Injury incidence rates in women's football: a systematic review and meta-analysis of prospective injury surveillance studies

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ABSTRACT

Objective To review the literature to establish overall, match and training injury incidence rates (IIRs) in senior (≥18 years of age) women's football (amateur club, elite club and international).

Design Systematic review and meta-analysis of overall, match and training IIRs in senior women's football, stratified by injury location, type and severity.

Data sources MEDLINE via PubMed; EMBASE via Ovid; CINAHL via EBSCO and Web of Science were searched from earliest record to July 2021.

Eligibility criteria for selecting studies (1) football players participating in a senior women's football league (amateur club or elite club) or a senior women's international football tournament; (2) the study had to report IIRs or provide sufficient data from which this outcome metric could be calculated through standardised equations; (3) a full-text article published in a peer-reviewed journal before July 2021; (4) a prospective injury surveillance study and (5) case reports on single teams were ineligible.

Results 17 articles met the inclusion criteria; amateur club (n=2), elite club (n=10), international (n=5). Overall, match and training 'time-loss' IIRs are similar between senior women's elite club football and international football. 'Time-loss' training IIRs in senior women's elite club football and international football are approximately 6–7 times lower than their equivalent match IIRs. Overall 'time-loss' IIRs stratified by injury type in women's elite club football were 2.70/1000 hours (95% CI 1.12 to 6.50) for muscle and tendon, 2.62/1000 hours (95% CI 1.26 to 5.46) for joint and ligaments, and 0.76/1000 hours (95% CI 0.55 to 1.03) for contusions. Due to the differences in injury definitions, it was not possible to aggregate IIRs for amateur club football.

Conclusion Lower limb injuries incurred during matches are a substantial problem in senior women's football. The prevention of lower limb joint, ligament, muscle and tendon injuries should be a central focus of injury prevention interventions in senior women's amateur club, elite club and international football.

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INTRODUCTION

Football (soccer) is the world's most popular sport with over 260 million participants globally, of which 30 million are female.[1] The Fédération Internationale de Football Association (FIFA) has the ambition of increasing the participation by girls and women in the sport to 60 million by 2026.[1] A report compiled by the Union of European Football Associations (UEFA) in 2017/2018 documented that the number of registered female players in UEFA member associations increased by 7.5% in 1 year from 1.27 million in 2016 to 1.37 million in 2017.[2] The report also highlighted that the number of registered professional and semiprofessional female players in UEFA's member associations more than doubled in 4 years from 1680 in 2013 to 3572 in 2017. The number of senior women's national teams among UEFA member associations rose from 47 in 2013 to 52 in 2017, with a concurrent increase in the number of senior domestic women's national leagues in UEFA member associations from 48 to 51.[2]

Women's football is a physically demanding contact sport involving intermittent bouts of sprinting, jogging, walking, jumping and changes of direction.[3–8] The physical demands of the game vary as a function of the level of play (ie, youth, amateur club, elite club, international), yet injury incidence rates (IIRs) across all levels of the women's game are high.[9–28] In a systematic review and meta-analysis of injuries in women's football, López-Valenciano *et al*[29] reported overall, match and training IIRs of 6.1/1000 hours (95% CI 4.6 to 7.7), 19.2/1000 hours (95% CI 16.0 to 22.4) and 3.5/1000 hours (95% CI 2.4 to 4.6), respectively. They also reported IIRs for the lower extremity, trunk, head and neck, and upper extremity of 4.8/1000 hours, 0.4/1000 hours, 0.3/1000 hours and 0.15/1000 hours, respectively. Regarding lower extremity injuries, they reported IIRs for the ankle, knee, thigh, lower leg/Achilles tendon, foot/toe and hip/groin of 1.1/1000 hours, 1.1/1000 hours, 0.9/1000 hours, 0.5/1000 hours, 0.4/1000 hours and 0.35/1000 hours, respectively. However, the systematic review and meta-analysis of López-Valenciano *et al*[29] has recently been criticised in a published commentary.[30] The main points of the criticism include: (1) a sole emphasis on 'time-loss' injuries; (2) lack of discussion regarding differences in injury reporting mechanisms and (3) drawing inferences from single-point estimates.

Injuries can have a substantial negative effect on team performance and can have a detrimental effect on the future career of football players.[31–33] FIFA's 2018 Women's Football Strategy outlines its plans to create women's football-specific medical and health programmes focused on injury prevention, playing conditions and female biology.[1] A thorough understanding of injury epidemiological outcome metrics in senior women's football, defined by FIFA

as age 18 and above, is a requisite initial step to inform the development and implementation of injury prevention initiatives.[34 35] Numerous prospective injury surveillance studies across different levels of play in senior women's football using different methodologies have been published in the past 30 years.[12–19 21 23 24 26 27] The objective of our systematic review and meta-analysis was to review the literature with the primary purpose of establishing overall, match and training IIRs in senior women's football (amateur club, elite club and international).

METHODS

We designed our review in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA-P) guideline.[36] Our PRISMA-P document is available as online supplemental file 1. Our review was registered in the PROSPERO International Prospective Register of Systematic Reviews (ID#CRD42020162895) before study selection and data extraction.

