T. (2004). Physiological changes associated with the pre-event taper in athletes. *Sports Med*, 34(13), 891–927. <https://doi.org/10.2165/00007256-200434130-00003>
- Ngota, J. O., Odhiambo, D. D., & Okoti, D. D. (2024). Interrogating the impact of climate change on multiple outdoor sports activities: a critical review. *International Journal of Research and Innovation in Social Science*, 8(1), 2193–2199.
- Nieto Torrejón, L., Martínez-Serrano, A., Villalón, J. M., & Alcaraz, P. E. (2024). Economic impact of muscle injury rate and hamstring strain injuries in professional football clubs. Evidence from LaLiga. *PLoS ONE*, 19. <https://doi.org/10.1371/journal.pone.0301498>
- Nilsson, T., Östenberg, A. H., & Alricsson, M. (2016). Injury profile among elite male youth soccer players in a Swedish first league. *J Exerc Rehabil*, 12(2), 83–89. <https://doi.org/10.12965/jer.1632548.274>
- Nitta, C. T., Baldan, A. R., Costa, L. P. B., Cohen, M., Pagura, J. R., & Arliani, G. G. (2021). Epidemiology of anterior cruciate ligament injury in soccer players in the Brazilian. *Acta Ortop Bras*, 29(1), 45–48. <https://doi.org/10.1590/1413-785220212901235225>
- Norbäck, P.-J., Olsson, M. & Persson, L. (2021) 'Talent development and labour market integration in European football', *The World Economy*, Wiley Blackwell, vol. 44, no. 2, pp. 367–408.
- Nuno Coelho, J., & Clara Tiesler, N. (2007). The Paradox of the Portuguese Game: The Omnipresence of Football and the Absence of Spectators at Matches. *Soccer & Society*, 8(4), 578–600. <https://doi.org/10.1080/14660970701440931>
- O'Connor, C., Chrystal, R., Mc Intyre, M., Delahunt, E., & Thorborg, K. (2024). Hip adduction and abduction strength values in elite-level male and female youth soccer players: A comparison between sexes, and across age-groups. *Physical Therapy in Sport*, 70, 7–14.
- O'Leary, L., Seltmann, M., & Smokvina, V. (2024). Elite Athletes and Worker Status. *Industrial Law Journal*, 54(2), 248–277. <https://doi.org/10.1093/indlaw/dwae025>

- Observatory, C. F. (2024). Twenty years of the Observatory: tribute studies on training clubs. Retrieved 12/03/2025 from <https://football-observatory.com/WeeklyPost493>
- OECD. (2004). Private Health Insurance in OECD Countries: The Benefits and Costs for Users. O. Publishing. <https://www.oecd.org/health/health-systems/34893062.pdf>
- Oliveira, R., Brito, J. P., Loureiro, N., Padinha, V., Ferreira, B., & Mendes, B. (2020). Does the distribution of the weekly training load account for the match results of elite professional soccer players? *Physiology & Behavior*, 225, 113118.
- Orr, R.; Schram, B.; Pope, R. (2020). Sports Injuries in the Australian Regular Army. *Safety*, 6, 23. <https://doi.org/10.3390/safety6020023>
- Osman, F., Haldar, S., & Henry, C. J. (2020). Effects of Time-Restricted Feeding during Ramadan on Dietary Intake, Body Composition and Metabolic Outcomes. *Nutrients*, 12(8). <https://doi.org/10.3390/nu12082478>
- Page, R. M., Field, A., Langley, B., Harper, L. D., & Julian, R. (2022). The Effects of Fixture Congestion on Injury in Professional Male Soccer: A Systematic Review. *Sports Medicine*, 53. <https://doi.org/10.1007/s40279-022-01799-5>
- Parliament, U. (1996). Employment Rights Act 1996. Retrieved 01/05/2025 from <https://www.legislation.gov.uk/ukpga/1996/18/contents>
- Parrish, R. (2003). Sports law and policy in the European Union. Manchester University Press.
- Pauly, M. V. (1968). The economics of moral hazard: comment. *The American Economic Review*, 58(3), 531–537.
- Pérez-Gómez, J., Adsuar, J. C., Alcaraz, P. E., & Carlos-Vivas, J. (2022). Physical exercises for preventing injuries among adult male football players: A systematic review. *Journal of Sport and Health Science*, 11. <https://doi.org/10.1016/j.jshs.2020.11.003>
- Peeters, T., & Szymanski, S. (2014). Financial Fair Play in European Football. *Economic Policy*, 29(78), 343–390. <https://doi.org/10.1111/1468-0327.12031>
- Pfiffmann, D., Herbst, M., Ingelfinger, P., Simon, P., & Tug, S. (2016). Analysis of Injury Incidences in Male Professional Adult and Elite Youth Soccer Players: A Systematic Review. *Journal of Athletic Training*, 51(5), 410–424. <https://doi.org/10.4085/1062-6050-51.6.03>
- Pillay, L., van Rensburg, D. C. J., Ramkilawon, G., Andersen, T. E., Kerkhoffs, G., & Gouttebauge, V. (2024). Don't forget to mind the mind: a prospective cohort study over 12 months on mental health symptoms in active professional male footballers.

