Injury profile in women's football: A systematic review and meta-analysis

Short title: Women's football injuries

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Authors' contributions: AL, JR and FA were responsible for the conception and design of the study. AL and JR were involved in data collection over the study periods. MD conducted the analyses together with the biostatistician (AG) and they were planned and checked with PS and AA. All authors contributed to the interpretation of findings and had full access to all data. AL wrote the first draft of the paper, which was critically revised by FA, MD and PS. The final manuscript was approved by all authors.

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Abstract

Background: Football is the most popular sport among women; however, little is known about the injury profile in this population. This information would help design tailored injury risk mitigation strategies that may make football safer for women.

Objective: The aim of this study was to perform a systematic review and meta-analysis of epidemiological data of injuries in women´s football.

Methods: A systematic review following PRISMA guidelines was performed up to January 2020 in PubMed, Web of Science, Sport discus and the Cochrane Library databases. Twenty-one studies reporting the incidence of injuries in women football were analysed. Two reviewers independently extracted data (intraclass correlation coefficient [ICC] for inter-reviewer reliability = 0.87) and assessed study quality using the STROBE statement, GRADE approach, Newcastle Ottawa Scale and Downs and Black assessment tools. Studies were combined in pooled analyses (injury incidence and injury proportion) using a Poisson random effects regression model.

Results: The overall incidence of injuries in female football players was 6.1 injuries/1000 hours of exposure. Match injury incidence (19.2 injuries/1000 hours of exposure) was almost six times higher than training injury incidence rate (3.5 injuries/1000 hours of exposure). Lower extremity injuries had the highest incidence rates (4.8 injuries/1000 hours of exposure). The most common types of injuries were muscle/tendon (1.8 injuries/1000 hours of exposure) and joint (non-bone) and ligament (1.5 injuries/1000 hours of exposure), which were frequently associated with traumatic incidents. Slight/minimal injuries (1–3 days of time loss) were the most common. The incidence rate of injuries during matches in the top 5 world ranking leagues was higher than the rest of the leagues (19.3 vs 10.7 injuries/1000 hours of exposure, respectively). The weighted injury proportion was 1.1 (95% confidence interval = 0.6–1.7) whereby on average players sustained more than one injury per season.

Conclusions: Female football players are exposed to a substantial risk of sustaining injuries, especially during matches that require the highest level of performance. In order to markedly reduce overall injury burden, efforts should focus on introducing and evaluating preventative measures that target match specific dynamics in order to make football players more capable of responding to the challenges that they have to deal with during match play.

Registration: This systematic review was registered in the PROSPERO international prospective register of systematic reviews (ID = CRD42019118152).

Key points

a) Match injury incidence is almost 6 times higher than the training injury incidence rate.

b) Lower extremity is the anatomical region more frequently injured and the most common types of injuries are muscle/ tendon strains and joint (non-bone) and ligament.
c) Although slight/minimal injuries are the most common, the number of severe injuries is high.
d) Match injury incidence rates in the top-5 world ranking leagues was nearly two-fold higher than the rest of the leagues in other countries.

1 Introduction

Women's football (soccer) has experienced exponential growth in recent years, almost tripling the number of players in the last decade, with more than 13 million women playing (at both amateur and elite levels) organized football worldwide [1–3]. Furthermore, there are currently more than 30 elite women football national leagues well-stablished in different countries (mainly in European countries such as France, Spain, Sweden, Germany, and England).

Although sport participation (including football) has several associated health-related benefits [4–6], the high physical demands of the game of football alongside exposure to physical contacts and tackles might place female players at high risk of injury. This injury risk may be higher at top levels due to the fact that the recent fast progression in the degree of professionalism in women's football has led to a substantive increase in frequency, intensity and competitiveness of both training sessions and match play [7–9]. Injuries could have significant physical, psychological and financial short and long-term negative consequences for an individual player and their sport organizations [10–12]. In order to design effective preventive, technical and risk mitigation strategies, the magnitude (i.e. incidence), severity and main characteristics of the injuries sustained in women´s football must be first well-described [13].

Some prospective epidemiological studies have been published investigating injuries sustained by female football players during national leagues [14–19] and international tournaments (e.g. World Cup, Olympic Games) [20–22]. These studies have reported overall incidence rates ranging from 1.9 to 9.6 and from 4.9 to 13.5 injuries per 1000 hours of exposure for national leagues [14–19] and international tournaments [20,22], respectively. In addition, the lower extremity seems to be the body area where most injuries are sustained with quadriceps muscle strains and ankle ligament sprains the most frequently diagnosed types of injuries [17,23-25]. Furthermore, female footballers seem to have more than two-fold higher incidence of severe knee injuries compared to men, regardless of the level of play [26]. However, differences in the number, age and level of play of the players included in these studies along with disparity in injury definitions and data collection procedures may have clouded the current understanding of the incidence, severity and characteristics of injuries in women´s football. Therefore, and similar to what has been recently conducted in men´s football [27], a study that meta-analyzed the available epidemiological data and provided robust estimates of the most common and severe injuries as well as where (anatomical location) and when (matches or training sessions) they usually occur is needed.

Therefore, the main purpose of this study was to conduct a systematic review and meta-analysis to quantify the incidence of injuries in women´s football. A secondary purpose was to carry out sub-analyses to determine overall effects regarding location of injuries, type of injuries, severity of injuries, overuse and traumatic injuries, new and recurrent injuries, level of play and national leagues (clubs) and international tournaments (national teams). The injury proportion was also calculated through a separate meta-analysis.

2 Methods

This systematic review and meta-analyses were carried out following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines [28]. The PRISMA checklist is presented in online supplementary appendix 1. The research protocol was registered with the PROSPERO International prospective register of systematic reviews (http://www.crd.york.ac.uk/PROSPERO/), registration number CRD42019118152.

2.1. Study selection

Eligibility criteria were established and agreed upon by all authors based on the concept of population, intervention/indicator, comparator/control and outcome (PICO) [29]. Thus, to be included in the meta-analysis, studies had to fulfil the following criteria:

1. Injury must be defined in terms of time loss (i.e injury that results in a player being unable to take a full part in future football training or match play) [30].
2. Participants had to be adult female football players (older than 18 years old). Participants younger than 18 years old were also included only if they played in elite football teams (i.e. players who belong to teams engaged in first or second national football leagues) [23].
3. The study had to be a full-text article published in a peer-reviewed journal before January 2020.
4. Study had to be prospective.
5. Injury surveillance had to be collected by a medical team.
6. Eligible studies must report either incidence rate or prevalence among the surveyed players or provide sufficient data from which these figures could be calculated through standardised equations.

Studies using injury definitions other than time loss were excluded. Finally, some authors were contacted to provide missing data or to clarify if data were duplicated in other publications. Incomplete data, or data from an already included study, were excluded.

2.2 Search strategy

Potential studies were identified by using a systematic search process. Firstly, the following bibliographical databases were searched: PubMed, Web of Science, Sportdiscus and the Cochrane Library following search terms included in Boolean search strategies. In addition, a complementary search of the reference lists of included articles was also a strategy. Finally, Google Scholar was used to search both academic and grey literature (articles not formally published by commercial academic publishers), using terms such as football, soccer, women, female, injuries and epidemiology. Search strategies can be found in online supplementary appendix 2.

Two reviewers independently (AL-V and JR-G): a) screened the title, abstract and reference list of each study to locate potentially relevant studies, and once hardcopies of the screened documents were obtained; b) reviewed them in detail to identify articles that met the selection criteria. A study was excluded immediately once it failed to meet a single inclusion criterionperformed. Relevant keywords were used to construct Boolean search. A third external reviewer (FA) was consulted to resolve discrepancies about the selection process.

2.3 Data extraction

With the aim of guaranteeing the maximum possible objectivity, a codebook was produced that specified the standards followed in coding each of the characteristics of the studies. The codebook can be obtained from the corresponding author upon request. The moderator variables of the eligible studies were coded and grouped into three categories: 1) general study descriptors (e.g.: authors, year of publication and study design); 2) description of the study population (e.g.: sample size, age and level of play [amateur or elite]); and 3) epidemiological data (e.g.: injury and exposure data, distribution of injuries by anatomic location, type of injury, injury severity). Online supplementary appendix 3 displays the moderator variables coded separately by category.

The purpose of the current meta-analysis was to determine the overall effects of: 1) football-related injury incidence (overall vs. training vs. match injuries rates), 2) location of injuries (lower extremity vs. trunk vs. upper extremity vs. head and neck), 3) type of injuries (fractures and bone stress vs. joint [non-bone] and ligament vs. muscle and tendon vs. contusions vs. laceration and skin lesion vs. central/peripheral nervous system vs. undefined/other), 4) severity of injuries (slight/minimal [1-3 days] vs. minor/mild [4-7 days] vs. moderate [8-28 days] vs. major/severe [>28 days]), 5) mechanism of injury (overuse vs. traumatic injuries), 6) new vs. recurrent injuries, 7) level of play (top-5 leagues vs. other leagues), 8) national leagues vs international championships and 8) injury proportion.

With regard to the category level of play, studies were classified into two different labels: top-5 leagues and other leagues. In the top-5 leagues label was included the top-4 European leagues according to the ranking emitted by UEFA in 2020 (https://www.uefa.com/memberassociations/uefarankings/) and the United States National Women's Soccer League (it has been widely considered as the top-1 league in the world).

2.4 Quality assessment, risk of bias and level of evidence

The reporting quality of included studies was assessed using an adapted version of the "Strengthening the Reporting of Observational Studies in Epidemiology" (STROBE) statement by Von Elm et al. [31]. Online supplementary appendix 4 displays a description of the 22 criteria designed to assess quality of the studies included in the meta-analysis with the STROBE scale. Although STROBE statement was not developed to directly assess the quality of publications, compliance to the STROBE checklist has been recognized as a proxy for quality of the publications on observational studies since there is no validated instrument for this purpose [32,33]. The items and subitems of the STROBE statement were scored as 0 or 1, with a score of 1 provided for each checklist item that was properly completed. Using this checklist, a maximum score of 34 would indicate the article fulfilled requirements for a high-quality publication.

Furthermore, to assess risk of bias of external validity quality, an adapted version of the Newcastle Ottawa Scale (NOS) for cohort studies was used. Thus, the instrument was adjusted to the purpose of this review (incidence of injuries) and the population of women football players. In particular two of the eight items were deleted. Item 2 was excluded because a selection of the non-exposed cohort was irrelevant as long as the total study population was exposed to football play and item 5 (comparability of cohorts on the basis of the design or analysis) was excluded because it was linked to item 2. Two new items were added to the original scale (items 1 and 3). Therefore, the criteria adopted to assess risk of bias were: 1) description or type of women football players, 2) definition of injury, 3) representativeness of the exposed cohort, 4) ascertainment of exposure, 5) demonstration that the outcome of interest was not present at the start of study, 6) assessment of outcome, 7) whether follow-up was long enough for outcomes to occur, 8) adequacy of follow-up of cohorts. An article could be awarded a maximum of one star for each item if appropriate methods had been clearly reported. Thus, a total of eight stars could be given to an article. The higher the number of stars given to an article the lower the risk of bias and studies scoring at least 6 stars were classified as high-quality studies [34]. Similar adaptations of the NOS scale have been undertaken by previous meta-analyses investigating the epidemiology of injuries in other cohorts of athletes: men football players [27] and runners [35,36]. Online supplementary appendix 5 displays a brief description of each item of the adapted version of the NOS tool used in this study.