Eligibility criteria

To be deemed eligible for inclusion, studies were required to fulfil the following criteria (framed according to PICO): Population (P)—the study had to include: football players participating in a senior women's football league (amateur club or elite club) or senior women's international football tournament. Elite club football was defined as the highest national football league (eg, Frauen-Bundesliga in Germany).[12] Amateur club football was defined as any league below the highest national football league (eg, 2 Frauen-Bundesliga in Germany). International football was defined as a match between two national teams (online supplemental file 2). Intervention (I)—in this case the intervention is actually an exposure. The exposure is considered as either of the following: (1) participation in a senior women's football league (amateur club or elite club) for a minimum duration of one season; (2) participation in a senior women's international football tournament (eg, FIFA Women's World Cup). Comparator (C)—not applicable. Outcome (O)—the outcome of interest was injury (ie, a player sustained an injury defined as either time-loss, medical attention or all physical complaints). We used IIR as the primary outcome metric to quantify 'injury'. The study had to report IIRs or provide sufficient data from which this outcome metric could be calculated through standardised equations. IIR was calculated per 1000 units of exposure to football training or match play (ie, per 1000 hours). Additional criteria were as follows: (1) the study had to be a full-text article published in a peer-reviewed journal before July 2021; (2) the study had to be a prospective injury surveillance study and (3) case reports on single teams were ineligible.

Search strategy and study selection

A systematic search strategy was undertaken across electronic bibliographic databases; MEDLINE via PubMed; EMBASE via Ovid; CINAHL via EBSCO and Web of Science. The search terms were mapped to Medical Subject Headings (MeSH) terms where possible. Initially, search terms were applied from conception of each database to August 2019. The same systematic search strategy undertaken in July 2021 did not lead to the inclusion of any new studies.

The following is an example of the search conducted on the PubMed database: ("women"[MeSH Terms] OR "women"[All Fields]) AND ("football"[MeSH Terms] OR "football"[All Fields]) OR ("soccer"[MeSH Terms] OR "soccer"[All Fields]) AND ("wounds and injuries"[MeSH Terms] OR ("wounds"[All Fields] OR "injuries"[All Fields])

Studies were imported from EndNote into the systematic review software, 'Rayyan' (Cambridge, Massachusetts, USA). We used Rayyan to identify, screen (title, abstract and full-text articles), and include eligible records. Duplicate records were identified and removed. We exported included studies to an Endnote folder for data extraction. Study selection was performed by two reviewers (DH and ED) independently. A third reviewer (MH) was available if required to resolve disagreements among these reviewers and to facilitate consensus. The two reviewers independently screened the titles and abstracts of the identified peer-reviewed articles to assess eligibility for inclusion in this review. Full-length texts of remaining peer-reviewed articles were sought and reviewed in full to determine eligibility when reviewers were uncertain about their eligibility from title and abstract screening. The reference lists of included articles were searched to identify other potentially relevant articles. In addition, citation tracking was also used to identify potentially eligible studies.

Outcome metrics

The primary outcome measure of interest was injury (ie, a player has sustained an injury defined as 'time-loss', 'medical attention' or 'all physical complaints'). We used IIR, quantified per 1000 units of exposure (ie, per 1000 hours), as the primary outcome metric to quantify 'injury' within each study. Where possible we included the following outcome metrics: (1) overall IIR, (2) match IIR and (3) training IIR. If possible these outcome metrics were also calculated for: (1) level of play, (2) location of injury, (3) type of injury and (4) severity of injury (online supplemental file 2).

Data extraction

A standardised data extraction sheet (created in Microsoft Excel) was used to extract data. Data extraction was performed by two reviewers (DH and ED) independently. A third reviewer (MH) was consulted to resolve disagreements among these reviewers and to facilitate consensus. The data extraction sheet included the following items: (1) study characteristics, (2) participant characteristics, (3) study outcomes and (4) IIR data.

Risk of bias assessment and study quality

Presently, we are unaware of any tools available to correctly assess risk of bias in prospective injury surveillance studies. In a recent two-part educational review, Büttner *et al* cautioned that study quality and risk of bias are not synonymous.[37 38] They also recommended against the modification of risk of bias tools by adding new items or omitting existing items for the purpose of suiting the study characteristics.[37 38] Hence, we did not perform any risk of bias assessment for the studies included. To evaluate the quality of the data collection procedures of the included studies, we mapped all studies to the methodological domains of the 'checklist of issues that should be included in reports of studies of football injuries'.[39] This was performed by DH and ED. The results of this mapping process are presented in online supplemental file 3.

Statistical analysis

We performed a meta-analysis when relevant data had sufficient conceptual and methodological homogeneity between studies to permit quantitative aggregation. This decision was made by the authors based on their interpretation of perceived differences between study subpopulations (eg, amateur club, elite club,

international), exposure type and outcome metrics reported, as recommended by Higgins and Green,[40] Borenstein *et al*,[41] and Borenstein *et al*.[42]

IIRs and 95% CI limits were extracted from each study. When IIRs were not directly reported, we calculated/computed incidence rates, if sufficient data were presented in each study. We required sufficient data, so that we could divide the total number of injuries reported in the relevant study by the total number of exposure units (ie, exposure hours), which was then expressed per 1000 exposure hours. Fixed-effects and random-effects Poisson regression meta-analysis models were performed (depending on the clinical and methodological heterogeneity between included studies) to estimate pooled IIRs, as conducted in previous meta-analyses that have aggregated the results of injury surveillance studies.[43–45] Poisson-normal models were fitted using the log incidence rate—the response variable was the total number of recorded injuries divided by the log of the number of exposure hours. The estimated pooled log incidence rate was then exponentiated (ie, back-transformed) to reflect the pooled IIR and corresponding 95% intervals, per 1000 hours of exposure. In addition to modelling the pooled incidence rates for injuries that occur in match play and training, IIRs were also stratified for different levels of play, location of injury, type of injury and severity of injury.