BMC Sports Sci Med Rehabil, 16(1), 214. <https://doi.org/10.1186/s13102-024-01005-1>

- Plumley, D., Ramchandani, G. & Wilson, R. (2018). Mind the gap: an analysis of competitive balance in the English football league system. *International Journal of Sport Management and Marketing*, vol. 18, no. 5, pp. 357–375. <https://doi.org/10.1504/IJSMM.2018.094344>
- Poli, R. & Ravenel, L. (2005) 'Migration and trade of African football players: historic, geographical and cultural determinants', CIES Football Observatory Working Paper, University of Neuchâtel.
- Poli, R., Ravenel, L. & Besson, R. (2015), 'Transfer values and the football player's labour market', CIES Football Observatory Monthly Report, no. 11. Available at: <https://football-observatory.com/IMG/sites/mr/mr11/en/>
- Poli, R., Ravenel, L. & Besson, R. (2021), 'Exporting countries in world football: analysis of the international migration of players', CIES Football Observatory Monthly Report, no. 62. Available at: <https://football-observatory.com/IMG/sites/mr/mr62/en/>
- Poli, R., Ravenel, L. & Besson, R. (2024), 'Global economic analysis of the transfer market (2015-2024)', CIES Football Observatory Monthly Report, no. 97. Available at: <https://football-observatory.com/IMG/pdf/mr97en.pdf>
- Poli, R., Ravenel, L., & Besson, R. (2023). Inflation in the football players' transfer market (2013/14-2022/23). *CIES Football Observatory Monthly Report*, 82.
- Proctor, M. R., & Cantu, R. C. (2000). Head and neck injuries in young athletes. *Clinics in Sports Medicine*, 19. [https://doi.org/10.1016/S0278-5919\(05\)70233-7](https://doi.org/10.1016/S0278-5919(05)70233-7)
- Professionnel, F. L. d. F. (2025). Regulatory frameworks. Retrieved 01/08/2025 from <https://www.fff.fr> & <https://www.lfp.fr>
- Pulici, L., Certa, D., Zago, M., Volpi, P., & Esposito, F. (2023). Injury burden in professional European football (soccer): Systematic review, meta-analysis, and economic considerations. *Clinical Journal of Sport Medicine*, 33(4), 450–457. <https://doi.org/10.1097/JSM.0000000000001107>
- Radhakrishnan, A., Belkin, M., & Uhler, C. (2022). Wide and deep neural networks achieve consistency for classification. *Proceedings of the National Academy of Sciences of the United States of America*, 120.
- Räikkönen, T. & Hedman, J. (2024), 'Unlocking the power of sports: an exploration of the nexus between shared place, community competence, and sense of community',

International Journal of Sport Policy and Politics, vol. 17, no. 1, pp. 81–99.  
<https://doi.org/10.1080/19406940.2024.2396836>

- Raimondi, S., & Taioli, E. (2007). Predictors of moderate and severe injuries in Italian major leagues soccer teams: results from a cohort study. *The Journal of sports medicine and physical fitness*, 47(4), 455–461. Available at: <https://pubmed.ncbi.nlm.nih.gov/18091687/>
- Ramkumar, P. N., Tariq, M. B., Amendola, A., Andrish, J. T., Brophy, R. H., Dunn, W. R., Flanigan, D. C., Huston, L. J., Jones, M. H., Kaeding, C. C., Kattan, M. W., Marx, R. G., Matava, M. J., McCarty, E. C., Parker, R. D., Vidal, A. F., Wolcott, M. L., Wolf, B. R., Wright, R. W., & Spindler, K. P. (2019). Risk Factors for Loss to Follow-up in 3202 Patients at 2 Years After Anterior Cruciate Ligament Reconstruction: Implications for Identifying Health Disparities in the MOON Prospective Cohort Study. *Am J Sports Med*, 47(13), 3173–3180. <https://doi.org/10.1177/0363546519876925>
- Raya-González, J., Suarez-Arrones, L., Larruskain, J., & Sáez de Villarreal, E. (2018). Muscle injuries in the academy of a Spanish professional football club: A one-year prospective study. *Apunts. Medicina de l'Esport*, 53. <https://doi.org/10.1016/j.apunts.2017.12.001>
- Relvas, H., Littlewood, M., Nesti, M., Gilbourne, D. & Richardson, D. (2020), 'Organizational structures and working practices in elite European professional football clubs: understanding the relationship between youth and professional domains', *European Sport Management Quarterly*, vol. 10, no. 2, pp. 165–187. <https://doi.org/10.1080/16184740903559891>
- Rennie, D. J., Vanrenterghem, J., Littlewood, M., & Drust, B. (2016). Can the natural turf pitch be viewed as a risk factor for injury within Association Football? *Journal of Science and Medicine in Sport*, 19. <https://doi.org/10.1016/j.jsams.2015.07.009>
- Rhini, M., Hickner, R. C., Naidoo, R., & Sookan, T. (2024). The physical demands of the match according to playing positions in a South African Premier Soccer League team. *S Afr J Sports Med*, 36(1), v36i31a16752. <https://doi.org/10.17159/2078-516X/2024/v36i1a16752>
- Robles-Palazón FJ, López-Valenciano A, De Ste Croix M, Oliver JL, García-Gómez A, Sainz de Baranda P, Ayala F. (2022). Epidemiology of injuries in male and female youth football players: A systematic review and meta-analysis. *Journal of Sport and*