The quality of the certainty of the main outcomes (i.e. overall, match and training incidences) was graded (high, moderate, low, or very low certainty) using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach [37]. Four different GRADE factors were used in this meta-analysis: risk of bias (i.e., the methodological quality of the studies), inconsistency (i.e., unexplained inconsistency of results across studies), indirectness (i.e., evidence from different populations than the population of interest in the review) and imprecision (i.e., total sample size of the available studies). The starting point was always the assumption that the pooled or overall result was of high quality. The quality of evidence was subsequently downgraded by one or two levels per factor to moderate, low, or very low when there is a risk of bias, inconsistency, imprecision or indirect results.

Finally, the Downs and Black quality assessment tool was applied to assess reporting, external validity, internal validity and power [38]. Similar to what was done in previously published systematic reviews [39,40], the original 27 items scale was shortened to 16 items because these items are not applicable for nonrandomised studies. The National Health and Medical Research Council (NHMRC) Evidence Hierarchy [41] was used to evaluate the level of evidence of the included studies. The level of evidence was plotted against the Downs and Black criteria as the methodological quality assessment score to illustrate the overall quality of the included studies [39].

The data extraction and quality assessment (including risk of bias of external validity) were conducted by two reviewers (AL-V and JR-G). To assess the inter-coder reliability of the coding process, these two reviewers (AL-V and JR-G) coded 11 studies randomly (52%) (including quality assessment). For the quantitative moderator variables intra-class correlation coefficients ($ICC_{3,1}$) were calculated, while for the qualitative moderator variables Cohen's kappa coefficients were applied. On average, the ICC was 0.87 (range: 0.73 - 1.0) and the kappa coefficient was 0.88 (range: 0.77 - 1.0), which can be considered highly satisfactory, as proposed by Orwin and Vevea [42]. Inconsistencies between the two coders were resolved by consensus, and when these were due to ambiguity in the coding book, this was corrected. As before, any disagreement was resolved by mutual consent in consultation with a third reviewer (FA).

2.5 Statistical analysis

Injury incidence rates per 1000 hours of player exposures were extracted from the included studies. If injury incidence rates were not specifically reported, they were, if possible, calculated from the available raw data using the following formulas:

Incidence = 1000 x (∑injuries/∑exposure hours)

Incidence = nº of injuries / (nº of matches x 11 players x match duration*) x 1000

* Match duration, using the factor 1.5, based on standard 90 min match play. For example, a hypothetical study reporting that a football team comprising of 18 players sustained a total of 4 injuries within the season (28

matches), the application of the second formula would estimate an incidence of 7.2 injuries per 1000 hours of match exposure.

Similar to previous meta-analysis on epidemiology of injuries in sports [27,43,44], data were modelled by a random effects Poisson regression model, as previously described [45]. The response variable in each meta-analysis was the number of observed injuries, offset by the log of the number of exposure hours (injury incidence rates). A random effects term was included to account for the correlation arising from using multiple rows of data from the same study. Factors of interest were included as random effects. A weighting factor used was: study exposure time (hours) / mean study exposure time (hours). For injury incidence data, the overall estimated means for each random effect factor were obtained from the model and then back-transformed to give incidence rates, along with 95% CIs (CIs that showed negative values were adjusted to 0 for better interpretability). Heterogeneity was evaluated using the I^2 statistic, which represents the percentage of total variation across all studies due to between-study heterogeneity [46]. I^2 values of <25%, 25-50%, 50-75% and >75% indicated no, small, moderate and significant heterogeneity, respectively [47]. The possible influence of the following variables on the model was analysed independently through univariate and multivariate analyses: registration period; year of the study publication, age of the players, STROBE score, NOS stars, Downs & Black and number of teams included in the study.

The injury incidence proportion was calculated using the following formula [39,48]:

Injury incidence proportion = Number of injuries / Number of football players.

The response variable was the number of participants divided by the number of injuries to calculate injury proportion for all injuries. For injury proportion, its standard error (SE), 95% confidence interval (CI) upper and lower bounds and the square of its SE (SE2) were calculated from extracted data when this information was not directly reported in the paper. All statistical analyses were performed using the statistical software package R Version 2.4.1 (The R Foundation for Statistical Computing) and the ‘‘metafor’’ package [49].

3 Results

3.1 Descriptive characteristics of the studies

A total of 1,903 references were identified with all search strategies, of which 22 met the inclusion criteria (resulting in 25 cohort groups as 2 studies had more than one group) [14-25,50–59]. Figure 1 shows the flow chart of the selection process of the studies. The studies were carried out between 1989 and 2019 and comprised players

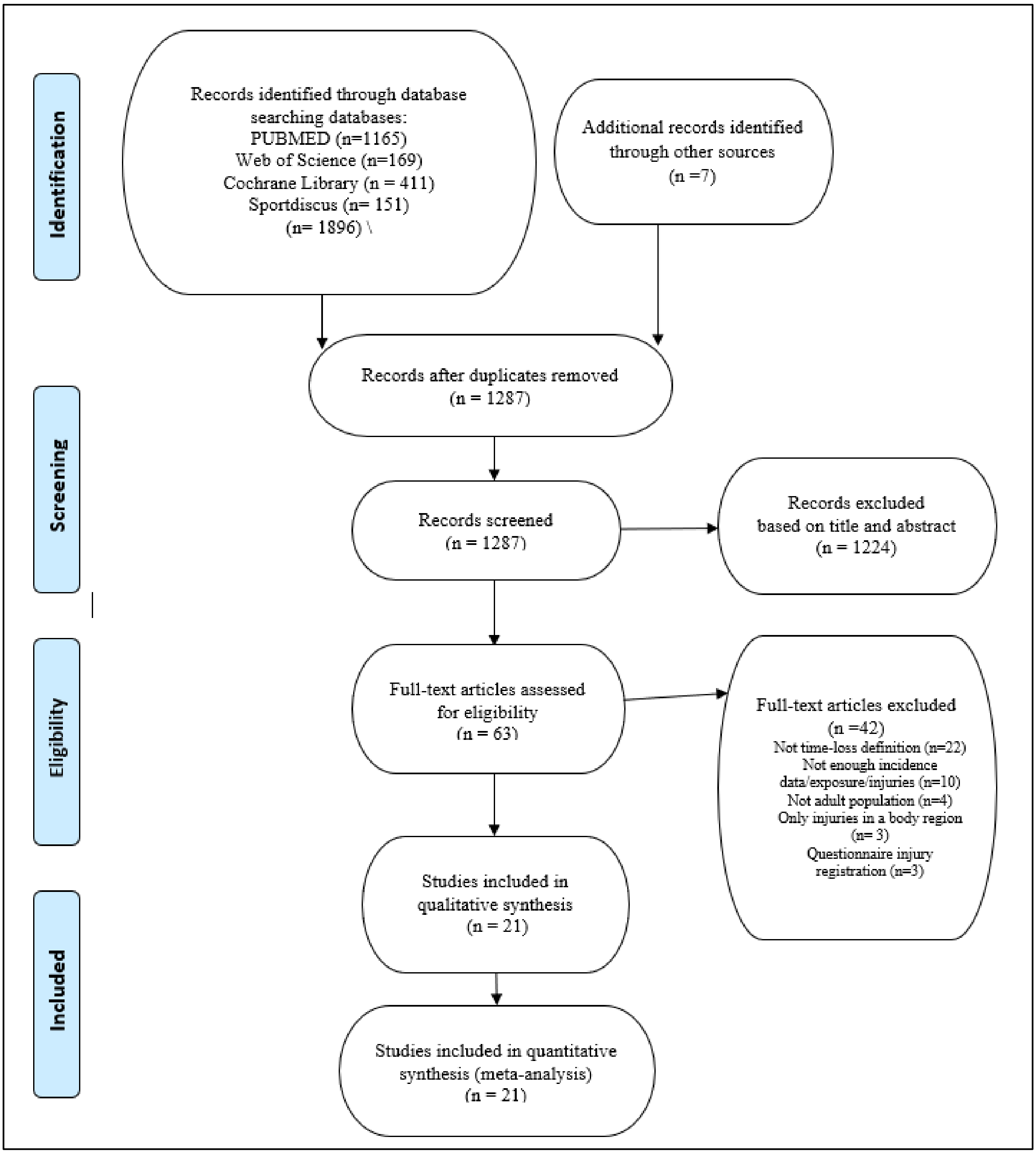

Figure 1 Flow chart of the selection of studies for the meta-analysis.

from both tournaments (world [21,54] and continental [20,22] tournaments) and elite [15-19,23,51,53,55,58,59] and amateur [14,24,25,50,52,56,57] football leagues in several countries. Of the 22 studies in this systematic review and meta-analysis, five were from Sweden [14,15,23,52,56], three from Germany [18,19,53], three from USA [16,24,25,51], three from Norway [55,58,59], one from Nigeria [57], one from Spain [17] and one from Trinidad y Tobago [50]. Four studies included data from several countries combined [20-22,54]. Table 1 provides a descriptive summary of the characteristics of the included studies.

Table 1 Characteristics of the studies included in the meta-analysis.

Reference	Study Duration*	Nº Teams	Exposure (hours)			Injuries			Incidence			STROBE - /34 (reporting) quality	NOS - /8 (methodological quality)
Country / Tournament		(Players)	Overall	Training	Match	Overall	Training	Match	Overall	Training	Match		
Babwah (50)[F] Trinidad & Tobago - 2009	16	16 (320)	-	-	940,5	-	-	29	-	-	27,6	20	7
Becker et al. (19) Germany - 2000/2001	36	12 (254)	86746	-	-	216	-	-	2,49	-	-	15	6
Ekstrand et al. (23)[F] Sweden - 2003/2008	256	5 (154)	48404	-	-	314	-	-	6,49	-	-	27	7
Ellias et al. (51) USA – 2011	390	- (-)	-	-	21804,5	-	-	232	-	-	10,64	12	5
Engström et al. (52) Sweden	39	2 (41)	6500	4142	2041	78	29	49	12	7	24	11	7
Faude et al. (53) Germany – 2003/2004	38	9 (165)	35310	30195	5115	241	-	-	6,8	-	-	25	7
FIFA (54) Canada WC - 2015	4	24 (552)	-	-	1717	-	-	42	-	-	24,46		
Fuller et al. (24-25) USA - 2005/2006	96	136 (-)	324751	280496	44255	1720	774	946	5,3	2,76	21,38	24	7
Gaulrapp et al. (18)[F] Germany	44	12 (254)	75438	67056	8382	246	91	155	3,3	1,4	18,5	22	7
Giza et al. (16) USA - 2001/2002	78	8 (202)	89637	-	-	173	-	-	1,93	1,17	12,63	13	6
Hägglund et al. (20) (a)[F] Switzerland/U19 EC - 2006	2	8 (144)	1707	1210	497	23	9	14	13,47	7,4	28,2	23	6
Hägglund et al. (20) (b)[F] Iceland/U19 EC - 2007	2	8 (144)	1407	906	501	12	1	11	8,5	1,1	22	23	6
Hägglund et al. (20) (c)[F] France /U19 EC- 2007	2	8 (145)	1635	1121	514	8	2	6	4,9	1,8	11,7	23	6
Jacobson et al. (14) Sweden – 2005	34	18 (253)	23854	11428	10000	229	96	133	9,6	8,4	13,3	23	6
Jacobson et al. (15) Sweden – 2000	43	12 (195)	51522	44815	8345	237	121	116	4,6	2,7	13,9	20	6
Junge et al. (21) (a)[F] FIFA WCs - 1999/2011	16	64 (1312)	-	-	4224	-	-	95	-	-	22,49	20	6
Junge et al. (21) (b)[F]	12	128 (828)	-	-	2904	-	-	81	-	-	27,89	20	6

