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Systematic Review

Injury Prevention Programmes in Male Soccer Players: An Umbrella Review of Systematic Reviews

Joel Barrera[1,*], Antonio J. Figueiredo[1], Filipe Manuel Clemente[2,3], Adam Field[4], Luis Valenzuela[6], Hugo Sarmento[1]

[1]University of Coimbra, Research Unit for Sport and Physical Activity, Faculty of Sport Sciences and Physical Education, Santa Clara, 3040-256 Coimbra, Portugal
[2]Escola Superior Desporto e Lazer, Instituto Politécnico de Viana do Castelo, Rua Escola Industrial e Comercial de Nun'Álvares, 4900-347 Viana do Castelo, Portugal
[3]Instituto de Telecomunicações, Delegação da Covilhã, 1049-001 Lisboa, Portugal
[4]Research Centre for Musculoskeletal Science and Sports Medicine, Department of Sport and Exercise Science, Manchester Metropolitan University, M1 7EL Manchester, UK
[5]Escuela de Educación en Ciencias del Movimiento y Deportes, Universidad Católica Silva Henríquez, 8320000 Santiago, Chile
*Correspondence: jibarrera@outlook.es (Joel Barrera)
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Abstract

Background: The incidence of lower-extremity injuries in soccer is high, with effective injury prevention programmes shown to reduce injury rates. Over the past decades, an exponential growth has occurred in the number of scientific publications including review articles on injury prevention programmes in male soccer. Accordingly, it is timely to summarise findings from potential systematic reviews and meta-analyses in the form of an umbrella review. **Objective**: This umbrella review was conducted to review, synthesise and appraise the findings of the published systematic reviews and meta-analyses that investigated the effects of injury prevention programs in male soccer players. **Methods**: Following pre-registration on the International Platform of Registered Systematic Review and Meta-analysis Protocols (https://inplasy.com/inplasy-2021-9-0066/) and according to PRISMA guidelines, a search of databases (Web of Science, Scopus, SPORTDiscus and PubMed) was conducted for studies published before June 2021. Studies were eligible if they included male (amateur to professional) soccer players, included studies that incorporated injury prevention programs with a control and intervention group(s), and adopted the form of a systematic review (with or without a meta-analysis). The methodological quality of the evidence was assessed using the AMSTAR 2 tool. **Results**: Eight systematic reviews (no meta-analyses) were included in the umbrella review. The review articles retained for analyses primarily focused on the prevention of injuries in the lower limbs, with primary focus on the hamstrings. Prevention programs principally incorporating strengthening, proprioception and multi-component protocols (balance, core stability, functional strength and mobility) revealed positive effects on injury incidence and severity. Implementing eccentric hamstring protocols demonstrated efficacy in decreasing hamstring injury and proprioception exercises reduced the risk of ankle sprains. It was also revealed that dynamic warm-ups were effective in reducing incidence, but not severity of injuries. Conversely, the evidence from the current umbrella review suggests that programs focusing on static stretching showed inconclusive injury preventative effects. Articles were of mixed methodological quality with one demonstrating high quality, two indicating low quality and five were of critically low quality. **Conclusions**: The systematic reviews in this area suggests that prevention programs developing muscle strength and proprioception are effective in reducing the incidence and severity of injury (time out). Dynamic movements performed before a match are effective in reducing injury incidence, whilst the effects of warm-ups incorporating static stretching are unclear. Future original studies on this topic with improved methodological quality and consistency among experimental study designs should be conducted to evaluate the benefits of different programs over longer periods in male soccer players.

Keywords: football; effectiveness; methodological quality; synthesis

1. Introduction

Soccer is a physically demanding sport, in which players compete in a large number of matches in a season, with limited recovery time separating each match [1]. In view of the challenge of contemporary fixture congested match scheduling [2], injury incidence has increased in professional soccer over recent years [3]. Injuries have great financial implications for professional clubs, with each player lost due to injury costing approximately €20,000 per day for elite clubs europeans [4], and availability correlating with team success [5]. Since injury propensity in soccer is high [6], costly [7] and impacts success [8], several strategies to reduce injury occurrence have been developed to address this concern. These include, but are not limited to, warm-up and cool down strategies [9], the warm-ups can include running in different directions, arm swings, skipping, trunk rotation, jumps and counter jumps, among others, and for an approximate period of 20 minutes [10], while cooling strategies can be by immersion in cold water [11] or

a low-intensity aerobic run as an active recovery mode [12] among others [13], the provision of protective equipment (i.e., shin pads) [14], movement screening [15] and injury prevention programs [16].

Additionally, the available systematic reviews (SR) with and without meta-analyses have showed some contradictions about the real impact of specific prevention programs: (i) Olsen *et al.* [17] pointed out that prevention strategies seem promising but lack proper evaluation in young soccer players; (ii) Rogan *et al.* [18] obtained some similar results, as no scientific evidence could be found on the effects of static stretching in preventing hamstring injuries; (iii) finally, Shadle and Cacolice [19] considered the evidence supporting the use of eccentric hamstring exercises to prevent a hamstring injury in elite adult male soccer players. However, despite some systematic reviews with meta-analyses claiming a 50% injury risk reduction with Nordic hamstring exercise (NHE) [20,21], a recent meta-analysis published by Impellizzeri *et al.* [22] noted that the evidence supporting the protective effect of NHE so far remains inconclusive and is mainly derived from randomized controlled trial (RCT) with high risk of bias.

The Federation International Football Association (FIFA) Medical and Research Centre developed the FIFA '11' prevention programme in 2003, with the '11+' later developed in 2006 [23]. These soccer-specific injury prevention protocols have also included eccentric exercises to reduce hamstring strain injuries [24,25], neuromuscular training strategies and strength, flexibility, stability and balance exercises to prevent anterior cruciate ligament injuries in male soccer players [26,27]. The 11+ consists of three parts and different levels depending on the level of the player, beginning with running exercises (part I), followed by six exercises to develop strength, balance, muscle control and core stability (part II), and ending with advanced running exercises (part III) [28]. Multifaceted protocols comprise varying exercises targeting modifiable risk factors to reduce occurrence of the most common injuries in soccer players. Preventative training programs have shown to reduce the risk of non-contact musculoskeletal injuries by 23% in professional soccer players [29], which may include, warm-up, muscle activation, balance, strength (concentric or eccentric) and core stability [30]. These preventative exercise protocols can be integrated within the applied environment by professional soccer practitioners. However, given the large number of preventative training programs and the influx of contrasting interpretations from the varying original and review articles, it may be difficult to apply such findings in the field. Therefore, an easily accessible umbrella review summarising the current state of knowledge on this topic is required.