- Health Science. Volume 11, Issue 6, November 2022, Pages 681-695.  
<https://doi.org/10.1016/j.jshs.2021.10.002>.
- Rogers, D. L., Tanaka, M. J., Cosgarea, A. J., Ginsburg, R. D., & Dreher, G. M. (2024). How Mental Health Affects Injury Risk and Outcomes in Athletes. *Sports Health*, 16(2), 222–229. <https://doi.org/10.1177/19417381231179678>
- Rohde, M. & Breuer, C. (2017). The market for football club investors: a review of theory and empirical evidence from professional European football. *European Sport Management Quarterly*, vol. 17, no. 3, pp. 265–289. <https://doi.org/10.1080/16184742.2017.1279203>
- Rookwood, J. (2019). Access, security and diplomacy: Perceptions of soft power, nation branding and the organisational challenges facing Qatar's 2022 FIFA World Cup. *Sport, Business and Management: An International Journal*, 9(1), 26–44. <https://doi.org/10.1108/SBM-02-2018-0016>
- Ross, A. G., McKay, M. J., Pappas, E., Fortington, L., & Peek, K. (2022). Direct and indirect costs associated with injury in sub-elite football in Australia: a population study using 3 years of sport insurance records. *Journal of Science and Medicine in Sport*, 25. <https://doi.org/10.1016/j.jsams.2022.06.005>
- Sadigursky, D., Braid, J. A., De Lira, D. N. L., Machado, B. A. B., Carneiro, R. J. F., & Colavolpe, P. O. (2017). The FIFA 11+ injury prevention program for soccer players: a systematic review. *BMC Sports Sci Med Rehabil*, 9, 18. <https://doi.org/10.1186/s13102-017-0083-z>
- Salmon, M. H. (2014). *Philosophy and archaeology*. New York, London, Paris, San Diego, São Paulo, Sydney, Tokyo, Toronto: Academic Press. eBook ISBN: 9781483295770
- Salti, N., Chaaban, J., & Raad, F. (2010). Health equity in Lebanon: a microeconomic analysis. *International Journal for Equity in Health*, 9. <https://doi.org/10.1186/1475-9276-9-11>
- Saltzman, E. B., Levin, J. M., Dagher, A.-M. B., Messer, M., Kimball, R., Lohnes, J., Mandelbaum, B. R., Williams, R. J., Amendola, A., Chiampas, G., & Lau, B. C. (2023). Injury prevention strategies at the 2019 FIFA Women's World Cup display a multifactorial approach and highlight subjective wellness measurements. *Journal of ISAKOS*, 8. <https://doi.org/10.1016/j.jisako.2023.04.007>