OG Tournaments - 2000/2012													
Junge et al. (21) (c)[F] FIFA U19/U20 WCs - 2002/2012	12	360 (1812)	-	-	5940	-	-	175	-	-	29,46	20	6
Larruskain et al. (17)[F] Spain - 2010/2015	260	1 (35)	25394	21850	3544	160	75	80	6,3	3,43	22,57	25	7
Maehlum et al. (55) Norway – 1984	1	332 (-)	11658	3440	8218	-	-	145	-	-	17,6	10	4
Nilstad et al. (59)[F] Norway – 2009	32	9 (159)	66387	53157	12694	232	135	97	3,49	2,54	7,64	21	7
Östenberg et al. (56) Sweden – 1996	281	8 (123)	9745	7027	2727	65	26	39	6,67	3,7	14,3	21	7
Owoeye et al. (57)[F] Nigeria – 2012	4	10 (300)	-	-	759	-	-	6	-	-	7,9	25	6
Tegnander et al. (58)[F] Norway – 2001	28	10 (181)	30619	-	3663	189	100	89	6,17	3,71	24,3	18	7
Waldén et al. (22)[F] England/ EC - 2005	2	8 (160)	1820	-	507	18	3	15	9,89	2,28	29,59	23	6

[F] Study was implemented according to the 2006 consensus statement for epidemiological studies in soccer.
(a);(b);(c): indicate different cohorts in the same study.
*: study duration expressed in number of weeks.
EC: European Championship; OG: Olympic Games; U: Under; WC: World Championship.

3.2 Quality assessment of the studies selected

With regards to the reporting quality of the studies, the mean score obtained with the STROBE quality scale was 19.9 (minimum: 10, maximum: 34). In general, more recent studies (published from 2007, since the consensus statement on injury definitions and data collection procedures in studies of football injuries was published [60] to 2018) had more information reported (22.2, 95%CI = 20.6 to 23.7) than older (published before 2007) studies (16.4, 95%CI = 12.2 to 20.5). The detailed data are presented in online supplementary appendix 6.

Regarding NOS scale, the mean score obtained was 6.4 (minimum: 4, maximum: 7). The detailed data are presented in online supplementary appendix 7.

Table 2 displays the summary of the findings obtained from the GRADE method.

Results relating to the methodological quality rating of reviewed studies are presented in online supplementary appendix 8. The mean score was 12.15 (minimum: 5, maximum: 16), which represents a compliance of 60.8% of the statements. Following NHMRC, all studies included in this review were cohort studies, which represent level III evidence. The level of evidence plotted against the Downs and Black can be observed in Figure 2.

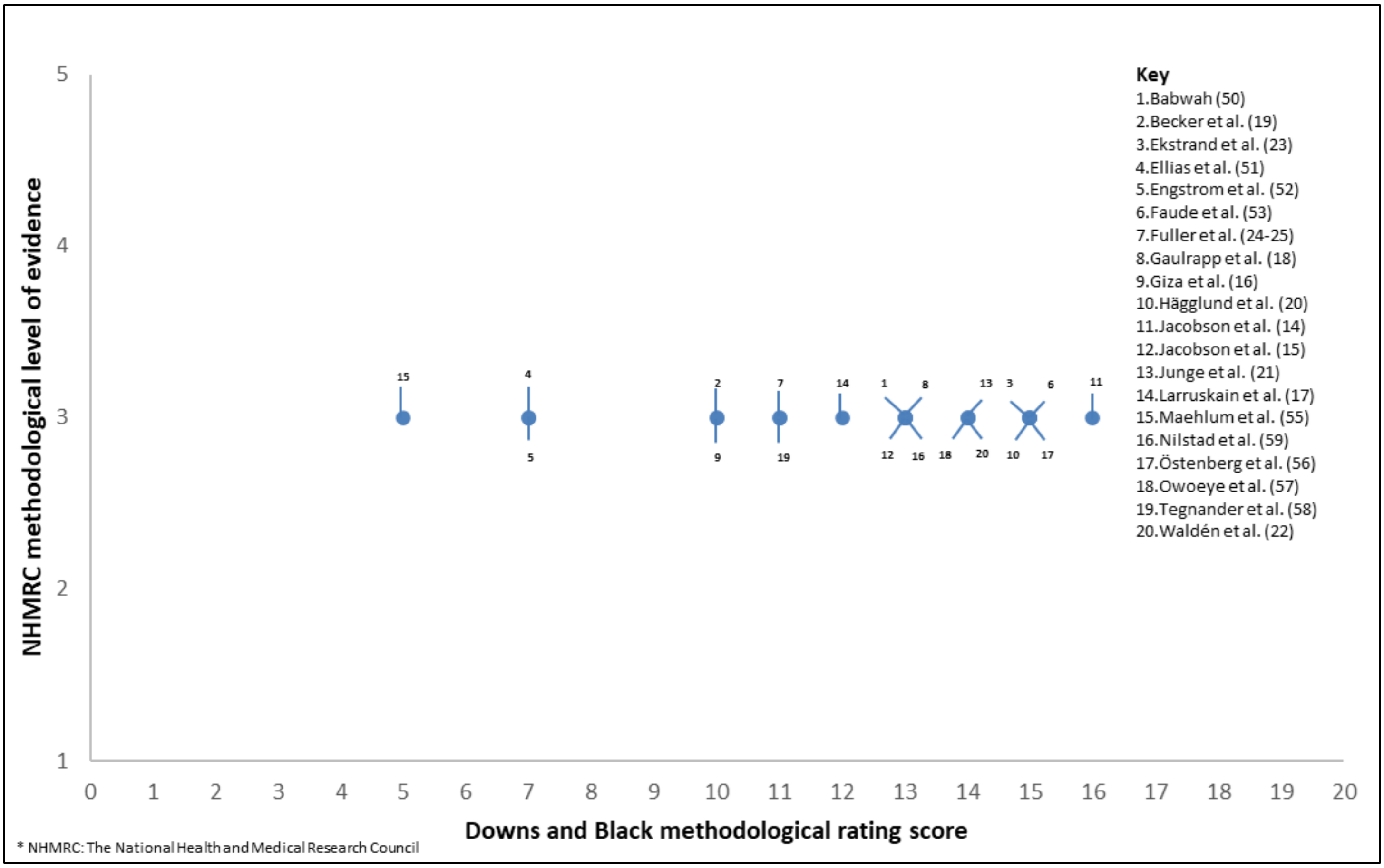

Figure 2 Methodological quality rating of reviewed papers plotted against the methodological level of evidence.

3.3 Meta-analyses

In the meta-analyses carried out, the effect sizes exhibited a moderate to large heterogeneity (based on the Q statistics and the I^2 indices), supporting the decision of applying random-effects models.

Neither registration period (i.e. the period of time /year when the data collection process was carried out), year of publication of the study, age, STROBE score, NOS stars, Downs & Black, and number of teams' variables had an impact on injury incidence rates and hence, the subsequent sub-analyses were not adjusted to these variables.

3.3.1 Injury incidence: overall, training and match

Sixteen studies (17 cohorts) reported overall injury incidence [14-20,22-25,52,53,56,58,59], eleven studies (13 cohorts) reported training injury incidence [14,15,17,18,20,22,25,52,56,58,59] and seventeen studies (21 cohorts) reported match injury incidence [14,15,17,18,20-22,24,50-52,54-59]. These studies comprised 4161 (overall), 1462 (training) and 2555 (match) injuries. The random effect models for injury incidence showed an overall incidence of 6.1 injuries per 1000 hours of exposure (95%CI = 4.6 to 7.7, I^2 = 98.8%), a training incidence of 3.5 injuries per 1000 hours of training exposure (95%CI = 2.4 to 4.6, I^2 = 97.7%) and a match incidence of 19.2 injuries per 1000 hours of match exposure (95%CI = 16.0 to 22.4, I^2 = 94.2%). Figures 3-4 display the forest plots with the training and match incidence of the analysed studies.

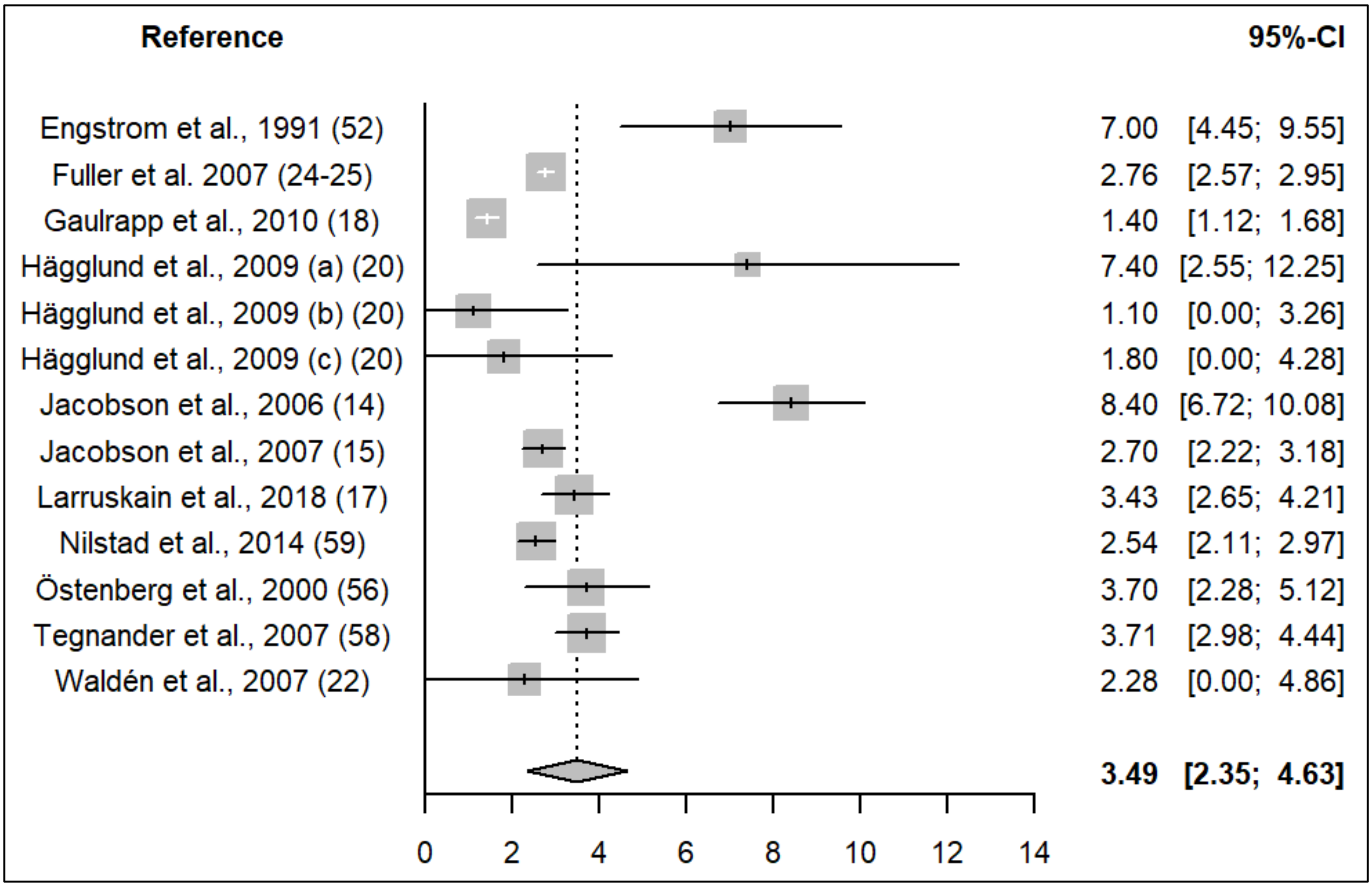

Figure 3 Training Injury incidence with 95% confidence intervals.