The purpose of this umbrella review article is to provide an overview of the systematic reviews and meta-analyses that have previously been conducted on injury prevention in professional soccer players. Considering the lack of consensus on the topic of interest, this umbrella review appears warranted to compile all the available evidence, report the effectiveness of the differing prevention programs, identify heterogeneity among studies and possible gaps within the literature, and provide recommendations for future research on injury prevention programs in male soccer players.

2. Methods

The umbrella review was conducted to evaluate the systematic reviews and meta-analyses that have been undertaken on injury prevention programmes in male soccer players. Programs included specific strengthening, balance, and jumping/landing exercises [31], and can be applied before, after or before and after the specific training session in the field [21]. This umbrella review was developed and reported in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analysis) statement (http://www.prisma-statement.org) [32]. The review was pre-registered on INPLASY (International Platform of Registered Systematic Review and Meta-analysis Protocols) prior to the searches (https://inplasy.com/inplasy-2021-9-0066/).

2.1 Eligibility Criteria

The eligibility criteria for this umbrella review are presented in Table 1. To be in included within the current review, articles were required to meet the following criteria: (1) included professional, semi-professional, university level or amateur male soccer players, (2) contained injury prevention programs, (3) incorporated both a control and intervention group(s), and (4) took the form of a systematic review (with or without a meta-analysis). Studies were omitted if they violated the following criteria: (1) articles are excluded if they were about female soccer players, (2) incorporated training programmes that did not target injury prevention, (3) did not implement a control group, (4) failed to include relevant data on injury prevention, and (5) were original studies, narrative reviews, conference proceedings or book chapters.

2.2 Search Strategy

The searches were carried out independently by two researchers (JB and HS) using the Web of Science (all data bases), Scopus, SPORTDiscus, and PubMed. All searches were conducted in June 2021, with the following search terms used: ((Soccer OR football) AND (Injur* OR "Injur* prevention" OR "Injur* characteristics" OR "Injur* prediction" OR "Injur* reduction" OR "game Injur*" OR "training Injur*" OR "prevention strategies" OR "muscle injur*" OR "joint injur*" OR "contusion injur*" OR "Anterior cruciate ligament" OR ACL) AND ("Systematic Review" OR "Meta-analysis")). The search strategy for each database is presented in **Supplementary Table 1**. Reference lists of the retained studies were also evaluated for any additional

Table 1. Inclusion and exclusion criteria.

	Inclusion	Exclusion
Population	Male professional football players	Female footballers
Intervention	Injury prevention programme	Incorporated other topics in their intervention programmes
Comparator	Programmes with control group and intervention group	Studies without a control group
Outcomes	Number of injuries	Does not include relevant data on injury prevention
Study design	Only systematic review with or without a meta-analysis	Studies that are not systematic reviews or meta-analyses

articles that fulfilled the selection criteria. Additionally, relevant studies that were previously known to the authors but not found during the searches were also incorporated in the umbrella review.

2.3 Data Extraction

For data extraction, a Microsoft Excel sheet 365 for business (Microsoft Corporation, Readmon, WA, USA) was prepared in accordance with the data extraction template of the Cochrane Consumers and Communication Review Group [33]. The Excel spreadsheet was used to evaluate the inclusion requirements. Articles were screened initially by titles, then abstracts and finally full texts were examined for their relevance. The full-text articles that were excluded were also recorded, along with the reason for non-inclusion. The process was carried out independently by two of the authors (JB and HS). A third author (FMC) helped resolve article eligibility if disagreements ensued between the first two authors. For each eligible review article, the following items were extracted: citation details, research purpose, type of analysis, matching background, personal and environmental limitations, and main results.

2.4 Risk of Bias Assessment of Studies

The overall reliability of the results from the eligible articles proposed by the AMSTAR-2 tool was defined as: (1) high — no, or a non-critical weakness: the systematic review provides an accurate and complete summary of the results, (2) moderate — more than one non-critical weakness but no critical flaws: the systematic review provides an accurate summary of the results, (3) low — a critical flaw, with or without non-critical weaknesses: the systematic review may not provide an accurate and complete summary of the results, (4) critically low — more than one critical flaw, with or without non-critical weaknesses: the systematic review should not be relied upon to provide an accurate and complete summary of the results [34].

2.5 Data Elements

The following information was extracted from the eligible studies: (1) number of articles included (n), age group (children, youth or adults), sex (males), competitive level (if available), design (systematic review and/or meta-analysis) and type of original articles included (experimental, observational, analytical or multiple designs); (2) identification of effectiveness, anatomical region targeted by the prevention program (trunk, groin, hamstrings, knee and/or ankle), results and main findings.

2.6 Assessment of Methodological Quality

The assessment of the methodological quality of systematic reviews (AMSTAR-2) tool was used to assess the methodological quality of the eligible studies included in this umbrella review [34]. The evaluation of eligible articles was carried out by two investigators (JB and HS) separately. If ambiguity around methodological quality occurred, then constructive debate ensued with a third author (FMC) until a consensus was reached.

3. Results

3.1 Identification and Selection of Studies

The searches yielded a total of 1252 titles. The studies were exported to reference management software (EndNote™ X9, Clarivate Analytics, Filadelfia, PA, EE. UU.). Duplicates were omitted automatically or manually (176 references). The remaining 1034 articles were reviewed for their relevance based on titles and abstracts, leading to the elimination of 1003 studies. Following this trimming, 31 articles were selected for in-depth reading and analysis. After reading the full texts, 22 were excluded for failing to align with the selection criteria and one article was removed for not being written in English (Fig. 1). Of the 8 articles included in this umbrella review, all were systematic reviews, with 7 of 8 articles (86%) being published between 2015 and 2021, and one article published in 2004 (16 years ago). This demonstrates a recent and growth in this area of research.