- Sahoo, R.; Karmakar, S (2023). Investigation of electrical tree growth characteristics and partial discharge pattern analysis using deep neural network. *Electric Power Systems Research* 2023.
- Sarmiento, H., Martinho, D. V., Gouveia É, R., Afonso, J., Chmura, P., Field, A., Savedra, N. O., Oliveira, R., Praça, G., Silva, R., Barrera-Díaz, J., & Clemente, F. M. (2024). The Influence of Playing Position on Physical, Physiological, and Technical Demands in Adult Male Soccer Matches: A Systematic Scoping Review with Evidence Gap Map. *Sports Med*, 54(11), 2841–2864. <https://doi.org/10.1007/s40279-024-02088-z>
- Sauer, T., Anagnostopoulos, C., Zülch, H. & Werthmann, L. (2024), 'Creating value in football: unveiling business activities and strategies of financial investors', *Managing Sport and Leisure*, pp. 1–21. <https://doi.org/10.1080/23750472.2024.2314568>
- Schwarz, E., Duffield, R., Lu, D., Fullagar, H., aus der Fünten, K., Skorski, S., Tröß, T., Hadji, A., & Meyer, T. (2025). Associations between injury occurrence and environmental temperatures in the Australian and German professional football leagues. *Environmental Epidemiology*, 9(1).
- Sedeaud, A., De Larochelambert, Q., Moussa, I., Brasse, D., Berrou, J.-M., Duncombe, S., Antero, J., Orhant, E., Carling, C., & Toussaint, J.-F. (2020). Does an Optimal Relationship Between Injury Risk and Workload Represented by the “Sweet Spot” Really Exist? An Example From Elite French Soccer Players and Pentathletes. *Frontiers in Physiology*, 11. <https://doi.org/10.3389/fphys.2020.01034>
- Segreti, A., Celeski, M., Guerra, E., Crispino, S. P., Vespasiano, F., Buzzelli, L., Fossati, C., Papalia, R., Pigozzi, F., & Grigioni, F. (2024). Effects of Environmental Conditions on Athlete's Cardiovascular System. *Journal of Clinical Medicine*, 13(16), 4961.
- Seshadri, D. R., Thom, M. L., Harlow, E. R., Drummond, C. K., & Voos, J. E. (2021). Case report: return to sport following the COVID-19 lockdown and its impact on injury rates in the German soccer league. *Frontiers in Sports and Active Living*, 3, 604226. <https://doi.org/10.3389/fspor.2021.604226>
- Sever, O., Çiğerci, E., Öztop, M., İpekoğlu, G., Gönülateş, S., Akyildiz, Z., & Nobari, H. (2023). How does the increase in foreign players affect football? *BMC Sports Science, Medicine and Rehabilitation*, 15. <https://doi.org/10.1186/s13102-023-00643-1>

- Shelley, C. (1996). Visual abductive reasoning in archaeology. *Philosophy of Science*, 63(2), 278-301. <https://doi.org/10.1086/289913>
- Siekmann, R. C. R. (2012). What is Sports Law? A Reassessment of Content and Terminology. In *Lex Sportiva: What is Sports Law?* (pp. 359–391). Springer. [https://doi.org/10.1007/978-90-6704-829-3\\_18](https://doi.org/10.1007/978-90-6704-829-3_18)
- Silva, M. & Filipe, J. (2013) 'The Main Portuguese SAD's Comparative Study between the Economic and Financial Viability and the Success of their Sports Clubs', *International Journal of Latest Trends in Finance and Economic Sciences*, vol. 3, no. 2, pp. 486–501. <https://doi.org/10.2047/ijltfsvol3iss2-16>
- Smpokos, E., Mourikis, C., Theos, C., & Linardakis, M. (2019). Injury prevalence and risk factors in a Greek team's professional football (soccer) players: a three consecutive seasons survey. *Res Sports Med*, 27(4), 439–451. <https://doi.org/10.1080/15438627.2018.1553779>
- Soek, J., & Siekmann, R. C. (2023). *Basic documents of international sports organisations*. Brill.
- Soligard, T., Schwellnus, M., Alonso, J. M., Bahr, R., Clarsen, B., Dijkstra, H. P., Gabbett, T., Gleeson, M., Hagglund, M., Hutchinson, M. R., Janse van Rensburg, C., Khan, K. M., Meeusen, R., Orchard, J. W., Pluim, B. M., Raftery, M., Budgett, R., & Engebretsen, L. (2016). How much is too much? (Part 1) International Olympic Committee consensus statement on load in sport and risk of injury. *Br J Sports Med*, 50(17), 1030–1041. <https://doi.org/10.1136/bjsports-2016-096581>
- Song, J., Choe, K., Neary, M., Zifchock, R. A., Cameron, K. L., Tropa, M., Hannan, M. T., & Hillstrom, H. (2018). Comprehensive biomechanical characterization of feet in USMA cadets: Comparison across race, gender, arch flexibility, and foot types. *Gait Posture*, 60, 175–180. <https://doi.org/10.1016/j.gaitpost.2017.12.001>
- Sonnier, J. H., Coladonato, C., Khan, I. A., Connors, G., Paul, R. W., Hall, A. T., Johnson, E. E., Bishop, M. E., Tjoumakaris, F. P., & Freedman, K. B. (2024). Rates of Reporting and Analyzing Race and Ethnicity in Athlete-Specific Sports Medicine Research: A Systematic Review. *Orthopaedic journal of sports medicine*, 12(10), 23259671241261679. <https://doi.org/10.1177/23259671241261679>
- Sousa, D. & Maguire, K. (2022) 'Towards the Development of an Innovative Sustainable Sports Tourism Management Framework for Portugal', *International Conference on Tourism Research*, vol. 15, no. 1, pp. 593–596. <https://doi.org/10.34190/ictr.15.1.375>