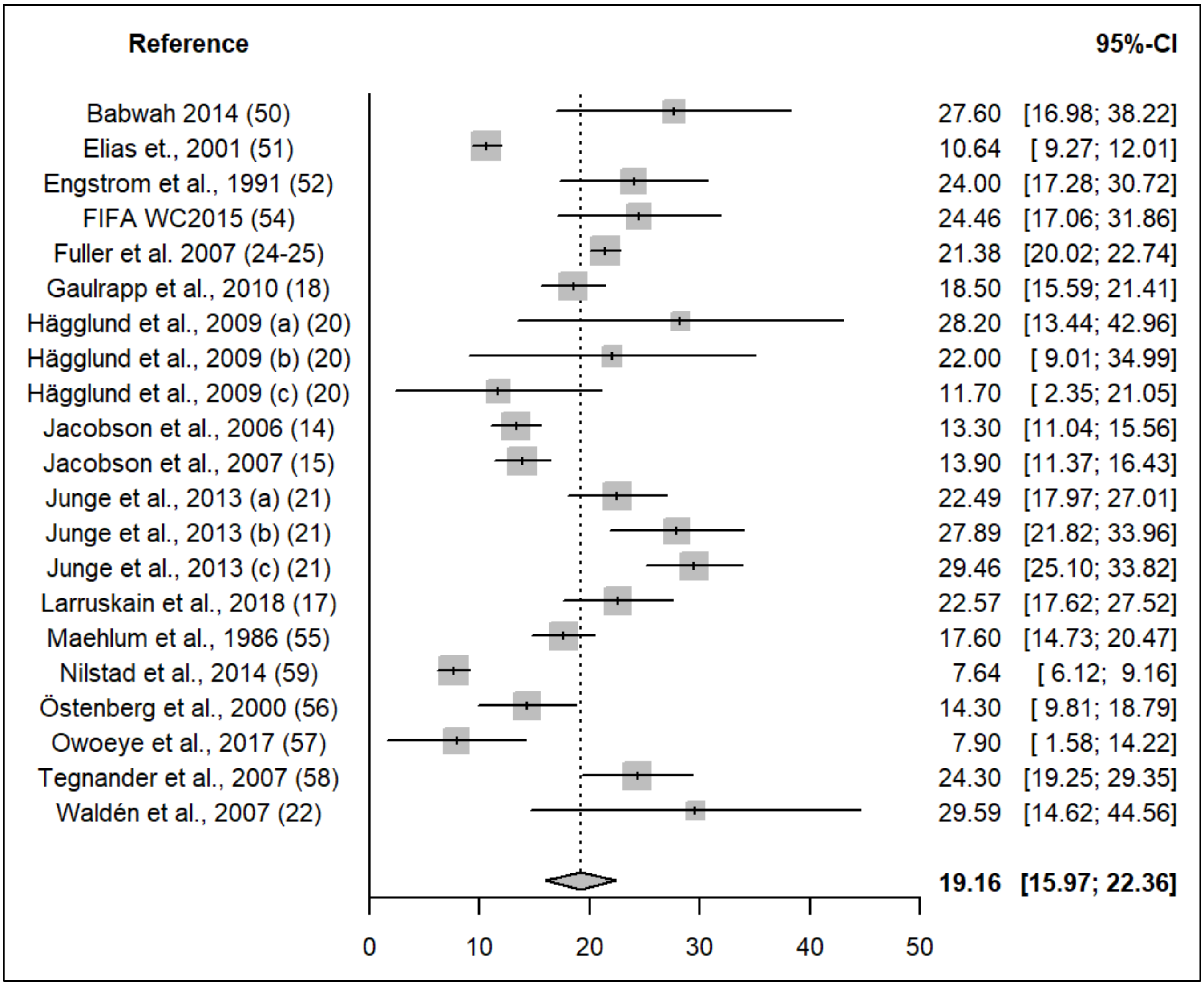

Figure 4 Match Injury incidence with 95% confidence intervals. WC: World cup.

3.3.2 Location of injury

Sixteen studies reported injury location and lower extremities region categories according to Fuller et al. [60] which were pooled in the meta-analysis [14-19,22,24,25,51-53,55,56,58,59]. Lower extremity injuries had the highest incidence rates (4.8 per 1000 hours of exposure, 95%CI = 3.4 to 6.1, I^2 = 99.1) compared to the other body regions. The trunk was the second most commonly injured region (0.4 per 1000 hours of exposure, 95%CI = 0.3 to 0.6, I^2 = 87.1), head and neck injuries was the third most commonly injured region (0.3 per 1000 hours of exposure, 95%CI = 0.2 to 0.4, I^2 = 85.2) and upper extremity had the lowest incidence rates (0.15 per 1000 hours of exposure, 95%CI = 0.1 to 0.2, I^2 = 83.0).

Regarding lower extremity injuries, six anatomical regions were analysed. The mean incidence per 1000 player hours of exposure with 95%CIs were in descending order: ankle (1.1, 95%CI = 0.7 to 1.4, I^2 = 97.6); knee (1.1, 95%CI = 0.9 to 1.2, I^2 = 76.0); thigh (0.9, 95%CI = 0.6 to 1.2, I^2 = 96.9); lower leg/Achilles tendon (0.5, 95%CI

Table 2 Summary of findings (GRADE)

Nº of studies	Certainty assessment					Effect			Certainty
	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Nº of events	Nº of individuals	Incidence (95% CI)	
Overall injury incidence in women football players									
16 [14-20, 22-25, 52, 53, 56, 58, 59]	Observational studies	Not serious	Serious [b]	Not serious	Not serious	2441	2609	6.1 injuries per 1000h of exposure (4.6 to 7.7)	⊕⊕⊕◯ MODERATE
Training injury incidence in women football players									
11 [14, 15, 17, 18, 20, 22, 25, 52, 56, 58, 59]	Observational studies	Not serious	Serious [b]	Not serious	Not serious	688	1834	3.5 injuries per 1000h of training exposure (2.4 to 4.6)	⊕⊕⊕◯ MODERATE
Match injury incidence in women football players									
17 [14, 15, 17, 18, 20–22, 24, 50-52,54-59]	Observational studies	Serious [a]	Serious [b]	Not serious	Not serious	1129	6799	19.2 injuries per 1000h of match exposure (16.0 to 22.4)	⊕⊕◯◯ LOW

a. Two studies [51,55] presented certain risk of bias (assessed with the Newcastle Ottawa Scale [NOS]).

b. High inconsistency (I2 > 90%).

= 0.3 to 0.6, I^2 = 87.2); foot/toe (0.4, 95%CI = 0.2 to 0.5, I^2 = 92.3); and hip/groin (0.35, 95%CI = 0.2 to 0.5, I^2 = 94.9) (Figure 5).

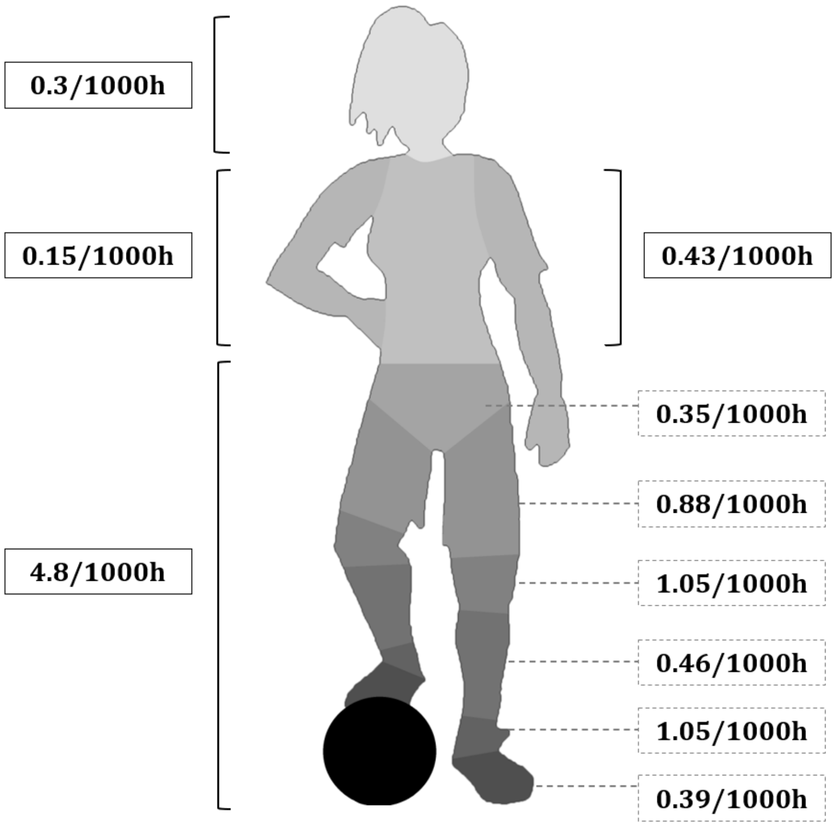

Figure 5 Injury incidence rates (with 95% confidence intervals) by location of lower extremity injuries.

3.3.3 Type of injury

Fifteen studies were included in the pooled analysis [14-19,22,24,25,52,53,55,56,58,59]. The mean incidence is presented per 1000 hours of exposure with 95%CIs. The most common type of injury grouping was muscle/tendon (1.8, 95%CI = 1.2 to 2.4, I^2 = 98.6), followed by joint [non-bone] and ligament (1.5, 95%CI = 1.1 to 1.9, I^2 = 96.3), undefined/other injuries (0.8, 95%CI = 0.3 to 1.4, I^2 = 99.8), contusions (0.7, 95%CI = 0.4 to 1.0, I^2 = 96.6), central/peripheral nervous system injuries (0.2, 95%CI = 0.1 to 0.3, I^2 = 86.8), fracture and bone stress (0.2, 95%CI = 0.1 to 0.3, I^2 = 64.7) and the least common injury type grouping was laceration and skin lesions (0.05, 95%CI = 0.03 to 0.07; I^2 = 66.6) (Figure 6).