3.2 Characteristics of the Study and Qualitative Synthesis

The characteristics of the eight eligible articles included in the umbrella review can be found in Table 2 (Ref. [3,17–19,35–38]). The summary of the main evidence found in each review article is outlined in Table 3 (Ref. [3,17–19,35–38]). There were 60 articles included in the eight systematic reviews, with 20 being repeated, two of which included female soccer players [39,40], two focused on injury prediction [41,42], one with a mixed sample [43], three systematic reviews, of which one was already within this review [18], another was mixed [44] and the last jointly involved risk factors, detection and prevention tests with articles that were already included in the other reviews [45], five of optimisation [46–50], one developed in Australian soccer [51] and one not available [52]. In total, 25 articles

Table 2. Summary of the eligible articles' characteristics included in the umbrella review.

Reference	Type of Review (SR, SRMA)	Original studies included (N)	Type of included studies (RCT, NRCT, QS, RD, CD)	Systematic review topic	Analysis of injury prevention programs					Types of programs used					Outcome		Risk of bias		
					Injury Prevention (Hamstrings)	Injury prevention (ACL tear)	Injury prevention (knee)	Injury prevention (ankle)	Injury prevention (Groin)	LL general	Strengthening	Mobility - flexibility	Propioception	Multi-component training/11+	Reduces the number of injuries	Little enlightening	High	Half	Low
Olsen *et al.* [17]	SR	4	1 RCT 1 NCG 1 TS	Prevention of injuries in general		x				x	x		x	x	x		N/A	N/A	N/A
Rogan *et al.* [18]	SR	4	1 RD 1 QS 1 NRCT	Static Stretching of the Hamstring Muscle for Injury Prevention	x					x		x			x	x	x		
Cruz-Ferreira *et al.* [35]	SR	5	4 RCT 1 NRCT	Prevention of injuries in general	x		x	x	x	x	x	x		x	x	x	N/A	N/A	N/A
Porter and Rushton *et al.* [36]	SR	8	8 RCT	Various Hamstring Injury Prevention Topics	x		x	x	x	x	x	x	x	x	x	x	x		
Shadle and Cacolice [19]	SR	3	2 RCT 1 NRCT	Hamstring Strains	x						x				x		N/A	N/A	N/A
Fanchini *et al.* [37]	SR	15	4 RCT 5 NRCT	Various Hamstring Injury Prevention Topics	x		x	x	x	x	x	x	x	x	x	x	x		
Pérez-Gómez *et al.* [3]	SR	11	7 RCT 2 NRCT 2 CD	Various Hamstring Injury Prevention Topics	x	x		x	x	x	x	x	x	x	x		N/A	N/A	N/A
Rosado-Portillo *et al.* [38]	SR	10	4 RCT	Hamstring Strains	x					x	x		x	x	x		N/A	N/A	N/A

SR, systematic review; SRMA, systematic review with meta-analysis; N/A, not applicable; RCT, Randomized controlled trial; NRCT, non-randomized-controlled trials; NCG, Nonequivalent control group; TS, Time series; RD, Retrospective design; QS, Qualitative study; CD, Cohort design; NHE, Nordic Hamstrings Exercise; FIFA, Fédération International de Football Association; NWP, New Warm-up Program; BEP, Bounding Exercise Program; ACL, Anterior cruciate ligament; LL, Lower limb.

Table 3. Summary of the main findings published in the eligible articles included in the umbrella review.

Reference	Type of study (SR - SRMA)	Included studies	Type of included studies (RCT, NRCT, TS, QS, RD, CD, ED)	Objectives of the studies	Age	Level	Instruments used to assess variables	Results	Conclusions
Olsen *et al*. [17]	SR	4	1. RCT (49) 2. NCG (68) 3. TS (69)	Examine the evidence on the effectiveness of current soccer injury prevention strategies, determine the applicability of the evidence to children and youth, and make recommendations on policy, programming, and future research.	1. 17 to 38 2. N/A. 3. N/A.	1. Community soccer league 2. Semi-professional and amateur teams 3. College soccer team	1. Injury history and persistent symptoms of past injuries, and by the stability of the knee and ankle joints. Lower limb strength and range of motion test 2. a careful clinical examination, KT-1000 measurement, standard X-ray, magnetic resonance imaging (MRI), or computed tomography (CT)-scan. 3. Recorded.	A total of 44 potentially relevant articles from electronic (n = 37) and hand (n = 7) searches yielded four that met inclusion criteria. Some of the strategies look promising but lack adequate evaluation or require further research among younger players.	There is a serious lack of prevention research targeting soccer players.
Rogan *et al*. [18]	SR	4	1. NRCT (24) 2. RD (71) 3. QS (70)	The aim of this review is to determine if static stretching reduces hamstring injuries in soccer codes.	1. N/A 2. 18.6 ± 1.5 3. N/A	1. Professional 2. Professional 3. University	1. Continuous injury registration protocol during the study period. 2. The clinical evaluation of a single certified athletic trainer. 3. Questionnaire.	35 studies were selected. Thirty-one articles were excluded after the review and 4 met the eligibility criteria and were analyzed. Studies with low qualitative and quantitative characteristics. The effects of static stretching in preventing hamstring injuries cannot be determined.	Study protocols vary in terms of duration of intervention and follow-up. No RCT studies are available, however RCT studies should be conducted in the near future.
Cruz-Ferreira *et al*. [35]	SR	5	1. RCT (50) 2. NRCT (24) 3. RCT (51) 4. RCT (25) 5. RCT (52)	To know the scientific evidence on the effectiveness of exercise programs in the prevention of hamstring injuries in male soccer players.	1. 25.0 ± 2.9 2. N/A 3. N/A 4. 23.3 ± 4.0 5. 24.8 ± 4.2	1. Professional 2. Professional 3. Professional 4. Professional and amateur 5. Amateur	1. The coaches, physical therapists and physicians register and report all hamstring injuries. 2. Continuous injury registration protocol during the study period). 3. The injury reports from each physiotherapist. 4. Ultrasound examination. 5. Questionnaire plus reported weekly by coaches.	The review identified 1920 studies. 1892 excluded. There were 23 studies considered potentially included of which 5 met the eligibility criteria. and that they were analyzed.	Heterogeneity of the duration and frequency of the exercise program; Small number of experimental studies with a control group carried out in male soccer players; Lack of follow-up study designs. More studies of high methodological quality should be conducted.

Table 3. Continued.