In a random-effects model, it is assumed that the observed estimates (IRR in this case) can vary across studies, because of true differences in IRR, as well as sampling variability. τ^2 is the variance in distribution of true outcomes. τ^2 is on the same scale as the outcome metric (ie, IIR) and reflects the absolute amount of true heterogeneity.[41 42] I^2 statistics were also calculated to estimate the proportion of total variation that is attributable to true variation/heterogeneity.[46] Tentative benchmarks have been proposed to interpret I^2 statistics whereby I^2 values of 25%, 50% and 75% are considered low, moderate and high heterogeneity, respectively.[47] I^2 values greater than 75% were taken to indicate considerable heterogeneity between the studies, as were statistically significant Wald χ^2 tests ($p<0.05$). Meta-analytical models were constructed in RStudio (The R Foundation for Statistical Computing, Vienna, Austria) using the 'metafor' package.[47]

RESULTS

Descriptive characteristics of the studies

A total of 10 767 titles were identified through database searching and an additional 7 were identified through hand searching reference lists. From this total, 3349 references (31.10%) were excluded as duplicates, 7365 (68.40%) were removed after reading the title and/or abstract, 23 (0.21%) were excluded due to being a wrong study design and 19 (0.18%) were eliminated due to wrong study population. One study could not be accessed. The search process led to 17 articles meeting the inclusion criteria.[12 14–19 23 26 27 48–54] The PRISMA flow chart for the inclusion of studies is outlined in online supplemental file 4. Included studies were categorised as follows: (1) amateur club (n=2), (2) elite club (n=10) and (3) international (n=5). Metrics extracted included overall, match and training IIRs. Where possible IIRs were also extracted for location of injury, type of injury and severity of injury. Outcome metrics extracted and suitable for meta-analysis are detailed in online supplemental file 5.

Amateur club football

Two women's amateur club football injury surveillance studies were included.[50 54] These studies used 'time-loss' and 'hybrid'—did not satisfy that of a 'time-loss' or an 'all physical complaints' injury definition—injury definitions, respectively; hence, meta-analyses of reported or calculable outcome metrics were not possible, and as such, individual study results are reported below.

Amateur club football: IIRs

Jacobson and Tegner[50] reported overall, match and training 'time-loss' IIRs of 9.6/1000 hours, 13.3/1000 hours and 8.4/1000 hours, respectively—95% CIs were not reported or calculable from the data reported in the article. McNoe and Chalmers[54] reported match and training IIRs of 80.1/1000 hours (95% CI 65.0 to 98.1) and 11.9/1000 hours (95% CI 6.8 to 20.7), respectively. From these data, it was possible to calculate an overall IIR, which equated to 47.84/1000 hours (95% CI 38.56 to 57.13).

Amateur club football: location of injury

Jacobson and Tegner[50] reported on overall, match and training 'time-loss' IIRs stratified by location of injury. The ankle, knee, thigh, spine and head had the highest match IIRs; 3.9/1000 hours, 3.5/1000 hours, 1.9/1000 hours, 0.9/1000 hours and 0.9/1000 hour, respectively—95% CIs were not reported or calculable from the data reported in the article. McNoe and Chalmers[54] did not report on IIRs stratified by location of injury among the senior (≥18 years) female players included in their study.

Amateur club football: type of injury

Jacobson and Tegner[50] reported on overall 'time-loss' IIRs stratified by type of injury, but these were not substratified by match and training exposures. The three most common types of injury were: sprains (3.6/1000 hours); contusions (1.3/1000 hours); and strains (0.7/1000 hours). McNoe and Chalmers[54] did not report overall, match or training IIRs stratified by type of injury among the senior (≥18 years) female players included in their study.

Amateur club football: severity of injury

Neither Jacobson and Tegner[50] nor McNoe and Chalmers[54] reported on IIRs stratified by severity of injury.

Elite club football

Ten women's elite club football injury surveillance studies were included.[12 14–18 23 26 48 49] The study by Nilstad *et al*[23] included separate injury incidence outcome metrics based on player self-report and the recordings of medical personnel; we included both sets of data. Since Ekstrand *et al*[12] reported separate injury incidence outcome metrics for matches played on grass and artificial turf, we included both sets of data. It was not possible to include data from Giza *et al*[15] in any meta-analyses. Therefore, in total, 11 data sets were available for potential aggregation. All studies used a 'time-loss' injury definition, with the study by Babwah[48] being the only study to present some 'all physical complaints' injury incidence outcome metrics.

Elite club football: IIRs

Data from 8, 7 and 7 'time-loss' injury definition data sets could be aggregated for overall, match and training IIRs, respectively. The overall, match and training IIRs were, 5.63/1000 hours (95% CI 4.03 to 7.86), 19.07/1000 hours (95% CI 13.73 to 26.47) and 3.27/1000 hours (95% CI 2.15 to 4.96), respectively (table 1).