3.3.4 Severity of injury

Concerning severity of injuries, nine studies (10 cohorts) were included in the pooled analysis [14,15,17,20,22,24,25,50,56]. Minimal injuries (2.2 per 1000 hours of exposure, 95%CI = 1.0 to 3.4, I^2 = 98.0) were the most usual injuries, followed by moderate (2.1 per 1000 hours of exposure, 95%CI = 1.4 to 2.4, I^2 = 89.6), minor (1.7 per 1000 hours of exposure, 95%CI = 0.9 to 2.4, I^2 = 95.1) and severe (1.1 per 1000 hours of exposure, 95%CI = 0.9 to 1.2, I^2 = 96.5) injuries. A figure displaying the injury severity categories and their respective incidence rates is available in the online supplementary appendix 9.

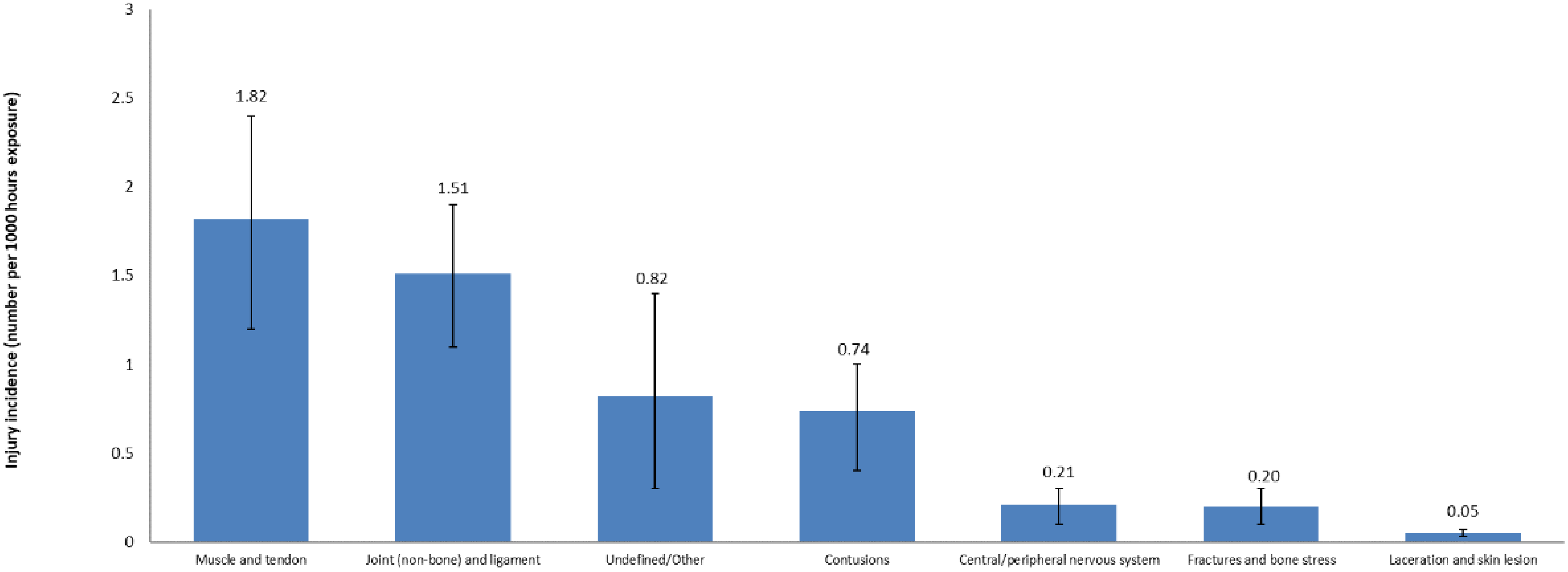

Figure 6 Injury incidence (with 95% confidence intervals) by type of injury.

3.3.5 Mechanism of injury

Fourteen studies (14 cohorts) were involved in the meta-analysis to compare overuse injuries versus traumatic injuries [14-20,22,23,52,53,56,58,59]. The incidence in traumatic injuries (4.5, 95%CI = 3.4 to 5.5, I^2 = 97.9) was higher than in overuse injuries (1.6, 95%CI = 1.0 to 2.1, I^2 = 97.6).

3.3.6 New vs. recurrent injuries

Seven studies (nine cohorts) were included in an analysis which compared the incidence of new versus recurrent injuries [14,15,17,18,20,50,53]. The incidence rate of new injuries (4.6 per 1000 hours of exposure, 95%CI = 3.4 to 5.8, I^2 = 92.5) was higher than recurrent injuries incidence rate (1.8 per 1000 hours of exposure, 95%CI = 0.6 to 3.0, I^2 = 98.1).

3.3.7 Level of play

Seven studies reported overall injury incidence [16-19,24,25,53], five studies reported training injury incidence [16-18,24,25] and five studies reported match injury incidence [16-18,24,25] in top-5 leagues. The random effect models for injury incidence showed an overall incidence of 4.3 injuries per 1000 hours of exposure (95%CI = 4.2 to 4.5, I^2 = 96.1%), a training incidence of 2.4 injuries per 1000 hours of training exposure (95%CI = 2.2 to 2.5, I^2 = 94.3%) and a match incidence of 19.3 injuries per 1000 hours of match exposure (95%CI = 18.2 to 20.4, I^2 = 94.5%).

Other leagues were represented by five overall injury incidence studies [14,15,23,58,59], four training injury incidence studies [14,15,58,59] and five studies from matches [14,15,50,58,59]. The random effect models for injury incidence showed an overall incidence of 5.4 injuries per 1000 hours of exposure (95%CI = 5.1 to 5.8, I^2 = 97.4%), a training incidence of 2.6 injuries per 1000 hours of training exposure (95%CI = 2.3 to 2.8, I^2 = 92.2%) and a match incidence of 10.7 injuries per 1000 hours of match exposure (95%CI = 9.8 to 11.8, I^2 = 94.0%).

3.3.8 National leagues vs. international tournaments

For this comparison, 19 studies were divided into two groups: a) national leagues - studies in football clubs leagues; and b) international tournaments - studies in national teams during international tournaments (World Cups, Olympic Games and European championships). Fourteen, ten, and eleven studies carried out in football clubs reported overall [14-19,23,24,25,52,53,56,58,59], training [14–18,25,52,56,58,59], and match [14-18,24,50,56-59] incidence rates. On the other hand, two (4 cohorts), two (4 cohorts), and four studies (8 cohorts) in national teams reported overall [20,22], training [20,22] and match [20–22,54] incidence rates. Incidence rate in international tournaments was higher than national leagues (8.8, 95% CI = 3.1 to 14.5 vs. 5.7, 95% CI = 4.2 to 7.1, respectively). In particular, the mean incidence rates in training and match were in descending order: international match: 24.6 (19.8 to 29.3, I^2 = 54.1); national match: 17.3 (13.7 to 21.0, I^2 = 95.7); national training: 3.8 (2.4 to 5.1, I^2= 98.5); and international training: 2.1 (0.0 to 3.4, I^2 = 0.0).

3.3.9 Injury proportion

Fourteen studies (16 cohorts) provided sufficient data (i.e. number of participants and number of injuries) to enable calculation of the injury IP [14-20,22,23,52,53,56,58,59]. The overall injury IP was 1.1 (95%CI = 0.6 to 1.7, I2 =

79.5%). The weighted injury IP varied from 0.06 to 4.6 and seven studies reported an injury IP of >1 due to multiple injuries sustained by the athletes or a long follow-up of the players. Online supplementary appendix 10 shows injury proportion forest plot.

4 Discussion

The purposes of this study were to perform a systematic review and meta-analysis quantifying the incidence of injuries in women´s football as well as to conduct sub-analyses to determine the overall effects regarding location of injuries, type of injuries, severity of injuries, overuse and traumatic injuries, new and recurrent injuries, level of play, national leagues (clubs) and international tournaments (national teams). Likewise, injury proportion was also calculated through a separate meta-analysis.

Both the methodology and statistical analyses used in the current study were identical to those in the systematic review and meta-analysis conducted by Lopez-Valenciano et al. [27] in professional (i.e. elite) male football players and hence, inter-sex comparisons in injury profile can be made.

4.1 Injury incidence: overall, training and match

The main findings of the current study indicate that the overall, training and match injury incidence rates (6.1, 3.5 and 19.2 injuries per 1000 hours of overall, training and match exposure, respectively) in women´s football are similar to the injury incidence rates provided by previous meta-analyses in other women´s team sports such as bat (i.e. cricket and softball) and stick (i.e. field hockey and lacrosse) sports (6.2, 3.1 and 15.8 injuries per 1000 hours of overall, training and match exposure, respectively) [39] and rugby union (1.5 and 19.6 injuries per 1000 hours of training and match exposure, respectively) [61].

However, overall injury incidence rates found in this study were lower than those recently reported in professional male football players (8.1 injuries per 1000 hours of overall exposure) [27]. This sex-related difference is mainly accounted for by the lower match incidence rate reported in females football players, which demonstrated a nearly two-fold lower value than their counterpart males (19.2 [females] vs. 36.0 [males] injuries per 1000 hours of match exposure). The results found in the current study together with the main findings reported in the meta-analysis conducted by Lopez-Valenciano et al. [27] seem to indicate that both female and male football players present comparable knee (1.1 [females] vs. 1.2 [males]) and ankle (1.1 [females] vs. 1.1 [males]) injury rates. Therefore, these sex-related differences in match injury incidence may be partially attributed to the fact that male football players report two times higher thigh (mainly muscle injuries) and contusion injury incidence rates than their female counterparts (1.8 [males] vs. 0.9 [females] and 1.4 [males] vs. 0.7 [females] thigh and contusion injuries per 1000 hours of exposure, respectively). The higher rate of contusions in male players might be due to higher intensity and more contact situations in men´s football [62] along with the fact that males appear to have a two-fold higher risk of suffering an injury in tackling situations [63]. Likewise, some observational studies have also identified that males are exposed to a larger number of aerial duels and challenges during matches than their female counterparts [63,64], which may also contribute to their higher risk of suffering contusions. This higher incidence of contusions might also explain the reason why males have a higher incidence of minimal injuries compared to females (3.1 [males] vs. 2.2 [females] injures per 1000 hours of exposure), as often a large number of contusions are minimal in severity [27].

Male football players perform more high intensity actions (e.g.: sprints, sudden changes of direction, fast accelerations and deaccelerations) and at higher absolute intensities during match play compared to females [65–68]. The succession of these high intensity actions during the course of a football match play could induce neuromuscular fatigue (mainly during the last 15 minutes of each half) that might significantly reduce eccentric strength [69,70] and alter explosive-type movement patterns (i.e. sprint, accelerations and deaccelerations) [65,71-73] in male football players, which are suggested to increase the risk of thigh muscle injuries (hamstring strains mainly) [74,75]. Furthermore, the higher match congestion and larger training and match exposure per player-season observed in male football players in comparison with female footballers has been previously associated with a higher muscle injury incidence [17]. The congested competitive calendar of professional men´s football might result in players developing chronic sub-optimal readiness situations (caused, among other factors, by an insufficient post-match recovery and/or accumulated fatigue [76]), which has been suggested as a primary risk factor for muscle injuries [77].