Reference	Type of study (SR - SRMA)	Included studies	Type of included studies (RCT, NRCT, TS, QS, RD, CD, ED)	Objectives of the studies	Age	Level	Instruments used to assess variables	Results	Conclusions
Porter & Rushton [36]	SR	8	1. RCT (50) 2. RCT (51) 3. RCT (53) 4. RCT (54) 5. RCT (25) 6. RCT (55) 7. RCT (52)	To carry out a systematic review to evaluate the efficacy of exercise in the prevention of injuries in adult male soccer.	1. 25.0 ± 2.9 2. N/A 3. N/A 4. 24.6 ± 2.6 5. 23.3 ± 4.0 6. N/A 7. 24.8 ± 4.2	1. Professional 2. Professional 3. Professional 5. Professional 6. Professional and amateur 7. Semi-professional 8. Amateur	1. The coaches, physical therapists and physicians register and report all hamstring injuries. 2. The injury reports from each physiotherapist. 3. N/A 4. The injury diagnosis was made within 1 hour of the injury event by 1 of the medical practitioners 5. Ultrasound examination 6. Coach reported every ankle injury. 7. Questionnaire plus reported weekly by coaches.	Eight trials (n = 3355) from five countries met the inclusion criteria. Two trials reported statistically significant reductions in hamstring injuries with eccentric exercise and two reported statistically significant reductions in recurrent ankle sprains with proprioceptive exercise. Four trials showed no statistically significant difference in injury incidence with exercise interventions targeting a variety of injuries.	Limitations in the context of study quality and heterogeneity resulted in the inability to reach a clear conclusion regarding the efficacy of exercise for injury prevention in adult male soccer.
Shadle and Cacolice [19]	SR	3	1. RCT (50) 2. RCT (25) 3. NRCT (24)	To determine the effect of eccentric exercises in preventing hamstring strain in adult male soccer players.	1. 25.0 ± 2.9 2. 23.3 ± 4.0 3. N/A	1. Professional 2. Professional and amateur 3. Professional	1. The coaches, physical therapists and physicians register and report all hamstring injuries. 2. Ultrasound examination. 3. Continuous injury registration protocol during the study period.	3 articles met the inclusion criteria. Two were randomized controlled trials and one was a cohort study. There is strong evidence to support the implementation of eccentric hamstring exercises to prevent injury in elite adult male soccer players.	There is strong supporting evidence that eccentric hamstring exercises can prevent a hamstring injury in an elite adult male soccer player.
Fanchini *et al.* [37]	SR	15	1. RCT (50) 2. RCT (56) 3. RCT (51) 4. RCT (57) 5. NRCT (24) 6. NRCT (62) 7. NRCT (63) 8. NRCT (64) 9. NRCT (65)	To assess the effectiveness of exercise-based muscle injury prevention strategies in elite soccer for adults.	1. 25.0 ± 2.9 2. 17 ± 1 3. N/A 4. 22 to 24 5. N/A 6. N/A 7. 28.6 ± 3 8. 21 to 35 9. 26.1 ± 4.5	1. Professional 2. Youth soccer 3. Professional 4. Professional 5. Professional 6. Professional 7. Professional 8. Professional 9. Professional	1. The coaches, physical therapists and physicians register and report all hamstring injuries. 2. Medical team registration. 3. The injury reports from each physiotherapist. 4. The OSTRC Overuse Injury. Questionnaire. 5. Continuous injury registration protocol during the study period. 6. Clinical diagnosis and magnetic resonance imaging (MRI). 7. N/A 8. Clinical diagnosis and magnetic resonance imaging (MRI). 9. The Australian football association injury form was used to collect incidence of injuries).	15 studies. Three systematic reviews showed inconsistent results, one supporting (high risk of bias) and two showing insufficient evidence (low risk of bias) to support exercise-based strategies to prevent muscle injury in elite players. Five RCTs and seven NRCTs support eccentric exercise, proprioception exercises, and a multidimensional component of an injury prevention program; however, all were at high/critical risk of bias. Only one RCT was found to be at low risk of bias and supported eccentric exercise to prevent groin problems.	Limited scientific evidence to support exercise-based strategies to prevent muscle injury in elite soccer players.

Table 3. Continued.

Reference	Type of study (SR - SRMA)	Included studies	Type of included studies (RCT, NRCT, TS, QS, RD, CD, ED)	Objectives of the studies	Age	Level	Instruments used to assess variables	Results	Conclusions
Pérez-Gómez *et al*. [3]	SR	11	1. NRCT (24) 2. RCT (50) 3. CD (66) 4. RCT (57) 5. CD (67) 6. RCT (54) 7. NRCT (63) 8. RCT (25) 9. RCT (58) 10. RCT (59) 11. RCT (60)	Carry out a systematic review of published studies on injury prevention programs for adult male soccer players, identify points of common understanding and establish recommendations that should be considered in the design of injury prevention strategies.	1. N/A 2. 25.0 ± 2.9 3. 18 to 25 4. 22 to 24 5. 14 to 65 6. 24.6 ± 2.6 7. 28.6 ± 3 8. 23.3 ± 4.0 9. 18 to 25 10. 18 to 25 11. 18 to 40	1. Professional 2. Professional 3. University 4. Professional 5. Amateurs 6. Professional 7. Professional 8. Professional and amateur 9. University 10. University 11. Amateurs	1. Continuous injury registration protocol during the study period. 2. The coaches, physical therapists and physicians register and report all hamstring injuries. 3. Team doctor and imaging studies. 4. The OSTRC Overuse Injury Questionnaire. 5. Injury reports. 6. Team doctor. 7. N/A 8. Ultrasound examination. 9. Internet-based injury surveillance system (HealtheAthlete; Cerner Corporation, Overland Park, KS, USA). 10. Internet-based injury surveillance system (HealtheAthlete; Cerner Corporation, Overland Park, KS, USA). 11. Medical team registration.	2512 studies, 11 met the inclusion criteria. Injury prevention programs in soccer have focused on strength training, proprioceptive training, multi-component programs (balance, core stability, and functional strength and mobility), and warm-up programs.	Soccer players can reduce the incidence of injury in games and training sessions by participating in dynamic warm-up programs that include preventive exercises before games or during training sessions.
Rosado-Portillo *et al*. [38]	SR	10	1. RCT (61) 2. RCT (60) 3. RCT (59) 4. RCT (25)	To review the exercise programs used to prevent acute hamstring injuries in eleven-player soccer players and their effectiveness.	1. 18 to 45 2. N/A 3. 18 to 40 4. 22 ± 2.6 5. 18 to 25 6. 19 to 39 7. 23.8 ± 3.1 8. 18.9 ± 1.4 9. 18 to 21 10. 23.3 ± 4.0	1. Amateurs 2. Amateurs 3. University 4. Professional and amateur	1. Medical team and players registration) 2. Medical team registration) 3. Internet-based injury surveillance system (HealtheAthlete; Cerner Corporation, Overland Park, KS, USA). 4. Ultrasound examination.	Ten studies were selected considering 14 interventions, including nine different programs: FIFA11 + (11+), Harmoknee, Eccentric Nordic Hamstring Exercise (NHE) exclusively, with eccentric exercises, with stretching or proprioceptive, New Warm-up Program (NWP), Bounding Exercise Program (BEP), the only one without positive results, and proprioceptive exercises.	The exercise programs discussed were effective in preventing acute hamstring injuries in soccer players, except BEP and partially Harmoknee. The exercises most used to reduce the risk of hamstring injuries are eccentric strength exercises due to their functionality, especially the NHE.