Elite club football: location of injury

Data from up to six 'time-loss' injury definition data sets could be aggregated for overall IIR stratified by location of injury

Table 1 Women's elite football: overall, match and training IIR (per 1000 hours of exposure)

Description		Poisson regression meta-analysis						
Category	Injury definition	Model	K	Summary incidence rate	95% CI	χ^2_{Wald}	T^2	I^2
Overall	Time-loss	Random	8	5.63	4.03 to 7.86	177.28 (p<0.001)	0.225	97.61%
Match	Time-loss	Random	7	19.07	13.73 to 26.47	66.73 (p<0.001)	0.181	93.92%
Training	Time-loss	Random	7	3.27	2.15 to 4.96	121.08 (p<0.01)	0.30	96.25%

T^2, tau-squared estimate (ie, the variance of true IIRs) ; I^2, I^2 statistic (ie, the proportion of observed variation that is attributable to true, between-study variation).
IIRs, injury incidence rates .

(head and neck; trunk; upper limb; lower limb). The location of injury with the highest overall IIR was the lower limb (4.54/1000 hours; 95% CI 3.97 to 5.19) (table 2).

It was possible to aggregate match data for 'time-loss' injury stratified by location of injury. Data from up to three 'time-loss' injury definition data sets could be aggregated for match IIR stratified by location of injury. The lower limb was the location of injury with the highest match IIR (11.52/1000 hours; 95% CI 9.97 to 13.32) (table 2).

Data from up to three 'time-loss' injury definition data sets could be aggregated for training IIR stratified by location of injury. The location of injury with the highest training IIR was the lower limb (2.33/1000 hours; 95% CI 2.03 to 2.68) (table 2).

Elite club football: type of injury

Three 'time-loss' data sets could be aggregated for overall IIR, stratified by type of injury (fractures and bone stress; joint and ligaments; muscle and tendon; contusion; laceration and skin lesion; central nervous system (CNS)/peripheral nervous system (PNS); other injuries). Muscle and tendon injuries had the highest overall IRR (2.70/1000 hours; 95% CI 1.12 to 6.50) (table 3). Data from two 'time-loss' injury definition data sets could be aggregated for match IIR stratified by type of injury. The type of injury with the highest match IIR was joint and ligaments injury (5.31/1000 hours; 95% CI 3.89 to 7.23) (table 3). Data from two 'time-loss' injury definition data sets could be aggregated for training IIR stratified by type of injury. The type of injury with the highest training IIR was muscle and tendon injury (1.10/1000 hours; 95% CI 0.82 to 1.48) (table 3).

Elite club football: severity of injury

Data from up to 4 'time-loss' injury definition data sets could be aggregated for overall IIR stratified by severity of injury (slight; minimal; mild; moderate; severe). Moderate injuries had the highest overall IIR (1.64/1000 hours; 95% CI 1.40 to 1.92) (online supplemental file 6). Data from two 'time-loss' injury definition data sets could be aggregated for match IIR stratified by severity of injury. Minimal injuries had the highest match IIR (4.51/1000 hours; 95% CI 3.22 to 6.31) (online supplemental file 6). Data from two 'time-loss' injury definition data sets could be aggregated for training IIR stratified by severity of injury. Mild and moderate injuries had the highest training IIRs (both 0.88/1000 hours; 95% CI 0.64 to 1.22) (online supplemental file 6).

International football

Data from five international women's football injury surveillance studies were included.[19 27 51–53] Junge *et al*[52] reported on some 'all physical complaints' injury incidence outcome metrics from the 1999 Women's World Cup and 2000 Olympic Games. Junge *et al*[53] reported on some 'all physical complaints' injury incidence outcome metrics from the 2004 Olympic Games. Junge and Dvorak[19] reported on some 'all physical complaint' injury incidence outcome metrics from the 2003 Women's World Cup, the 2002 and 2004 FIFA U-19 Women's World Championships, as well as the 2006 FIFA U-20 Women's World Championships. Hägglund *et al*[51] reported on some 'time-loss' injury incidence outcome metrics from the 2006, 2007 and 2008 UEFA U-19 Women's European Championships. Waldén *et al*[27] reported on some 'time-loss' injury incidence outcome metrics for the

Table 2 Women's elite football: overall, match and training IIRs (per 1000 hours of exposure) stratified by location of injury

Description			Poisson regression meta-analysis						
Category	Injury definition	Anatomical location	Model	K	Summary incidence rate	95% CI	χ^2_{Wald}	T^2	I^2
Overall	Time-loss	Head and neck	Random	5	0.35	0.26 to 0.48	6.65 (p=0.16)	0.031	26.46%
Overall	Time-loss	Upper limb	Random	6	0.18	0.11 to 0.30	12.62 (p=0.027)	0.193	55.69%
Overall	Time-loss	Trunk	Random	5	0.35	0.22 to 0.55	9.40 (p=0.052)	0.141	61.74%
Overall	Time-loss	Lower limb	Random	6	4.54	3.97 to 5.19	27.30 (p<0.001)	0.021	77.19%
Match	Time-loss	Head and neck	Fixed	2	1.06	0.53 to 2.12	0.31 (p=0.58)	NA	NA
Match	Time-loss	Upper limb	Fixed	3	0.25	0.09 to 0.67	0.09 (p=0.96)	NA	NA
Match	Time-loss	Trunk	Fixed	2	0.66	0.28 to 1.59	0.01 (p=0.99)	NA	NA
Match	Time-loss	Lower limb	Fixed	3	11.52	9.97 to 13.32	0.49 (p=0.78)	NA	NA
Training	Time-loss	Head and neck	Fixed	2	0.17	0.08 to 0.36	0.69 (p=0.41)	NA	NA
Training	Time-loss	Upper limb	Fixed	3	0.11	0.05 to 0.20	3.69 (p=0.16)	NA	NA
Training	Time-loss	Trunk	Fixed	2	0.05	0.01 to 0.20	0.01 (p=0.99)	NA	NA
Training	Time-loss	Lower limb	Fixed	3	2.33	2.03 to 2.68	1.44 (p=0.49)	NA	NA

T^2, tau-squared estimate (ie, the variance of true IIRs); I^2, I^2 statistic (ie, the proportion of observed variation that is attributable to true, between-study variation).
IIRs, injury incidence rates; NA, not available.