In line with other team sports (independent of the sex of the players) such as basketball [78], field hockey [79], floorball [80], handball [81] and rugby union [61], match injury incidence is always significantly higher than training incidence. A number of studies have attributed these differences in injury incidence rates between match and training to several factors, including: the higher physical demands of players during matches in comparison with training sessions, the variability and uncertainty generated in players when competing against rivals [82], the number of contacts and collisions accounted for during matches [62,83] and the fatigue generated during the course of the match [84]. Although still under debate, it has been suggested that training may not replicate match-play enough to provide robustness and readiness to perform in competitive play [85]. In order to reduce the number of injuries sustained during football match play, training session design (i.e., workload, intensity, duration), when possible, should mimic match demands so that players are better prepared for what they face during matches [86,87].

4.2 Location and type of injuries

In women´s football and similar to what has been found for men´s football [27], lower extremity injuries had the highest incidence rates compared to the other body regions. In the current study the knee and ankle (1.1 injuries per 1000 hours of exposure) were the anatomical regions most frequently injured in women´s football, closely followed by the thigh (0.9 injuries per 1000 hours of exposure). However, the location of the most frequently reported injuries in men´s football was slightly different, whereby the thigh was the anatomical region where injuries occurred most (1.8 injuries per 1000 hours of exposure), followed by the knee (1.2 injuries per 1000 hours of exposure) and ankle (1.1 injuries per 1000 hours of exposure). This higher thigh injury incidence rate documented in men´s football may be explained by the fact that male footballers sustain more muscle injuries (1.8 [females] vs. 4.6 [males] [27] injuries per 1000 hours of exposure) than their female counterparts, in particular in hamstring muscle strains [17,88]. This is supported by a recent five-year prospective study, carried out in two male and female elite football teams, which found that males presented a 93% higher rate of hamstrings strains than females [17]. It should be also highlighted that in women´s football, and similar to what has been observed for men´s football (0.2 per 1000 hours of exposure, 95%CI = 0.1 to 0.3) [27], neck and head injury incidence rate (0.3 per 1000 hours of exposure, 95%CI = 0.2 to 0.4) may be considered worrying high (mainly concussions and mild traumatic brain injuries) due to their potential acute and chronic changes (structural and functional) that could be elicited in the brain [89,90]. In addition, some studies have suggested that these neck and head injury figures may be even higher as they are frequently underdiagnosed due to inconsistencies in the interpretation of their symptoms and reporting [91]. Player-to-player contact has been identified as the mechanism responsible for the greatest proportion of concussions in both male and female football players (with purposeful heading rarely resulting in concussion) [91]. Therefore, reducing player contact through rule changes or stricter enforcement has been suggested as an effective measure to prevent neck and head injuries [92]. Stricter rules punishing aerial challenges that involve elbows to the head, head-to-head or hand-to-head contact (e.g., goalkeeper) may diminish rates of head injury. Strength and awareness training may increase a player ability to prepare and brace for an impact to the body or head, reducing the likelihood of suffering a serious head injury. The use of lower ball inflation pressures and novel technological devices such as the neck collar [93] may help mitigate the risks of dangerous head injury. Finally, recognition and awareness of concussions through external observation and removal of athletes from play is also of paramount importance.

With respect to the location of injuries, it should be highlighted that female footballers presented with a three-fold lower hip/groin injury incidence rate than males (0.3 vs. 0.9 injuries per 1000 hours of exposure). Although reasons for these sex-related differences are still unclear, it might be explained by the fact that women have a lighter and wider pelvis and larger subpubic angle, which may help in the transference of destabilizing forces away from the hip/groin area to the lower extremities [94]. In this sense, the frontal plane angle between the midline of the body and the line-of-action of the hip adductors is probably greater for women (∼ 90º) than men (∼ 65º), which may influence the force vectors at their proximal attachments and thus enhancing the transmission of loading force to the lower extremities [95]. Sex-related differences in inguinal anatomy may also explain why groin pain is more common in men than women soccer players. Compared with men, women have a narrower superficial [96] and deep inguinal ring [97] as the diameter of the round ligament is smaller than the spermatic cord. Furthermore, the transversus abdominis muscle and transversalis fascia (contributing to the posterior wall of the inguinal canal) are usually better developed and stronger in women than in men. The less robust nature of these structures may lead men players be more prone to groin pain. Finally, Other possible reasons for this sex bias in hip/groin injury incidence rates may include differences in muscle strength and force development, training and match load and playing intensity [98].

The most common types of injury in female football players were muscle/tendon (1.8 injuries per 1000 hours of exposure) and joint [non-bone] and ligament (1.5 injuries per 1000 hours of exposure). Due to the lack of epidemiological studies reporting incidence rates in female footballers separately for different muscle groups (e.g.: hamstring, quadriceps, triceps surae) and joints (non-bone) and ligaments (e.g.: anterior cruciate ligament [ACL] of the knee, anterior inferior tibiofibular ligament of the ankle) a sub-analysis aimed at identifying the most injured muscle groups and joint (non-bone) and ligament was not possible. However, previous studies have consistently reported that quadriceps and hamstring strains and ankle sprains were the most frequent injuries diagnosed in female football players [99].

As it has been mentioned before, the muscle injury rate found in the current study for female footballers was three-fold lower than the ones reported by Lopez-Valenciano et al. [27] in males. Furthermore, and unlike that which has previously been reported for males, quadriceps strains are more frequently diagnosed than hamstring strains in female football players [17]. Kicking has been acknowledged as the primary mechanism of quadriceps strain, and the activation of hip flexors seems important in protecting the quadriceps during the swing phase [100]. It has been documented that female football players show a lower iliacus activation compared to males during ball kicking [101], which might predispose females to sustaining more quadriceps strains than males. The fact that males and females play football with a ball of the same weight also needs to be considered, as females kick a relatively heavier ball [102,103]. Sex-related differences in training content may be another important factor (e.g., the type and amount of kicking, strength, or preventive training) [17].

Female football players showed four-fold higher joint [non-bone] and ligament incidence rates than their male counterparts (1.5 [females] vs. 0.4 [males] injuries per 1000 hours of exposure). In this sense, and for example, previous studies have documented that female athletes engaged in intermittent team sports (including football) have 2 to 6 and 2 to 5 [17,39] more likelihood of suffering ACL tears [17,26,104] and severe ankle sprains [17], respectively, than males. Sex-related differences in body architecture [106] and hormonal fluctuations [96] as well as in biomechanics and neuromuscular control of the trunk, hip and knee [107–111] may potentially explain why female athletes are more prone to sustain severe ligament injuries then males. These differences may lead female players to be more prone to adopt altered lower extremity movements and motor control strategies during the execution of high intensity soccer-specific dynamic tasks (e.g.: cutting and landing) such as an excessive dynamic valgus motion at the knee and limited hip, knee and ankle flexion ranges of motion, which have been identified as dominant patterns for knee and ankle ligament injuries [112-113].

4.3 Severity of injury

Although injuries occur frequently in female football players, the majority appear to be of minimal (1–3 days lost from football play) or minor (4–7 days lost from football play) in terms of severity. However, the severe injury incidence rate found in this study may be consider high (1.1 severe injuries per 1000 hours of exposure) due to the fact that in applied settings, it might imply that in a typical football squad comprised of 20 female players, that 2 - 3 players would sustain a severe injury per season (value calculated using the data provided in [14,15,17,22,24,25,50,56]). This circumstance may have a meaningful short and long-term impact not only on the players well-being but also on the team's success [114] and clubs' financial performance [115]. As previous studies exploring the location and type of football-related injuries have only reported incidence rates and not the average number of days lost from football (time loss), it was not possible for us to calculate the injury burden (the cross-product of severity [consequences] and incidence [likelihood]) to build a risk matrix. The risk matrix would have helped to identify the importance (i.e. burden) of each football-related injury and may provide information to help prioritize injury prevention measures used in applied football environments. However, and based on the findings shown in previous studies [17,62,99,116], the most burdensome injuries in women´s football may be quadriceps and hamstring muscle injuries and knee (ACL mainly) and ankle ligament injuries. For example, Larruskain et al. [17] reported that, in an elite football team, 43% and 10% of the days that female players were away from playing football were due to ACL and quadriceps muscle injuries, respectively.

Compared to males, female football players showed a higher severe injury rate (1.1 [females] vs. 0.8 [males] minimal injuries per 1000 hours of exposure]. Although from a statistical standpoint this sex-related difference in severe injury incidence may not be significant, it could be relevant from an injury burden perspective. Thus, this difference of 0.3 could mean that, per season, a female football team comprised by 20 players will suffer approximately 1.3 severe injuries more than a male team with equal number of players. Several reasons have been suggested for this sex-related differences observed in severe injury rate, including: a) the higher incidence of severe joint/ligament injuries (mainly ACL and severe ankle ligament injuries) observed in females [17,117], b) the level of professionalism is much lower in the female leagues and c) the medical support is lower in the female clubs and a delayed diagnosis and/or less optimal rehabilitation of injured players could lead to more severe injuries [62].

As it has been documented for young players [118-120], the application of football-specific neuromuscular training programs with the aim of optimizing players' motor competency, joint stability and delaying the onset of fatigue might reduce the relative risk of these severe injuries.

4.4 New versus recurrent injuries

As expected, and similar to what has been reported in male football players [27], recurrent injury incidence in women´s football is lower than the new injuries rate (1.8 vs 4.6 injuries per 1000 hours of exposure). However, the recurrent injury rate identified in both female (1.8 injuries per 1000 hours of exposure) and male (1.2 injuries per 1000 hours of exposure [27]) football players may be considered high. This circumstance may reflect a premature return to train/play and incomplete or inadequate rehabilitation. The lack of evidence-based criteria for a safe return to train/play alongside the fact that team managers and coaches may be tempted to let injured players return to play important matches or to let them play with ongoing minor symptoms might be two reasons behind the high recurrent injuries incidence rates.

4.5 Level of play

The results of this study highlight that top-5 leagues presented similar overall and training incidence rates than non-top 5 world ranking leagues (4.3 [top-5] vs 5.4 [other leagues] and 2.4 [top-5] vs 2.6 [other leagues] injuries per 1000 hours of overall and training exposure, respectively). However, top-5 leagues reported higher match injury incidence rates than other leagues (19.3 [top-5] vs. 10.7 [other leagues] injuries per 1000 hours of match exposure). These findings may be attributed to the documented differences in the physical demands, number and density (i.e. match congestion) of matches played across the season between teams engaged in top-5 world ranking leagues and teams from other leagues [121,122], which may situate players engaged in the top leagues at a higher risk situation during matches. Slightly different findings were found in men´s football, whereby the injury incidence rates (overall, during training and match play) were similar between top-5 level European leagues and the rest of the professional leagues [27]. It is likely that the gap in terms of professionalism (e.g.: number of medical and performance staff members, available testing and training equipment), match physical demands and training status of players between women´s top-5 leagues and the rest of the leagues may be wider than in men´s football, which may explain the reason why, and unlike men footballers, match injury rates were higher in female players engaged in top-5 leagues than their peers in the other leagues.