- Spain. (1985). Royal Decree 1006/1985, of June 26, regulating the special employment relationship of professional athletes. *Boletín Oficial del Estado*, No. 160, 5 July 1985, pp. 20638–20640. Available at: <https://www.boe.es/eli/es/rd/1985/06/26/1006/com>
- SRIJ - Serviço de Regulação e Inspeção de Jogos. (2024). Online betting statistics – 2nd Quarter of 2024 [PDF]. Turismo de Portugal. Available at: [https://www.srij.turismodeportugal.pt/sites/default/files/2024-08/estatisticas\\_online\\_2t\\_2024.pdf](https://www.srij.turismodeportugal.pt/sites/default/files/2024-08/estatisticas_online_2t_2024.pdf)
- Stolowy, H. & Wu, H. (2025) 'The recognition of football players in the balance sheet', HEC Paris Research Paper No. ACC-2025-1562. Available at: <http://dx.doi.org/10.2139/ssrn.5221994>
- Stuart, M. J., Morrey, M. A., Smith, A. M., Meis, J. K., & Ortiguera, C. J. (2002). Injuries in Youth Football: A Prospective Observational Cohort Analysis Among Players Aged 9 to 13 Years. *Mayo Clinic Proceedings*, 77. <https://doi.org/10.4065/77.4.317>
- Suarez-Arrones, L., De Alba, B., Röhl, M., Torreno, I., Strütt, S., Freyler, K., & Ritzmann, R. (2020). Player Monitoring in Professional Soccer: Spikes in Acute: Chronic Workload Are Dissociated From Injury Occurrence. *Frontiers in Sports and Active Living*, 2. <https://doi.org/10.3389/fspor.2020.00075>
- Sutskever, I., Martens, J., Dahl, G., & Hinton, G. (2013). On the importance of initialization and momentum in deep learning. *International conference on machine learning*,
- Svensson, K., Alricsson, M., Karneback, G., Magounakis, T., & Werner, S. (2016). Muscle injuries of the lower extremity: a comparison between young and old male elite soccer players. *Knee Surg Sports Traumatol Arthrosc*, 24(7), 2293–2299. <https://doi.org/10.1007/s00167-015-3527-6>
- Tabben, M., Eirale, C., Singh, G., Al-Kuwari, A., Ekstrand, J., Chalabi, H., Bahr, R., & Chamari, K. (2022). Injury and illness epidemiology in professional Asian football: lower general incidence and burden but higher ACL and hamstring injury burden compared with Europe. *Br J Sports Med*, 56(1), 18–23. <https://doi.org/10.1136/bjsports-2020-102945>
- Taylor, L., & Rollo, I. (2014). Impact of Altitude and Heat on Football Performance. Gatorade Sport Science Institute (GSSI) Sport Science Exchange (SSE).
- Teixeira, E., Silva, C., Romero, F., Costa, J. P., & Vicente, A. (2024). The Quality of Life of Former Portuguese Football Players. *Sports*, 12(8), 200. <https://doi.org/10.3390/sports12080200>

- Teixeira, E., Silva, C., Romero, F., Miguel, M., & Vicente, A. (2025). Severe Injuries of Former Portuguese Football Players: A Post-Career Burden? *Sports*, 13(1), 17. <https://doi.org/10.3390/sports13010017>
- Toma, S.-G., & Catana, S. (2021). The value of brand in the football industry. *Annals-Economy Series*, Constantin Brancusi University, Faculty of Economics, 1, 27–31.
- Toohey, L. A., Antcliff, A., Drew, M. K., Wells, F., Saunders, N., Piromalli, L. E., West, S., White, S., & Fox, A. S. (2022). Epidemiology of injuries sustained in professional Australian netball: A three season cohort study. *Journal of Science and Medicine in Sport*, 25. <https://doi.org/10.1016/j.jsams.2021.12.004>
- Torvaldsson, K., Lindblom, H., Sonesson, S., Senorski, E. H., Stigson, H., Tamm, L., Sandberg, J., & Hägglund, M. (2023). Swedish Olympic athletes report one injury insurance claim every second year: a 22-year insurance registry-based cohort study. *Knee Surgery, Sports Traumatology, Arthroscopy*, 31(10), 4607–4617. <https://doi.org/https://doi.org/10.1007/s00167-023-07511-y>
- Tranaeus, U., Gledhill, A., Johnson, U., Podlog, L., Wadey, R., Wiese Bjornstal, D., & Ivarsson, A. (2024). 50 Years of Research on the Psychology of Sport Injury: A Consensus Statement. *Sports Med*, 54(7), 1733–1748. <https://doi.org/10.1007/s40279-024-02045-w>
- Transfermarkt (n.d.) Sporting Lissabon transfers. Available at: <https://www.transfermarkt.pt/sporting-lissabon/allemtransfers/verein/336>
- Trojjan, T. H., & Collins, S. (2006). The anterior cruciate ligament tear rate varies by race in professional Women's basketball. *Am J Sports Med*, 34(6), 895–898. <https://doi.org/10.1177/0363546505284384>
- Tuakli-Wosornu, Y. A., & Kirby, S. L. (2022). Safeguarding Reimagined: Centering Athletes' Rights and Repositioning Para Sport to Chart a New Path. *Frontiers in Psychology*, 13. <https://doi.org/10.3389/fpsyg.2022.815038>
- Turnbull, M. R., Gallo, T. F., Carter, H. E., Drew, M., Toohey, L. A., & Waddington, G. (2024). Estimating the cost of sports injuries: A scoping review. *Journal of Science and Medicine in Sport*, 27. <https://doi.org/10.1016/j.jsams.2024.03.001>
- van Beijsterveldt, A. M. C., Stubbe, J. H., Schmikli, S. L., van de Port, I. G. L., & Backx, F. J. G. (2015). Differences in injury risk and characteristics between Dutch amateur and professional soccer players. *Journal of Science and Medicine in Sport*, 18. <https://doi.org/10.1016/j.jsams.2014.02.004>