Table 3 Women's elite football: overall, match and training IIRs (per 1000 hours of exposure) stratified by type of injury

Description			Poisson regression meta-analysis						
Category	Injury definition	Injury type	Model	K	Summary incidence rate	95% CI	χ^2_{Wald}	T^2	I^2
Overall	Time-loss	Fractures and bone stress	Random	3	0.43	0.10 to 1.82	28.39 (p<0.001)	1.38	87.45%
Overall	Time-loss	Joint and ligaments	Random	3	2.62	1.26 to 5.46	32.65 (p<0.01)	0.38	91.31%
Overall	Time-loss	Muscle and tendon	Random	3	2.70	1.12 to 6.50	57.45 (p<0.001)	0.568	94.35%
Overall	Time-loss	Contusion	Random	3	0.76	0.55 to 1.03	2.51 (p=0.29)	0.10	23.43%
Overall	Time-loss	Laceration and skin lesion	Random	3	0.07	0.003 to 1.33	11.95 (p<0.01)	4.62	84.51%
Overall	Time-loss	CNS/PNS	Random	3	0.23	0.13 to 0.41	1.68 (p=0.43)	0.05	21.62%
Overall	Time-loss	Other injuries	Random	3	0.17	0.09 to 0.34	1.62 (p=0.44)	0.08	26.79%
Match	Time-loss	Fractures and bone stress	Fixed	2	0.13	0.02 to 0.94	0.01 (p=0.99)	NA	NA
Match	Time-loss	Joint and ligaments	Fixed	2	5.31	3.89 to 7.23	0.13 (p=0.72)	NA	NA
Match	Time-loss	Muscle and tendon	Fixed	2	3.32	2.24 to 4.91	0.19 (p=0.66)	NA	NA
Match	Time-loss	Contusion	Fixed	2	3.45	2.35 to 5.06	0.04 (p=0.85)	NA	NA
Match	Time-loss	Laceration and skin lesion	Fixed	2	0.13	0.02 to 0.94	0.01 (p=0.99)	NA	NA
Match	Time-loss	CNS/PNS	Fixed	2	0.93	0.44 to 1.95	0.02 (p=0.89)	NA	NA
Match	Time-loss	Other injuries	Fixed	2	0.53	0.19 to 1.40	0.01 (p=0.99)	NA	NA
Training	Time-loss	Fractures and bone stress	Fixed	2	0.20	0.10 to 0.39	0.10 (p=0.75)	NA	NA
Training	Time-loss	Joint and ligaments	Fixed	2	1.08	0.80 to 1.45	4.53 (p=0.03)	NA	NA
Training	Time-loss	Muscle and tendon	Fixed	2	1.10	0.82 to 1.48	1.92 (p=0.17)	NA	NA
Training	Time-loss	Contusion	Fixed	2	0.32	0.19 to 0.55	0.02 (p=0.90)	NA	NA
Training	Time-loss	Laceration and skin lesion	Fixed	2	NA*	NA*	NA	NA	NA
Training	Time-loss	CNS/PNS	Fixed	2	0.10	0.04 to 0.26	0.20 (p=0.66)	NA	NA
Training	Time-loss	Other injuries	Fixed	2	0.10	0.04 to 0.26	5.50 (p=0.02)	NA	NA

T^2, tau-squared estimate (ie, the variance of true IIRs) ; I^2, I^2 statistic (ie, the proportion of observed variation that is attributable to true, between-study variation).
*Zero events reported in studies included in this meta-analysis, thus yielding no summary effect estimate.
CNS, central nervous system; IIRs, injury incidence rates; NA, not available; PNS, peripheral nervous system.

2005 UEFA Women's European Championships. Seven data sets were available for potential aggregation using an 'all physical complaints' injury definition, with four data sets being available for potential aggregation using a 'time-loss' injury definition.

International football: IIRs

Data from four 'time-loss' injury definition data sets could be aggregated for overall, match and training IIRs, respectively. The overall, match and training IIRs were, 9.28/1000 hours (95% CI 7.22 to 11.93), 22.78/1000 hours (95% CI 17.07 to 30.42) and 3.30/1000 hours (95% CI 1.99 to 5.47), respectively (table 4). Data from seven 'all physical complaints'injury definition data sets could be aggregated for match IIR; the match IIR was 67.39/1000 hours (95% CI 61.00 to 74.45) (table 4).

International football: location of injury

Data from two 'all physical complaints' injury definition data sets could be aggregated for match IIR stratified by location of injury (head and neck; trunk; upper limb; lower limb). The location of injury with the highest match IIR was the lower limb (42.16/1000 hours; 95% CI 31.77 to 55.95) (table 5).