SR, systematic review; SRMA, systematic review with meta-analysis; N/A, not applicable; RCT, Randomized controlled trial; NRCT, non-randomized-controlled trials; NCG, Nonequivalent control group; TS, Time series; RD, Retrospective design; QS, Qualitative study; CD, Cohort design; NHE, Nordic Hamstrings Exercise; FIFA, Fédération International de Football Association; NWP, New Warm-up Program; BEP, Bounding Exercise Program.

Table 4. AMSTAR 2 evaluation of each of the eligible studies included in the umbrella review.

Study	AMSTAR 2 - ITEMS																Overall items
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
Olsen *et al.* [17]	Yes	No	Yes	Yes	No	Yes	Yes	Yes	No	No	No MA	No MA	No	No	No MA	No	Critically low
Rogan *et al.* [18]	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No MA	No MA	Yes	Yes	No MA	Yes	Low
Cruz-Ferreira *et al.* [35]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No MA	No MA	No	Yes	No MA	Yes	Critically low
Porter & Rushton, [36]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No MA	No MA	Yes	Yes	No MA	Yes	High
Shadle and Cacolice [19]	Yes	No	Yes	Yes	No	No	No	Yes	No	No	No MA	No MA	No	No	No MA	No	Critically low
Fanchini *et al.* [37]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No MA	No MA	Yes	Yes	No MA	No	Low
Pérez-Gómez *et al.* [3]	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No MA	No MA	No	No	No MA	Yes	Critically low
Rosado-Portillo *et al.* [38]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No MA	No MA	No	Yes	No MA	Yes	Critically low

Yes, Complies; NO, Fails; No MA, No metanalysis.

remained accessible among the eight systematic reviews, which incorporated male soccer players of different competitions, levels, and ages. The intervention period for the different intervention protocols ranged from four weeks to four years. Most of the studies included in the reviewed systematic reviews were randomized controlled trials (RCT) (n = 14) [25,53–65], five were non-randomized controlled trials (NRCT) [24,66–69], two cohort designs (CD) [70,71], one non-equivalent control group (NCG) [72], one series of time (TS) [73], one qualitative study (QS) [74], and one retrospective design (RD) [75].

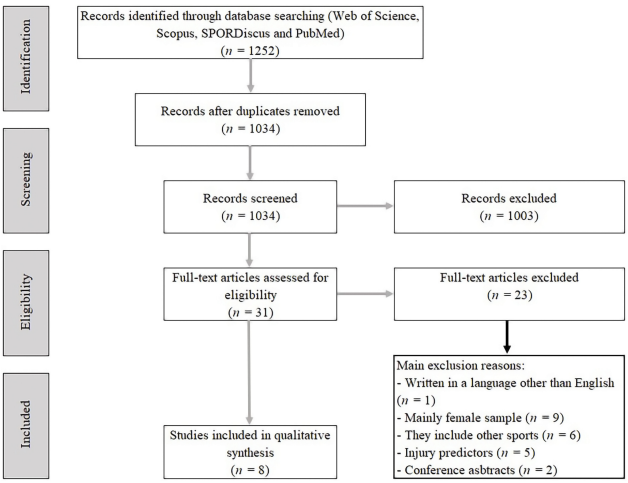

Fig. 1. PRISMA flow chart highlighting the selection process of the studies included in the umbrella review.

Olsen *et al.* [17] included young soccer players, while the remainder of the studies incorporated adult professional, semi-professional, amateur and college/university soccer players [3,18,19,35–38]. Despite two systematic reviews including two studies with female athletes and one with mixed genders, 95% of the included studies focused on male players. Four systematic reviews included a generalised lower-limb injury prevention programme [3,17,36,37] and four assessed the efficacy of training programs on hamstring injury prevention [18,19,35,38]. Two of the systematic reviews focusing on lower-limb injury prevention programmes questioned the quality of the evidence obtained in the studies [36,37]. Porter and Rushton [36] and Fanchini *et al.* [37] identified that the use of eccentric hamstring exercises may be effective in preventing hamstring injuries and that proprioceptive training may be effective in preventing recurrent ankle sprains. Rosado-Portillo *et al.* [38] suggested that soccer players can reduce the incidence of injury in games and training sessions by participating in dynamic warm-ups, including, strength, balance and mobility training exercises. Olsen *et al.* [17] demonstrated that the prevention strategies used in young soccer players appear effective, but further evaluation is required before robust inferences can be drawn. Programmes that focused on the prevention of hamstring muscle injuries [19,35,38] were shown to be efficacious when containing eccentric contraction force (Nordic) exercises. Injury prevention programmes utilising static stretching did not present quality scientific evidence to support its use [18].

3.3 Methodological Quality

The methodological quality of the 8 included articles is summarized in Table 4 (Ref. [3,17–19,35–38]). Five articles were rated as 'critically low' methodological quality, two reviews were rated as 'low' quality and one study was rated as 'high' quality.

In total, 63% of the articles included in this umbrella review (n = 5) did not adopt a satisfactory technique to assess the risk of bias in the individual studies that were included in the systematic review articles. Four of the systematic reviews had not been pre-registered. despite calls for more transparency around research practices [76].

The correct analysis of the RoB of the individual studies included in the SRs plays an important role when interpreting and discussing their results, which can profoundly affect the conclusions derived from the reviews, both qualitatively and quantitatively. Also, observing heterogeneity in the results, the authors should provide a satisfactory explanation and critical discussion on the subject. Our umbrella review is supported by the growing need to improve the quality of SRs, as well as the studies published on this matter, in order to avoid fragile conclusions or recommendations or those without strong scientific support.