4.6 National leagues versus international tournaments

As expected, the incidence rate during international matches (8.8 injuries per 1000 hours of exposure) was higher than during national matches (5.7 injuries per 1000 hours of exposure). Similar to that which has been found for male football players, the higher density of matches played, the mental stress and anxiety generated in the players, and the fact that international competitions are usually played during summer periods (at the end of a long season where accumulated fatigue may play a part) may be contributing factors for this difference [123,124].

4.7 Injury proportion

The overall injury proportion for female football players was 1.1 (95%CI = 0.6 – 1.7). An injury IP of >1 is indicative of multiple injuries sustained by a single player, and this was reported in seven of the 14 cohorts included in this meta-analysis. One of the main reasons that could explain this injury proportion score of 1.1 might be attributed to the fact that most of the epidemiological studies in which the same teams were prospectively followed up during two or more seasons did not report the number of injuries recorded per season, but only provided the total number of injuries accounted within the whole follow up period. Subsequently, it is very likely that in these studies a player sustained more than one injury throughout the follow up period, which may have biased the injury proportion score. Therefore, when the number of injuries per season is not reported in multi-season prospective studies then the longer the follow up period the higher the likelihood of a player is of sustaining multiple injuries and consequently inflating the injury proportion score. A clear example of this circumstance can be found in the study conducted by Larruskain et al. [17], where the same team was followed up during five seasons, and whose injury proportion score was 4.6. An injury IP of >1 could also be due to differences in injury definitions, data collection methods and the manner in which injuries are classified. For example, a medical- attention-based injury definition could underestimate the true burden of injuries because it might not capture minor injuries and some chronic/overuse injuries because these injuries might not require treatment.

4.8 Level and quality of evidence

Item 26 of the Downs and Black appraisal criteria [38] relates to the reporting of study participants lost to follow-up. All articles reviewed, except one [53], failed to clearly define the loss of participants to follow-up. This further highlights the need to follow reporting guidelines such as STROBE when designing and reporting relevant surveillance studies. Reporting of loss to follow-up is an important aspect of an epidemiological study, and incomplete follow- up can compromise the validity of the study (type II error) and increase the bias [125]. In this sense, thirteen of the twenty-one studies included in this study obtained more than 20 points, which demonstrates the good quality of the studies. However, the three oldest studies demonstrated a very low quality and low validity. Finally, the Newcastle-Ottawa scale showed an overall very high quality of the studies included, with only one study below 5 points. None of the studies included pointed out the presence or absence of injuries in the players collected at the beginning of their studies. Thus, future epidemiological studies should clearly report the number of female players who enter and exit study cohorts to enable calculation of loss to follow-up and report findings accordingly. This information is vital to calculate overall effect sizes and limited which studies could be included in the meta-analyses. It is strongly recommended that such detail is included in the reporting of future studies.

4.9 Limitations

Like other meta-analysis conducted in sport medicine settings [27,40,44], variations in injury and severity definitions associated with older studies resulted in a substantive number of excluded articles. Only those studies that rigorously and clearly followed the definitions of injury described by Fuller et al. [60] were included. Also, when different epidemiological data were used (e.g.: hours of athlete exposure, total number of injuries, number of matches played) and therefore various methods of data collection, we applied standardised formulas to account for this discrepancy. Nevertheless, even when our inclusion criteria for sub-analysis and standardised formulas were applied the degree of inconsistency of the results across studies were still very high ($I^2 > 90\%$). Similar to men´s football, other potential sources of inconsistency may have been the differences existing among the national leagues in terms of climatic regions (cooler and warmer areas) [126], periods of fixed match congestion [79,127], numbers of matches and in-season breaks [128] as well as the level of professionalism [8,129]. Additionally, the sample size of studies included was not sufficient to investigate interactive effects within factors (e.g. playing position by level of play; contact or non-contact situations) or whether injury rates are associated with a violation of the competition rules (a variable that has not been thoroughly explored). Furthermore, the lack of studies that reported the average number of days lost from football, caused by specific types of injuries, did not allow us to present data on injury burden. In our analysis separate incidence rates reported in studies that covered multiple seasons or cups were considered as independent when multiple comparisons were conducted. In this instance the same player may have been counted more than once over the different seasons. However, for each separate incidence rate recorded, the same player was counted only one time. Unfortunately, only three authors corresponded when asked for additional information subsequently limiting the data we had access to.

4.9 Future directions

Unlike research in professional male football, epidemiology studies in female football players are still scarce, with a large proportion of data from European countries (mainly German and Sweden), so further global research in this field is necessary. To meet the epidemiological challenges presented by women´s football, future studies should report incidence and severity separately for different muscle groups (e.g.: hamstring, quadriceps, triceps surae) and joints (non-bone) and ligaments (e.g. ACL of the knee, anterior inferior tibiofibular ligament of the ankle). This knowledge may be used to assist the design of tailored measures aimed at reducing the occurrence of the most burdensome injuries. Furthermore, in order to improve the methodological quality of the further epidemiological studies, the loss of players to follow-up should be clearly define and report findings accordingly.

5 Conclusions

Female football players, both elite and amateur, are exposed to a substantial risk of sustaining injuries, especially during matches. Lower extremities are the most common location of injuries, specially knee and ankle injuries, which is related with the high injury incidence of joint (non-bone) and ligament. High level football players have a lower risk of injury, although international tournaments continue to have the highest incidence of match injuries. Future studies should focus on introducing and evaluating preventative measures that target the most common diagnoses, namely, muscle/tendon and joint (non-bone) and ligament injuries highlighted in this meta-analysis, in order to reduce the number and severity of injuries within female football players.

Data Availability

The authors declare that data supporting the findings of this study are available within the article and its supplementary information files.

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Appendices

Appendix 1. PRISMA checklist.

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	3
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	3
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	4
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	4
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	4
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	4
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	4
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	5

Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	5
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	5-6
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	7
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	7
Section/topic	**#**	**Checklist item**	**Reported on page #**
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	6
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	7
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	7-8
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	8
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	8
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	8-9
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	8-11
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	8
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	8-11
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	11-16

Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	17
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	17
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data), role of funders for the systematic review.	No funding

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit: **www.prisma-statement.org**.

Appendix 2. Search strategies.

Search strategy in PubMed -1165 results

#1 (soccer[tiab] OR "soccer"[MeSH Terms] OR football[tiab] OR "football"[MeSH Terms]) AND (injury[tiab] OR "injury"[MeSH Terms] OR injuries[tiab] OR "injuries"[MeSH Terms] OR incidence[tiab] OR "incidence"[MeSH Terms] OR prevalence[tiab] OR "prevalence"[MeSH Terms] OR epidemiology[tiab] OR "epidemiology"[MeSH Terms]) AND (adult[tiab] OR "adult"[MeSH Terms] OR senior[tiab] OR "senior"[MeSH Terms]) AND (female[tiab] OR "female"[MeSH Terms] OR women[tiab] OR "women"[MeSH Terms])

#2 #1 Filters: Published up to December 31st, 2019.

Search strategy in the Cochrane Central Register of Controlled Trials – 411 results

#1 soccer [Title/Abstract/Key Word] OR football [Title/Abstract/Key Word] AND injur [Title/Abstract/Key Word] AND women [Title/Abstract/Key Word] OR female [Title/Abstract/Key Word]

#2 football [Title/Abstract/Key Word] AND injur [Title/Abstract/Key Word] OR incidence [Title/Abstract/Key Word] OR epidemiolog [Title/Abstract/Key Word] AND female [Title/Abstract/Key Word]

#3 football [Title/Abstract/Key Word] AND injur [Title/Abstract/Key Word] OR incidence [Title/Abstract/Key Word] OR epidemiolog [Title/Abstract/Key Word] AND women [Title/Abstract/Key Word]

#4 #1 AND #2 AND #3

#5 #4 Filters: Published up to December 31st, 2019 (by hand).

Search strategy in Web of Science – 169 results

#1 TI=(football OR soccer)

#2 TI=(injur* OR incidence OR prevalence OR epidemiology)

#3 TI=(women OR girl OR female)

#4 #3 AND #2 AND #1

Search strategy in Sportdiscus – 151 results

#1 ('Football' OR 'soccer') AND ('injury' OR 'incidence' OR 'epidemiolog*' OR 'prevalence') AND (female OR women)

Appendix 3. Moderator variables codded.

General study descriptors
▪ Authors
▪ Year of the study
▪ Country / Tournament
▪ Sampling time (number of seasons)
Description of the study population
▪ Sample size
▪ Number of teams
▪ Age
▪ Level of play (amateur or elite)
Epidemiological descriptors
▪ Injury definition
▪ Number of injuries (total, match and training)
▪ Exposure time (total, match and training)
▪ Incidence (total, match and training)
▪ Injury burden or days lost per injury
▪ Injury location
▪ Type of injury
▪ Severity of injury
▪ Recurrence
▪ Injury mechanism (traumatic or overuse)
▪ Quality of the study (STROBE scale)
▪ Quality of the study (Downs & Black)
▪ Risk of bias (adapted NOS scale)

Appendix 4. Description of the 22 criteria designed to assess quality of the studies included in the meta-analysis with the STROBE scale.

	Item	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed
		(*e*) Describe any sensitivity analyses
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—e.g. numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (ego demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (e.g., average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (ego, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period

Other analyses	17	Report other analyses done—e.g. analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Appendix 5. Description of the 8 criteria designed to assess risk of bias of external validity quality in the studies[T]. This instrument is an adapted version of the Newcastle Ottawa Scale (NOS) for cohort studies.

Criterion	Description of criteria
1. Description or type of football players.	There are several types of football players (amateur vs. professional, males vs. females). Without the description regarding to the type of football players it is impossible to conclude which population the incidence rates refer to. Studies that reported a description of the football players or informed the type of football players receive a star for this criterion. Studies conducted in football tournaments (which may determine the type of football players, e.g., World cup tournaments) and which describe the race characteristics receive a star for this criterion as well. Studies that did not describe the characteristics or the type of football players, and studies conducted in football tournaments that did not describe the characteristics of the tournament did not receive a star for this criterion.
2. Definition of football-related injury.	Studies that aimed to investigate football-related injuries should present a definition of an injury informing what was considered as an injury in the study. Studies that present a definition of time-loss injury received a star for this criterion.
3. Representativeness of the exposed cohort.	(a) Truly representative of the average football players in the community*; (b) somewhat representative of the average football players in the community*; (c) selected group of users; (d) no description of the derivation of the cohort.
4. Ascertainment of exposure.	(a) Secure record*; (b) structured interview*; (c) written self-report; (d) no description
5. Demonstration that outcome of interest was not present at start of study.	(a) Yes*; (b) no. Studies that described that all football players included were injury-free at baseline received a star for this criterion.
6. Assessment of outcome.	(a) Independent blind assessment*; (b) record linkage*; (c) self-report; (d) no description.
7. Was follow-up long enough for outcomes to occur risk factors.	(a) Yes*; (b) no. Studies that carried out a follow-up period of at least 12 weeks received a star for this criterion.
8. Adequacy of follow-up of cohorts	(a) Complete follow-up of all subjects accounted for*; (b) subjects lost to follow-up unlikely to introduce bias (up to 20 % loss) or description provided of those lost*; (c) follow-up rate <80% and no description of

	those lost; (d) no statement. A loss to follow-up greater than 20 % may increase the risk of bias in prospective studies (Fewtrell et al., 2008).