- Van der Burg, T. (2024) 'Why transfer fee systems improve market competition, and why the Bosman ruling was flawed', *International Sports Law Journal*, vol. 24, pp. 177–187. <https://doi.org/10.1007/s40318-024-00271-y>
- van Hooff, M., Colenbrander, F. F. C., Bender, M. H. M., Loos, M. M. J. A., Brini, A., Savelberg, H. H. H. C. M., Scheltinga, M. R., & Schep, G. (2023). Short- and long-term outcomes after endarterectomy with autologous patching in endurance athletes with iliac artery endofibrosis. *Journal of Vascular Surgery*, 78. <https://doi.org/10.1016/j.jvs.2023.03.501>
- Vasilakis, C. (2017). Does talent migration increase inequality? A quantitative assessment in football labour market. *Journal of Economic Dynamics and Control*, 85. <https://doi.org/10.1016/j.jedc.2017.10.003>
- Velema, T. (2019) 'Upward and downward job mobility and player market values in contemporary European professional football', *Sport Management Review*, vol. 22. <https://doi.org/10.1016/j.smr.2018.02.004>
- Velema, T. (2025) *Football Clubs and the Global Transfer Market*, Routledge. <https://doi.org/10.4324/9781003452881>
- Verwaltungs-Berufsgenossenschaft. (2023). *Satzung der Verwaltungs-Berufsgenossenschaft*. Retrieved 01/08/2025. Available at: <https://www.vbg.de>
- Video Games Europe. (2023). *Understanding the value of a European video games society* [Report]. Interactive Software Federation of Europe (ISFE). Available at: <https://www.europacreativa-media.it/documenti/allegati/2023/understanding-the-value-of-a-european-video-games-society.pdf>
- Vidoni, A., Gillett, M., Botchu, R., & James, S. (2018). Lower limb muscle injuries: The good, the bad and the ugly. *European Journal of Radiology*, 104. <https://doi.org/10.1016/j.ejrad.2018.05.008>
- Waldén, M., Hägglund, M., Magnusson, H., & Ekstrand, J. (2016). ACL injuries in men's professional football: a 15-year prospective study on time trends and return-to-play rates reveals only 65% of players still play at the top level 3 years after ACL rupture. *British journal of sports medicine*, 50(12), 744–750.
- Weatherill, S. (2014). *European Sports Law*. Springer Science & Business Media. <https://doi.org/10.1007/978-90-6704-939-9>
- Weatherill, S. (2017). *Principles and practice in EU sports law*. Oxford University Press.