International football: type of injury

Data from two 'all physical complaints' injury definition data sets could be aggregated for overall IIR stratified by type of injury (fractures and bone stress; joint and ligaments; muscle and tendon; contusion; laceration and skin lesion; CNS/PNS; other injuries). The type of injury with the highest overall IIR was joint and ligaments injury (16.69/1000 hours; 95% CI=10.65 to 26.16) (table 6).

International football: severity of injury

Data from four 'time-loss' injury definition data sets could be aggregated for overall IIR stratified by severity of injury (slight; minimal; mild; moderate; severe). Minimal injuries had the highest overall IIR (5.02/1000 hours; 95% CI 3.57 to 7.07) (online supplemental file 6). Data from two 'all physical complaints' injury definition data sets could be aggregated for match IIR stratified by severity of injury (slight, minimal, mild, moderate and; severe). Slight injuries had the highest match IIR (33.38/1000 hours; 95% CI 24.29 to 45.87) (online supplemental file 6).

Study quality

We mapped all included studies to the 'checklist of issues that should be included in reports of studies of football injuries'

Table 4 Women's international football: overall, match and training injury incidence rates (per 1000 hours of exposure)

Description		Poisson regression meta-analysis				
Category	Definition	Model	K	Summary incidence rate	95% CI	χ^2_{Wald}
Overall	Time-loss	Fixed	4	9.28	7.22 to 11.93	6.42 (p=0.093)
Match	Time-loss	Fixed	4	22.78	17.07 to 30.42	4.22 (p=0.24)
Match	All physical complaints	Fixed	7	67.39	61.00 to 74.45	23.85 (p<0.001)
Training	Time-loss	Fixed	4	3.30	1.99 to 5.47	7.30 (p=0.063)

Table 5 Women's international football: match injury incidence rates (per 1000 hours of exposure) stratified by location of injury

Description			Poisson regression meta-analysis				
Category	Injury definition	Anatomical location	Model	K	Summary incidence rate	95% CI	χ^2_{Wald}
Match	All physical complaints	Head and neck	Fixed	2	13.18	7.94 to 21.85	0.59 (p=0.44)
Match	All physical complaints	Upper limb	Fixed	2	5.27	2.37 to 11.73	0.10 (p=0.75)
Match	All physical complaints	Trunk	Fixed	2	1.76	0.44 to 7.02	0.03 (p=0.85)
Match	All physical complaints	Lower limb	Fixed	2	42.16	31.77 to 55.95	1.26 (p=0.26)

(amended from Fuller *et al*[39]) (table 7). All studies included in our review specified study design, duration of study, organisational setting, gender of players, level of play and geographical location. Twelve per cent of the included studies did not include a definition of injury, involve medical personnel, clarify the frequency of recording of injuries, and specify the number of match injuries. Twenty-four per cent of the studies did not specify the number of teams or number of players included and the frequency of recording of exposure data. Thirty-five per cent of the studies did not confirm whether training was provided to club/national team staff to improve the quality of data collection and did not specify the number of training injuries. Forty per cent did not include the age range of the players. Forty-one per cent and 59% of the studies did not include the number of match exposures and the number of training exposures, respectively.

DISCUSSION

We performed a systematic review and meta-analyses (where possible) to quantify IIRs in senior women's football (amateur club, elite club and international). Our analyses indicated that when using a 'time-loss' definition of injury, overall, match and training IIRs are similar between senior women's international football (overall, match and training IIRs were 9.28/1000 hours, 22.78/1000 hours and 3.30/1000 hours, respectively) and senior women's elite club football (overall, match and training IIRs were, 5.63/1000 hours, 19.07/1000 hours and 3.27/1000 hours, respectively). It was not possible to perform meta-analyses for the data extracted from the two included studies on senior women's amateur club football.

Injury incidence rates

Our meta-analyses showed that the overall, match and training 'time-loss' IIRs for women's elite club football were 5.63/1000 hours, 19.07/1000 hours and 3.27/1000 hours, respectively. López-Valenciano *et al*[45] reported that the overall, match and training 'time-loss' IIRs in men's elite club football (ie, professional national leagues) were 7.5/1000 hours, 32.3/1000 hours and 3.8/1000 hours, respectively. Thus it appears that training 'time-loss' IIRs in men's and women's elite club football are similar, but that match 'time-loss' IIRs in men's football are substantially higher.

A potential reason for the differences in match 'time-loss' IIRs between men's and women's elite club football could be attributed to the higher sprinting demands in men's football[55 56] (although direct comparisons are limited by the lack of consensus on speed thresholds in women's elite club football),[3] the high number of contact injuries in men's elite club football,[16 21 52] and the provision of better medical support in men's elite club football—leading to earlier and more accurate injury diagnoses.[21 57]

Our meta-analyses showed that the overall, match and training 'time-loss' IIRs for women's international football were 9.28/1000 hours, 22.78/1000 hours and 3.30/1000 hours, respectively. López-Valenciano *et al*[45] reported that the overall, match and training 'time-loss' IIRs in men's international tournaments were 9.8/1000 hours, 41.1/1000 hours and 3.5/1000 hours, respectively. The same pattern emerges in international football as in elite club football, with similar 'time-loss' training IIRs between men's and women's international football but a substantially higher 'time-loss' match IIR in men's compared with women's international football. The reasons for the differences in 'time-loss' match IIRs between men's and women's international football are likely to be similar to those already discussed for elite club football.