3.4 Synthesis of Results

The synthesis of results obtained and extracted from the systematic reviews is presented in Table 5 (Ref. [3,17–19,35–38]).

4. Discussion

The present umbrella review aimed to synthesise the current evidence from the previously published systematic reviews on injury prevention programmes. Up to the present time, no articles are available that have specifically evaluated the current state of knowledge of injury prevention programmes in soccer through the analysis of systematic reviews and meta-analyses on this topic. This article is topical given the increasingly demanding competitive schedules and subsequent potential of increasing injury incidence in professional soccer. Given these contemporary factors the current article is specific to the systematic reviews focusing on programmes targeted at the prevention of lower limb injuries and, the prevention of hamstring injuries.

4.1 Lower Limb Injury Prevention Programmes

This umbrella review showed that among the eight systematic reviews included, four focused on lower-limb injury prevention (general). One of these reviews included young soccer players [17] and the other three included senior players of different ages and competitive levels [3,36,37].

Among the most common injuries declared in one of the studies included by Olsen *et al*. [17], in young athletes, 177 lower limb injuries were documented, of which 69% were trauma and 29% sprains, which resulted in 93% of them involving the ankle 59% and the knee 34% [53]. Despite these findings, Olsen *et al*. [17], point out that at the time of the review, there was a serious lack of research in the area, which could have been due to the time of publication of the study, since it is the oldest article included in this umbrella review.

The most common injuries in adult players are hamstring strains [24,25,54–56,60,64,66], therefore, it is recommended that prevention programs should incorporate eccentric exercises, neuromuscular training program that includes core stabilization exercises, eccentric quadriceps exercises and eccentric hamstring exercises [44]. Haroy [77], used a programme based on the Copenhagen adduction exercise (CA). This study reported that the male soccer players that completed the CA programme showed a reduced prevalence of groin injuries. Hölmich *et al*. [57] also used a prevention programme based on six exercises, (1) isometric adduction with a ball between the feet (2) isometric adduction with a ball at the knees, (3) combined abdominal and hip flexion, (4) coordination of a flexed leg “cross country skiing on one leg”, (5) hip adduction versus partner hip abduction, and (6) iliopsoas muscle stretch. Despite these exercises reducing the risk of groin injury by 31%, the changes did not reach statistical significance. It was also found that having suffered a previous groin injury almost doubles the risk of a recurrent groin injury and playing at a higher level increases the risk of developing a groin injury three-fold. A common recurrent injury is the knee sprain, Engebretsen *et al*. [55] proposed the use of exercises for instability on the balancing equipment, and unilateral activities. However, these individualised programmes did not reduce injury-risk, which could be attributed to the low participation in the programme, which varied between 19 and 30% during the intervention period. Compliance is an important factor in the effectiveness of an injury prevention programme and should be reported by the authors of scientific articles investigating injury prevention training protocols.

Ankle sprains have been studied by several authors. Mohammadi [58] compared three injury prevention programmes to determine their effectiveness. The groups either completed a proprioceptive programme, strength training programme, orthosis, or a control group. The results showed that the incidence of recurrent ankle sprain injuries was significantly lower for the group that used the proprioceptive programme compared to the control group. However, there were no significant differences for the strength training programme and orthosis groups. Tropp *et al*. [59] compared three groups, including an orthosis group, a group that completed co-ordination on an ankle disc and a control group (no intervention). The intervention groups proved to be effective in reducing functional instability in players with a previous ankle sprain injury, with both techniques also decreasing reccurent ankle injuries. Therefore, it appears that propioception and balance exercises are effective in reducing ankle sprains.

Owen *et al*. [67] used a multicomponent prevention programme, including, balance exercises on different surfaces, functional strength, core stability, and mobility. A reduction in solely muscle injuries were observed during an entire season where players performed the structured intervention programme bi-weekly versus a control season (no intervention). Other multi-component interventions are FIFA programmes [62,63,70,71], whose application has shown to decrease injury-risk in matches and training, and a reduction in time-loss from training and competition. These programmes have also been shown to substantially reduce the chances of suffering an ACL injury. Melegati *et al*. [68] and Engebretsen *et al*. [55] incorporated both individualised and group programmes based on previous injuries. Melegati *et al*. [68] demonstrated that group and individualised injury prevention programmes are effective in reducing the number of muscle injuries and days absent from competition. Engebretsen *et al*. [55] reported no differences for injury-risk between the intervention and control groups, perhaps given the low engagement with both group and individual protocols. Izzo *et al*. [69] used an injury prevention programme based on dynamic movements and

Table 5. Synthesis of results — evidence map.

Reference	Type of study	Article review process					Study design %								Competitive level %				Injury prevention			Conclusions
	SR ou SRMA	Total articles	Duplicates	1st revision articles	2st revision articles	Included studies	RCT	NRCT	NCG	QS	RD	ED	CD	TS	SR	Professional Players	Amateur Players	University Players	Youth Players	General lower limbs	Hamstrings	Built-in programs	
Olsen *et al.* [17]	SR	44		5		4	25		25					50 (25)			25		75	x		Various programs	Serious lack of evidence in young players. No specific practical recommendations for young soccer players are generated.
Rogan *et al.* [18]	SR	502		35	21	4		25		25	25	–25				50		25			x	Static stretching	Studies with low qualitative and quantitative characteristics. There are no RCT studies available. Therefore, it is not possible to find documentation on the effects of static stretching in preventing hamstring injuries.
Cruz-Ferreira *et al.* [35]	SR	1910		1892	23	5	80	20								70	30				x	Various programs	Limited and moderate evidence in the various programs analyzed, but concentric and eccentric force to be effective in reducing the incidence of injuries to the hamstrings as well as the Nordic hamstrings appear to be effective in reducing the incidence of new injuries.
Porter & Rushton [36]	SR	1942	1179	763	19	8	100 (13)													x		Various programs	Very low-quality evidence on the efficacy of exercise in preventing injuries in adult men's soccer, suggests some support for the use of eccentric exercises for the hamstrings and proceptive training for ankle sprains.
Shadle and Cacolice [19]	SR	3		3		3	67	33								83	17				x	Eccentric exercises	There is strong supporting evidence that eccentric hamstring exercises can prevent a hamstring injury in an elite adult male soccer player.