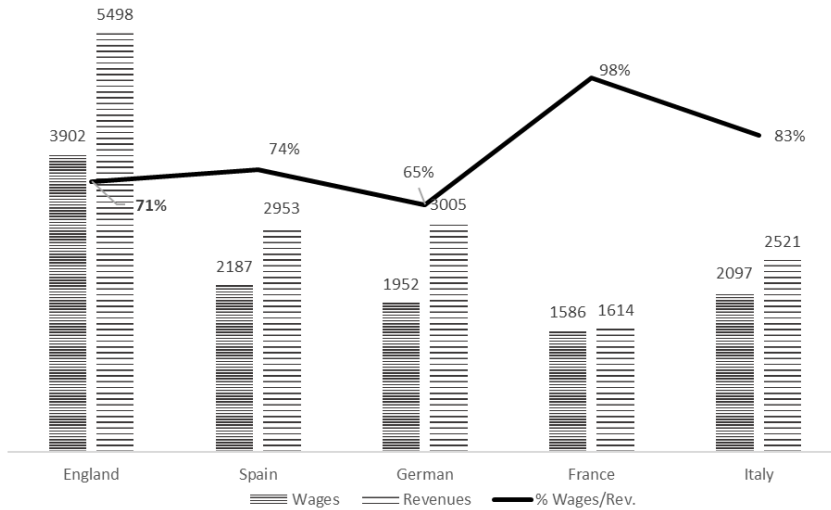
- Weber, A. E., Bolia, I. K., Korber, S., Mayfield, C. K., Lindsay, A., Rosen, J., McMannes, S., Romano, R., Tibone, J. E., & Gamradt, S. C. (2021). Five-Year Surveillance of Vitamin D Levels in NCAA Division I Football Players: Risk Factors for Failed Supplementation. *Orthop J Sports Med*, 9(1), 2325967120975100. <https://doi.org/10.1177/2325967120975100>
- Wik, E. H., Lolli, L., Chamari, K., Materne, O., Di Salvo, V., Gregson, W., & Bahr, R. (2021). Injury patterns differ with age in male youth football: a four-season prospective study of 1111 time-loss injuries in an elite national academy. *British journal of sports medicine*, 55(14), 794. <https://doi.org/10.1136/bjsports-2020-103430>
- Wilke, C. F., Coimbra, C. C., Drummond, F. R., Drummond, L. R., Campos, H. O., Kanope, T., & Ramos, G. P. (2023). Differences between 48 and 72-hour intervals on match load and subsequent recovery: a report from the Brazilian under-20 national football team. *Frontiers in Sports and Active Living*, 5. <https://doi.org/10.3389/fspor.2023.1164454>
- Wills, G., Tacon, R., & Addesa, F. (2022). Uncertainty of outcome, team quality or star players? What drives TV audience demand for UEFA Champions League football? *European Sport Management Quarterly*, 22(6), 876–894. <https://doi.org/10.1080/16184742.2020.1836010>
- Wilson, A. G., & Izmailov, P. (2020). Bayesian deep learning and a probabilistic perspective of generalization. *Advances in neural information processing systems*, 33, 4697–4708.
- Windt, J., Ekstrand, J., Khan, K. M., McCall, A., & Zumbo, B. D. (2018). Does player unavailability affect football teams' match physical outputs? A two-season study of the UEFA champions league. *Journal of Science and Medicine in Sport*, 21. <https://doi.org/10.1016/j.jsams.2017.08.007>
- Windt, J., Gabbett, T. J., Ferris, D., & Khan, K. M. (2017). Training load--injury paradox: is greater preseason participation associated with lower in-season injury risk in elite rugby league players? *Br J Sports Med*, 51(8), 645–650. <https://doi.org/10.1136/bjsports-2016-095973>
- Yiapanas, G. (2025). A Europe-wide panorama of football club finances: Revenue trends, expenditure patterns and regional disparities. *Sustainable Economies*, 3(2). <https://doi.org/10.62617/se2025>
- Yiapanas, G., Thrassou, A., & Vrontis, D. (2024). The contemporary football industry: a value-based analysis of social, business structural and organisational

- stakeholders. *Accounting, Auditing & Accountability Journal*, 37(2), 552–585.  
<https://doi.org/10.1108/AAAJ-06-2022-5855>
- Yoon, Y. S., Chai, M., & Shin, D. W. (2004). Football injuries at Asian tournaments. *Am J Sports Med*, 32(1 Suppl), 36s–42s. <https://doi.org/10.1177/0095399703258781>
- Zech, A., & Wellmann, K. (2017). Perceptions of football players regarding injury risk factors and prevention strategies. *PLoS ONE*, 12. <https://doi.org/10.1371/journal.pone.0176829>
- Zengin, A., Pye, S. R., Cook, M. J., Adams, J. E., Wu, F. C., O'Neill, T. W., & Ward, K. A. (2016). Ethnic differences in bone geometry between White, Black and South Asian men in the UK. *Bone*, 91, 180–185. <https://doi.org/10.1016/j.bone.2016.07.018>
- Zhang, C., Bengio, S., Hardt, M., Recht, B., & Vinyals, O. (2021). Understanding deep learning (still) requires rethinking generalization. *Communications of the ACM*, 64(3), 107–115.
- Zhang, Y., Wang, M., Zhao, X., Wang, M. & Wang, H. (2024), 'Unveiling the Cumulative Impact: Major Sports Events as Catalysts for the Construction of Sport City in China', *International Journal of Qualitative Methods*, vol. 23. <https://doi.org/10.1177/16094069241232348>
- Zweigert, K., Kötz, H., & Weir, J. A. (1998). *Introduction to comparative law*. Clarendon Press. Oxford.