Our analyses indicate that when a 'time-loss' injury definition is used, women's elite club football and women's international football have similar match IIRs (19.07/1000 hours vs 22.78/1000 hours, respectively). This is surprising, as previous research has highlighted that international players reach higher velocities and complete longer distances at high speed and sprinting intensities than domestic elite club players.[4 9 58 59]

In contrast, 'time-loss' match IIRs for men's professional club (ie, elite) and men's international football are not completely comparable, with IIRs of 32.3/1000 hours and 41.1/1000 hours, respectively, being reported in published literature.[45] We speculate that this difference between men's and women's data could be explained by the fact that during a typical season, men's elite clubs play 50–60 matches,[60 61] with international players then competing in international tournaments involving a congested

Table 6 Women's international football: match injury incidence rates (per 1000 hours of exposure) stratified by type of injury

Description			Poisson regression meta-analysis				
Category	Injury definition	Injury type	Model	k	Summary incidence rate	95% CI	χ^2_{Wald}
Match	All physical complaints	Fractures and bone stress	Fixed	2	0.88	0.12 to 6.24	0.01 (p=0.99)
Match	All physical complaints	Joint and ligaments	Fixed	2	16.69	10.65 to 26.16	3.54 (p=0.06)
Match	All physical complaints	Muscle and tendon	Fixed	2	10.54	5.99 to 18.56	2.43 (p=0.12)
Match	All physical complaints	Contusion	Fixed	2	15.81	9.96 to 25.09	5.87 (p=0.02)
Match	All physical complaints	Laceration and skin lesion	Fixed	2	3.51	1.32 to 9.36	0.01 (p=0.99)
Match	All physical complaints	CNS/PNS	Fixed	2	3.51	1.32 to 9.36	0.07 (p=0.79)
Match	All physical complaints	Other injuries	Fixed	2	6.15	2.93 to 12.90	0.01 (p=0.99)

CNS, central nervous system; PNS, peripheral nervous system.

Table 7 Checklist of issues that should be included in reports of studies of football injuries (amended from Fuller *et al*)[39]

	Studies																
	McNoe and Chalmers[54]	Jacobson and Tegner[50]	Ibikunle *et al*[49]	Babwah[48]	Nilstad *et al*[23]	Giza *et al*[15]	Ekstrand *et al*[12]	Gaulrapp *et al*[17]	Hägglund *et al*[51]	Tegnander *et al*[26]	Jacobson and Tegner[18]	Faude *et al*[14]	Hägglund *et al*[51]	Waldén *et al*[27]	Junge and Dvorak[19]	Junge *et al*[53]	Junge *et al*[52]
Study design	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Duration of study	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Organisational setting	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Geographical location	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
No of teams	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗
No of players	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗
Age range of players	✓	✓	✓	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗
Gender of players	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Level of play	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Medical personnel involved	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓
Frequency of recording injuries	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✓	✓	✓	✓	✓
Frequency of recording exposure data	✓	✓	✗	✗	✓	✗	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓
Training to improve the quality of data collection	✓	✓	✓	✗	✓	✗	✓	✗	✓	✗	✓	✗	✓	✓	✓	✓	✗
Definition of injury	✓	✓	✓	✓	✓	✗	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓
Definition of exposure	✓	✓	✗	✗	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✗	✓
No of match exposures	✗	✗	✓	✓	✗	✗	✓	✗	✓	✓	✓	✗	✓	✓	✗	✓	✓
No of match injuries	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓
No of training exposures	✗	✗	✓	✗	✗	✗	✓	✗	✓	✓	✓	✗	✓	✓	✗	✗	✗
No of training injuries	✓	✓	✓	✗	✓	✗	✓	✓	✓	✓	✓	✗	✓	✓	✗	✗	✗

match fixture list at the end of the season. The accumulation of fatigue at the end of the season may heighten the risk of injury during men's international tournaments. In comparison, women's elite clubs play 20–40 games during the season,[12 14–18 23 26 48 49] and thus may be able to better tolerate the loads of international tournaments at the end of the season.

A majority of time in women's football is spent training but, similar to the results of the UEFA male elite club injury study,[62] our analyses show that 'time-loss' training IIRs in women's elite club football (3.27/1000 hours) and women's international football (3.30/1000 hours) are approximately 6–7 times lower than their equivalent match IIRs (elite club=19.07/1000 hours; international=22.78/1000 hours). It is possible that the composition of training sessions at elite club and international levels of the women's game do not prepare players sufficiently for the physical demands of match play.

Injury location

Our meta-analysis of women's elite club football studies showed overall highest to lowest 'time-loss' IIRs by location main grouping as follows: lower limbs, head and neck, trunk, and upper limbs. The pattern that López-Valenciano *et al*[45] reported in their meta-analysis of overall 'time-loss' IIRs stratified by location main grouping in men's elite club football were, from highest to lowest: lower limbs, trunk, upper limbs and head and neck. The biggest difference between men's and women's football IIRs stratified by location main grouping is that head and neck injuries are the least common in men's elite club football but they are the second most common in women's elite club football and women's international football.