Table 5. Continued.

Reference	Type of study	Article review process					Study design %								Competitive level %				Injury prevention			Conclusions
	SR ou SRMA	Total articles	Duplicates	1st revision articles	2st revision articles	Included studies	RCT	NRCT	NCG	QS	RD	ED	CD	TS	SR	Professional Players	Amateur Players	University Players	Youth Players	General lower limbs	Hamstrings	Built-in programs	
Fanchini *et al.* [37]	SR	8382	4207	15		12	33 (7)	47 –13							–20	92			8	x		Various programs	Level 1, 2, 3 and 4 evidence limited in injury prevention programs and at high or unclear risk of bias. Therefore, it is considered useful evidence for professionals.
Pérez-Gómez *et al.* [3]	SR	2512	1597	1505	92	11	64	18					18			50	23	27		x		Various programs	Supports prevention programs carried out in training and match warm-ups (FIFA 11+, NHE, balance, mobility end strength at least twice a week.
Rosado-Portillo *et al.* [38]	SR	923	625	298	11	10	100 (60)									25	35	20	10		x	Various programs	Supports the use of different programs such as NHE, NHE + eccentrico, FIFA 11+, NWP and proprioception except BEP and Harmoknee.

SR, systematic review; SRMA, systematic review with meta-analysis; N/A, not applicable; RCT, Randomized controlled trial; NRCT, non-randomized-controlled trials; NCG, Nonequivalent control group; TS, Time series; RD, Retrospective design; QS, Qualitative study; ED, Experimental Design; CD, Cohort design; NHE, Nordic Hamstrings Exercise; FIFA, Fédération International de Football Association; NWP, New Warm-up Program. Note: Within parenthesis we presented the percentages of articles eliminated for deviating from the objectives of this research.

preventative work. It was determined that this programme significantly reduced the occurrence of muscle strain injuries.

4.2 Hamstring-Targeted Muscle Injury Prevention Programmes

Hamstring strain injuries are common in sports involving sprinting, kicking, and high-speed movements or extensive muscle lengthening-type maneuvers with hip flexion and knee extension [77]. Training-related hamstring injury rates have markedly increased over the last 20 years, but game injury rates have remained constant [78]. A major factor that can influence hamstring injuries is fatigue, which can last up to 72 hours after a game [79]. Therefore, if players do not return to pre-performance strength values (high speed movements/high load/accelerations/decelerations) after 72 hours or more, this could result in injury [80].

The injuries can cause an initial loss of flexibility and strength [77,81], which combined with an insufficient recovery time and premature return to sport, can lead to a risk of acute and chronic injuries [82]. for example, for central tendon disruption the median recovery time was 91 days. Nerveless, the median recovery times for biceps femoris injuries with and without central tendon disruption were 21 and 72 days respectively [83].

On the other hand, it is essential to use some procedures based on the recommendations of the rehabilitation protocols based on exercises of progressive agility and stabilization of the trunk and ice (PATS) and static stretching, isolated progressive resistance exercise of the hamstrings and ice application (PRES) based on three phases; phase 1, minimizing pain and edema, restructuring neuromuscular control at slower speeds and preventing excessive scar tissue; phase 2, increases the intensity of the exercises, the neuromuscular training is carried out at greater speed and amplitude, in conjunction with the start of eccentric resistance training; phase 3, high-speed neuromuscular training and an eccentric resistance training in a lengthened position in preparation for the return to sport [77,84,85].

The above-mentioned procedures can help the injury process recovery, reducing the risk of injury relapse given the complexity that characterizes the hamstring injury. Therefore, it is essential to review, analyze and understand the benefits of the different intervention plans available in scientific literature.

Rogan *et al*. [18] were the first — included in the umbrella review — to perform a systematic review on the prevention of hamstring injuries. This article attempted to determine whether static stretching reduced hamstring injuries in soccer players. However, due to the heterogeneity of the intervention programme methods included in the studies, the data were considered inconclusive. A systematic review incorporated in the current review article assessed the effectiveness of different protocols on the prevention of hamstring injuries [35]. The programme included proprioceptive, balance, neuromuscular and postural control training, with heterogeneity in the duration and frequency of the programmes. It was established that a combined concentric and eccentric strength programme was most effective in reducing the incidence of recurrent hamstring injuries, whereas the Nordic hamstring eccentric strength programme decreased the incidence of new hamstring injuries. However, the evidence was limited, and the authors suggested that follow-up studies, with higher methodological quality, are required. Askling *et al*. [54] used a control group and an experimental group, with the training group performing additional hamstrings strength training (concentric and eccentric YoYo^{TM} wheel ergometer) once every five days for the first 4 weeks and every four days for the last six weeks of the programme. The addition of specific strength training for the hamstrings was beneficial for injury prevention and performance in elite soccer players. Petersen *et al*. [25] performed a 10-week intervention with a total of 27 sessions of Nordic hamstring eccentric strength exercises. The study observed a reduction in the incidence of recurrent injuries, new injuries and recovery time from injury with the intervention programme. Arnason *et al*. [24] included Nordic hamstring eccentric strength exercises, a stretching-based warm-up and elasticity exercises three times a week in preseason and 1–2 times during the season, in addition to the regular training regime. The evidence suggests that there was a decrease in the incidence of injuries, but not in severity or recurrence. However, the programme not incorporating the Nordic hamstring strength programme did not obtain differences in incidence, recurrence and severity of injuries [24]. Engebretsen *et al*. [55] identified that completion of a Nordic hamstring eccentric strength exercise programme for 10 weeks did not reduce injury-risk, which could be due to low compliance (19–30%). van Beijsterveldt *et al*. [56] incorporated an exercise programme (thigh eccentric exercises, proprioceptive training, dynamic stabilisation and plyometric exercises) in the warm-up phase for 9 months, twice a week for 10-to-15 minutes each time. However, the programme did not influence the overall injury incidence or severity versus the control group.