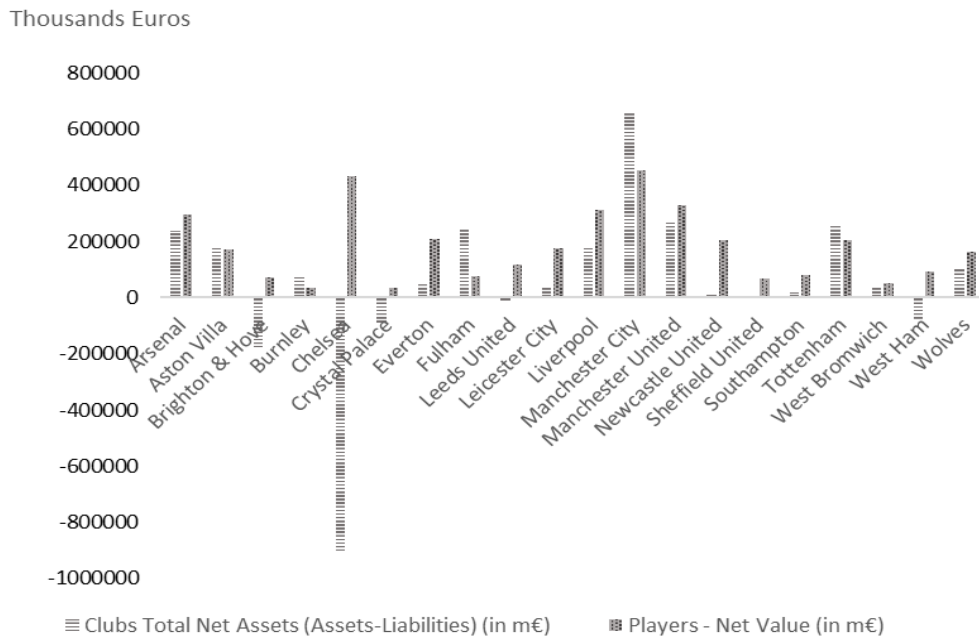
# APPENDIX:

Figure A2.1. *Weight of salaries on total revenues of the 5 main professional European leagues (million euro), during the 2020/21 season.*



Source: Author's own elaboration based on data from Deloitte Annual Review of Football Finance (Deloitte, 2023).

Figure A2.2. *Value of the total net assets vs players net value in the end of the 2020/21 season*



Source: Author's own elaboration based on data from Deloitte Annual Review of Football Finance (Deloitte, 2023).

Table A3.1. Sample description for 30 runs (values are the arithmetic means).

Sample Description		N (mean)	Per cent (mean)
Sample	Training	828	50.52%
	Testing	779	47.53%
Valid		1607	98.05%
Excluded		22	1.34%
Total		1639	100%

Table A3.2. Empirical analysis of the DNN classification performance.

		Predicted						
		Class	1	2	3	4	5	Per cent Correct
Training	1	0	5.2	15.8	2	0	0%	
	2	0	9.8	38.2	1.8	0.4	20%	
	3	0	3.4	213	27.4	4.4	86%	
	4	0	0	19	342.4	14.8	91%	
	5	0	0	0	7.6	122.8	94%	
	<b>Overall Percent Correct</b>							83%
Testing	1	0	4.2	13	1.4	0	0%	
	2	0	5.6	44.4	4.8	0	10%	
	3	0	8.6	170.8	37	5.8	77%	
	4	0	0.2	37.2	308.4	19.4	84%	
	5	0	0	0	10.2	108	91%	
	<b>Overall Percent Correct</b>							76%

Table A4.1. Description of the variables used

Variable	Description	Scale	Values
Season	The season during which the injury took place.	Nominal	1,2,3,4, or 5
Competitive level	1st or 2nd league	Nominal	1 = First League; 2 =Second League
Age	Age of the player at the start of the season	Ratio	
Ethnicity	Player origin	Nominal	1 = Europe 2 = Southern Europe 3 = Africa 4 = North Africa 5 = America 6 = South America 7 = Middle East 8 = Asia
Number of Injuries	The number of injuries during the season.	Ratio	
Days of recovery	Time spent in injury recovery – number of days	Ratio	
Injury severity	The degree of severity of the last injury sustained by the player – Transformation of the variable Days of recovery'	Ordinal	1 = Minimal (1–3 days) 2 = Minor (4–7 days) 3 = Moderate (8–28 days) 4 = Major (28- 120 days) 5 = Severe (= > 120 days)
Player Participation Tier	Player participation rank - Matches played (in %)	Ordinal	A = play in more than 80% of matches B = play between 50% and 79% matches C = play between 21% and 49% matches D = play in less than 20% of matches
Tactical-Position	Position of the player on the field during the season	Nominal	1 = Midfielder 2 = Defensive Midfielder 3 = Full-back 4 = Defender 5 = Winger 6 = Forward 7 = Second Striker/Supporting Forward 8 = Goalkeeper
GDMF	Tactical-Position in the field	Nominal	G = Goalkeeper D = Defender M = Midfielder F = Forwards
LCR	Tactical-Position in the field	Nominal	L = Left C = Centre R = Right