[T]: The articles could be awarded a maximum of one star for each item. A total of 8 stars could be given for the articles.

* Articles with this alternative received a star for this criterion.

Appendix 6. Analysis of the selected studies' methodological quality-STROBE (n = 20).

Study	1a	1b	2	3	4	5	6a	6b	7	8	9	10	11	12a	12b	12c	12d	12e	13a	13b	13c	14a	14b	14c	15	16a	16b	16c	17	18	19	20	21	22	Score
Babwah (50)	+	+	+	+	+	+	-	-	+	+	-	-	+	-	+	-	-	-	+	+	-	-	-	+	+	+	-	-	-	+	+	+	+	-	19
Becker et al. (19)	+	+	+	+	-	-	-	-	+	+	-	-	-	-	-	-	-	-	+	-	-	+	-	+	+	+	-	-	-	+	-	+	+	+	15
Ekstrand et al. (23)	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	-	-	-	+	-	-	+	-	+	+	+	+	+	+	+	+	+	+	+	27
Ellias et al. (51)	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	+	-	+	+	+	12
Engstrom et al. (52)	+	+	+	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	+	-	+	+	-	11
Faude et al. (53)	+	+	+	+	+	+	+	-	+	+	-	-	+	+	+	-	+	-	+	+	-	+	-	+	+	+	+	+	-	+	+	+	+	-	25
Fuller et al. (24-25)	+	+	+	+	+	+	+	-	+	+	-	+	+	+	+	-	-	-	+	-	-	+	-	+	+	+	+	+	+	+	-	+	+	-	24
Gaulrapp et al. (18)	+	+	+	+	+	+	+	-	+	+	-	-	+	-	-	-	-	-	+	-	-	+	-	+	+	+	-	+	-	+	+	+	+	+	21
Giza et al. (16)	+	+	+	+	-	-	-	-	+	-	-	-	+	-	-	-	-	-	+	-	-	-	-	+	+	-	-	-	-	+	+	+	+	-	13
Hägglund et al. (20)	+	+	+	+	+	+	+	-	+	+	-	-	+	+	+	-	-	-	+	-	-	+	-	+	+	+	-	+	-	+	+	+	+	+	23
Jacobson et al. (14)	+	+	+	+	+	+	+	-	+	+	-	-	+	+	+	-	-	-	+	-	-	+	-	+	+	-	+	+	+	+	-	+	+	+	23
Jacobson et al. (15)	+	+	+	+	-	+	+	-	+	+	-	-	+	-	-	-	+	-	+	+	-	+	-	+	+	+	-	-	-	+	-	+	+	+	20
Junge et al. (21)	+	+	+	+	-	+	+	-	+	+	-	-	+	+	-	-	-	-	+	-	-	+	-	+	+	+	+	-	-	+	-	+	+	+	20
Larruskain et al. (17)	+	+	+	+	+	+	+	-	+	+	-	-	+	+	+	-	-	-	+	-	-	+	-	+	+	+	+	+	+	+	+	+	+	+	25
Maehlum et al. (55)	+	+	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	-	-	-	-	+	-	+	+	-	10
Nilstad et al. (59)	+	+	+	+	+	+	+	-	+	+	-	-	+	+	+	-	-	-	+	-	-	+	-	+	+	+	-	-	-	+	-	+	+	+	21
Östenberg et al. (56)	+	+	+	+	+	+	+	-	+	+	-	-	+	+	+	-	+	-	+	-	-	+	-	+	+	+	-	-	-	+	-	+	+	+	22
Owoeye et al. (57)	+	+	+	+	+	+	+	-	+	+	-	-	+	+	+	-	-	-	+	-	-	+	-	+	+	+	+	+	+	+	+	+	+	+	25
Tegnander et al. (58)	+	+	+	+	+	+	+	-	+	-	-	-	+	-	-	-	-	-	+	-	-	+	-	+	+	+	-	-	-	+	-	+	+	+	18
Waldén et al. (22)	+	+	+	+	+	+	+	-	+	+	-	-	+	+	+	-	-	-	+	-	-	+	-	+	+	+	-	-	+	+	+	+	+	+	23

Appendix 7. Risk of bias assessment of the studies (Newcastle-Ottawa scale).

Study	Criteria for assessing risk of bias								Total
	1	2	3	4	5	6	7	8	
Babwah (50)	*	*	*	*		*	*	*	7
Becker et al. (19)	*	*	*			*	*	*	6
Ekstrand et al. (23)	*	*	*	*		*	*	*	7
Ellias et al. (51)			*	*		*	*	*	5
Engstrom et al. (52)	*	*	*	*		*	*	*	7
Faude et al. (53)	*	*	*	*		*	*	*	7
Fuller et al. (24-25)	*	*	*	*		*	*	*	7
Gaulrapp et al. (18)	*	*	*	*		*	*	*	7
Giza et al. (16)	*	*	*			*	*	*	6
Hägglund et al. (20)	*	*	*	*		*		*	6
Jacobson et al. (14)	*	*	*			*	*	*	6
Jacobson et al. (15)	*	*	*			*	*	*	6
Junge et al. (21)	*	*	*	*		*		*	6
Larruskain et al. (17)	*	*		*		*	*	*	7
Maehlum et al. (55)	*		*			*		*	4
Nilstad et al. (59)	*	*	*	*		*	*	*	7
Östenberg et al. (56)	*	*	*	*		*	*	*	7
Owoeye et al. (57)	*	*	*	*		*		*	6
Tegnander et al. (58)	*	*	*	*		*	*	*	7
Waldén et al. (22)	*	*	*	*		*		*	6

Criteria for assessing risk of bias: (1) description or type of football players; (2) definition of injury; (3) representativeness of the exposed cohort; (4) ascertainment of exposure; (5) demonstration that outcome of interest was not present at start of study; (6) assessment of outcome; (7) was follow-up long enough for outcomes to occur; (8) adequacy of follow-up of cohorts.

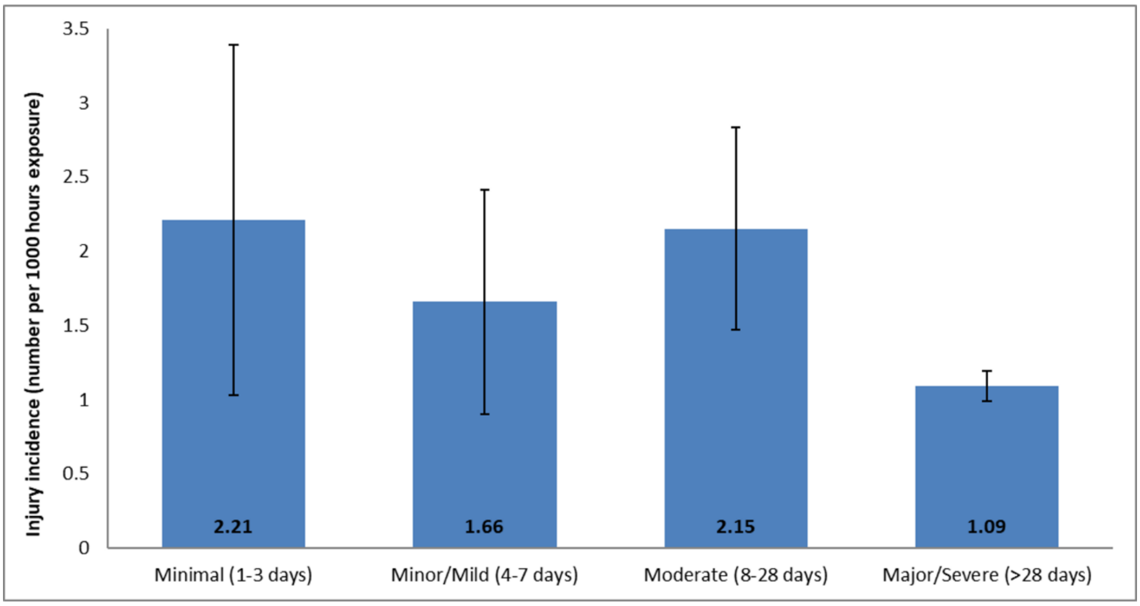
*Star(s) awarded for each criterion.

Appendix 8. Methodological quality ratings of reviewed studies.

Reference	DOWNS AND BLACK APPRAISAL CRITERIA																Total Score (/20)	(%)
	1	2	3	5	6	7	9	10	11	12	16	18	20	25	26	27		
Babwah (50)	1	1	0	0	1	1	0	1	0	1	1	0	1	0	0	5	13	65
Becker et al. (19)	1	0	1	0	1	0	0	0	0	1	1	0	1	0	0	4	10	50
Ekstrand et al. (23)	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	3	15	75
Ellias et al. (51)	1	0	1	1	1	0	0	0	0	1	1	0	1	0	0	0	7	35
Engstrom et al. (52)	1	0	1	0	1	0	0	0	1	1	1	0	1	0	0	0	7	35
Faude et al. (53)	1	1	1	0	1	1	1	0	1	1	1	1	1	0	1	3	15	75
Fuller et al. (24-25)	1	1	0	1	1	1	0	1	1	1	1	1	1	0	0	0	11	55
Gaulrapp et al. (18)	1	1	1	0	1	1	0	0	1	1	1	0	1	0	0	4	13	65
Giza et al. (16)	1	0	0	0	1	0	0	1	0	1	1	0	1	0	0	4	10	50
Hägglund et al. (20)	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	3	15	75
Jacobson et al. (14)	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	4	16	80
Jacobson et al. (15)	1	1	1	0	1	0	1	0	1	1	1	0	1	0	0	4	13	65
Junge et al. (21)	1	1	0	0	1	1	0	0	1	1	1	1	1	0	0	5	14	70
Larruskain et al. (17)	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	0	12	60
Maehlum et al. (55)	0	0	0	0	1	0	0	1	0	1	1	0	1	0	0	0	5	25
Nilstad et al. (59)	1	1	0	1	1	1	0	0	1	1	1	1	1	0	0	3	13	65
Östenberg et al. (56)	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	2	15	75
Owoeye et al. (57)	1	1	1	0	1	1	0	0	1	1	1	1	1	0	0	4	14	70
Tegnander et al. (58)	1	1	1	0	1	0	0	0	1	1	1	0	1	0	0	3	11	55
Waldén et al. (22)	1	1	0	1	1	1	0	1	1	1	1	1	1	0	0	3	14	70

Reference	DOWNS AND BLACK APPRAISAL CRITERIA																Total Score (/20)	(%)
	1	**2**	**3**	**5**	**6**	**7**	**9**	**10**	**11**	**12**	**16**	**18**	**20**	**25**	**26**	**27**		
Total (/20)	19	15	13	9	20	13	3	10	15	20	20	11	20	0	1	15	12.15 / 12.75	60.8
(%)	95	75	65	45	100	65	15	50	75	100	100	55	100	0	5	54	62.4	

Appendix 9. Injury incidence (with 95% confidence intervals) by severity of injury.



Appendix 10. Injury proportion (with 95% confidence intervals) forest plot.