Rosado-Portillo *et al*. [38] conducted a systematic review assessing the effectiveness of acute hamstring injury prevention programmes in soccer players. The exercises programmes incorporating eccentric exercises, especially Nordic hamstring exercises were most effective. Programmes involving concentric and isometric contraction exercises were also effective in improving strength and injury reduction. Naclerio *et al*. [47] implemented two different injury prevention programmes. One group completed eccentric knee flexor exercises, including Nordic hamstring exercises, and a separate group performed proprioceptive exercises (both 18 sessions in 6 weeks). It was found that both protocols reduced hamstring and ACL in-

jury incidence. Additionally, a four-week resistance training programme that included a stable eccentric open kinetic chain and two unstable closed kinetic chain exercises was shown to significantly alter the isometric ratio of the hamstrings between the angle of the knee and torsion by improving the maximum torque produced in a more closed position (80°). These adaptations are considered positive for the prevention of injuries as they protect athletes from both muscle and joint injuries [48]. Daneshjoo *et al.* [50] and Daneshjoo *et al.* [86] analysed the effects of the 11+ and HarmoKnee injury prevention programmes on knee strength in male soccer players. The first study focused on the conventional force ratio, the dynamic control ratio and the fast/slow speed ratio. It was identified that the 11+ improved the conventional force ratio and fast/slow speed ratio and reduced the rate of knee injuries in soccer players. However, the HarmoKnee programme showed no improvement. It was also found that programmes 11+ and HarmoKnee are useful warm-up protocols to improve concentric hamstring strength in soccer players, but programme 11+ yielded greater improvements in concentric hamstring strength. However, in the study of Daneshjoo [86] the authors tried to determine the effects of 11+ and Harmoknee on performance measures in professional football players, concluding that carrying out the 11+ heating program for 8 weeks can improve jump height, agility and football skill. On the other hand, the HarmoKnee program only improves football skill in young professional men's football players.

Rogan *et al.* [18] suggest that the effects of static stretching programmes are unclear concerning the prevention of the hamstring injury incidence. Cruz-Ferreira *et al.* [35] suggest that eccentric and concentric strength programmes appear to be effective in reducing the incidence of hamstring injuries in male soccer players, as are Nordic exercise eccentric strength programmes. Shadle and Cacolice [19] performed a systematic review that incorporated evidence obtained from Arnason *et al.* [24], Askling *et al.* [54], and Petersen *et al.* [25], which were previously described. These studies conclude that eccentric hamstring exercises can prevent hamstring injuries in elite adult male soccer players.

4.3 Limitations of Current Research on Injury Prevention

The existing systematic reviews included in the present article have revealed primarily low methodological quality. However, it must also be noted that there are large differences in quality ratings for the same study between systematic reviews, potentially due to different methodological quality criteria tools being used and subjective interpretations of quality ratings. Few articles preregistered the systematic reviews at inception to reduce duplication and facilitate comparisons between reported review methodologies. Another commonality between studies was inadequate procedures used to identify sources of bias. There are no meta-analyses that qualified for the current review to evaluate the quality and strength of the evidence, thus, no statistical conclusions have been established across studies [22]. The umbrella review does not incorporate other team sports, which may have given interesting perspectives. However, a decision was taken to limit the analyses to solely soccer given its unique activity profile.

4.4 Directions for Future Research on Injury Prevention

There are a number of future research avenues that should be explored. Considering the low methodological quality across studies, future articles in this area should address this by conducting research superior in quality to the reviews previously conducted. Longitudinal studies should be conducted (i.e., minimum of one season) to determine the impact of injury prevention programmes over longer periods of time. This could allow adaptations to the different programmes to take effect to determine if there is a genuine difference between players participating in prevention programmes compared with those who do not partake in such protocols. Moving forward, research avenues should also assess different team sports and explore to what extent the same types of prevention programmes have an effect, based on the notion that the demands will differ between each team sport (i.e., lower and upper limbs). Exploring how psychological processes (emotional well-being, motivation, etc.) link with injury prevention could help established a more comprehensive depiction of athlete health, not only in competitive football, but also in recreational football [87]. Researchers should prospectively and publicly record systematic reviews and meta-analyses on an appropriate platform to avoid others completing a review on the same topic.

5. Conclusions

Injury prevention programmes are becoming increasingly important in competitive soccer, and in recent years evidence has shown that injury rates are associated with team success [5]. There have been many systematic reviews conducted on this topic mainly over the last decade, and as such, it appears warranted that an umbrella is undertaken to summarise the findings of all previous review articles. In general, there is low methodological quality in the systematic reviews included and, consequently, any inferences drawn must be interpreted with caution. Despite the lack of consistency in the literature and the absence of meta-analyses, the existing evidence suggests that prevention programmes focused on strength and proprioception prevent the incidence and severity of injuries. The systematic reviews included also revealed that dynamic warm-ups can decrease injury incidence, but the influence of static stretching on subsequent injury susceptibility is less well known. These findings collate a grouping of evidence that can inform future research endeavors enabling flaws and gaps to be addressed. Reducing injury rates and increasing player availability can lesser the economic costs for profes-

sional soccer clubs and enhance success. Practitioners responsible for optimising prevention protocols could use the current comprehensive summary of the literature to direct their future practices. Soccer practitioners should implement injury prevention programmes in their weekly plans during the pre-competitive and competitive phases of the season to minimise injury and use some of the current data to inform their practices. To address the low methodological quality, future research should possess greater rigor, employ longer periods of intervention, incorporate a control group in their study design, and record the level of programme compliance.

Key Points

This umbrella review provides a comprehensive evidence synthesis of injury prevention programs in male soccer, including various beneficial practices for players, teams, and clubs.

Preventative programs targeted at enhancing muscle strength and proprioception reduce injury incidence and severity, particularly hamstring strains and ankle sprains.

Warm-ups implementing dynamic activity before soccer matches have shown to decrease incidence, while the impact of static stretching as an injury preventative strategy appears ambiguous.

There is a lack of consistency between the studies reporting on prevention programs in male soccer players. More homogenous research is required to elucidate the efficacy of injury prevention protocols to inform practice in the applied environment.

Registration

The umbrella review was pre-registered in the International Platform of Registered Protocols for Systematic Review and Meta-analysis (10.37766 / inplasy2021.9.0066).

Amendment to the Information Provided in the Registry or in the Protocol

Injury prevention programmes in male soccer players: an umbrella review of systematic reviews.

Author Contributions

JB, AJF and HS led the project, established the protocol, and wrote and revised the original manuscript. FMC, AF and LV wrote and revised the original manuscript. All authors have read and agreed to the published version of the manuscript.

Ethics Approval and Consent to Participate

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Conflict of Interest

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Supplementary Material

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.31083/j.jomh1810200.

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