Fuller *et al*[63] examined all head injuries from multiple FIFA competitions and reported that concussions accounted for 22% of head and neck injuries in female players but only 8% of head and neck injuries in male players, with associated IIRs of 2.6/1000 hours in women's football and 1.1/1000 hours in men's football. Fuller *et al*[63] speculated that risk factors for head and neck injuries in female players may include the greater head-neck segment peak angular acceleration and displacement in females than in males when heading the ball, as well as females' lower levels of isometric neck strength, neck girth and head mass—resulting in lower levels of head-neck segment stiffness. There is a need for high-quality longitudinal prospective studies to investigate risk factors for head and neck injuries in women's football. Of interest, many of the injury surveillance studies in women's football included in our review were conducted prior to the introduction of the rule change whereby a straight red card (ie, sent off) is now received by a player for deliberate elbow-to-head contact. There is evidence from men's elite football that this rule change led to a 29% reduction in head injuries in the first German Bundesliga.[64]

Injury type

Our meta-analysis of women's elite club football studies[12 49] showed overall 'time-loss' IIRs for injury type of 2.70/1000 hours for muscle and tendon, 2.62/1000 hours for joint and ligaments, 0.76/1000 hours for contusion, 0.43/1000 hours for fractures and bone stress, and 0.23/1000 hours for CNS/PNS injuries. In their meta-analysis of injuries in men's professional football, López-Valenciano *et al*[45] reported 'time-loss' IIRs for injury type of 4.6/1000 hours for muscle and tendon, 1.4/1000 hours for contusion, 0.6/1000 hours for other injuries, 0.4/1000 hours for joint and ligaments, and 0.2/1000 hours for fractures and bone stress. Muscle and tendon injuries are the most common overall injury type in women's elite club football with an IIR of 2.70/1000 hours, but we urge caution as this finding is based on aggregation of data from only two studies. However, it would appear that the combined findings of data stratified by injury location main grouping and injury type suggest that muscle and tendon injuries of the lower limb (and particularly the thigh) are a primary problem in women's elite club football. This may be due to the higher running demands in women's elite club football in comparison to lower levels of the game.[4 9 59 65]

Despite an 'all physical complaints' injury definition being used in women's international football[52 53] and a 'time-loss' injury definition being used in women's elite club football,[12] the same match IIR pattern emerges for injury types. In women's international football, our meta-analysis shows that the five injury types with the highest match IIRs are: joint and ligaments (16.69/1000 hours), contusions (15.81/1000 hours), muscle and tendons (10.54/1000 hour), other injuries (6.15/1000 hours) and CNS/PNS injuries (3.51/1000 hours). In women's elite club football, our meta-analysis shows that the five injury types with the highest match IIRs injury are: joint and ligaments (5.31/1000 hours), contusions (3.45/1000 hours), muscle and tendons (3.32/1000 hours), CNS/PNS injuries (0.93/1000 hours) and other injuries (0.53/1000 hours).

Injury severity

Comparisons between overall 'time-loss' injury severity IIRs in women's elite club football and women's international football were possible. The majority of injuries in international football were of minimal severity (IIR 5.26/1000 hours),[27 51] whereas the IIRs for minimal, mild and moderate injuries in elite club football were 1.21/1000 hours, 1.26/1000 hours and 1.64/1000 hours, respectively.[12 16 18] It is possible that the high IIR of minimal severity injuries in women's international football in comparison to women's elite club football could be due to a higher level of medical care at international level versus elite club level. The FIFA Benchmarking Report in women's football in 2021 highlighted the gaps in medical care at elite club level by showing that of the 30 elite-level women's football leagues and their respective clubs surveyed, 30% did not have access to a doctor and 26% did not have access to a physiotherapist.[66] Greater access to medical care at international level might mean that more minimal injuries are diagnosed and treated.[19]

Despite an 'all physical complaints' injury definition being used in international match data[52 53] and a 'time-loss' injury definition being used in elite club match data,[12] the same pattern of match injury severity emerges. In women's international football, our meta-analysis shows that match injury severity IIRs are slight (33.38/1000 hours), minimal (14.05/1000 hours), mild (6.15/1000 hours), moderate (6.15/1000 hours) and severe (0.88/1000 hours). In women's elite club football our meta-analysis shows that match injury severity IIRs are minimal (4.51/1000 hours), moderate (3.85/1000 hours), mild (3.45/1000 hours) and severe (2.12/1000 hours).

Injury definitions

In the consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries, Fuller *et al*[39] defined an 'all physical complaints' injury as any injury sustained by a player that results from a football match or football training, irrespective of the need for medical attention or time-loss from football activities. An injury that results in a player receiving medical attention is referred to as a 'medical attention' injury, and an injury that results in a player being unable

to take a full part in future football training or match play as a 'time-loss' injury. Online supplemental file 7 outlines the injury definitions used in all the studies included in our review. Best practice, as per the consensus statement,[39] includes the simultaneous reporting of injury outcome metrics for 'all physical complaints', 'medical attention' and 'time-loss' injuries. The two amateur club studies included in our review used a 'time-loss' and a 'hybrid' (ie, does not satisfy the criteria for classification as 'all physical complaints' or 'time-loss') injury definition, respectively.[50 54] Ninety per cent of the elite club studies used a 'time-loss' injury definition. Of the 11 international data sets included in our analyses, 4 (36%) used a 'time-loss' injury definition and 7 (64%) used an 'all physical complaints' injury definition. As specified by Fuller *et al*,[39] we would endorse the comprehensive and transparent reporting of injury outcome metrics, categorised by injury definition to reflect the true nature of injuries incurred during training and match play.

Injury reporting mechanisms

Fuller *et al*[39] recommend that injury report forms should be completed by medical professionals after each recordable injury. The two amateur club studies in our review used a player self-report system to record injuries.[50 54] This is to be expected at the amateur level of the game due to the lack of medical resources available to teams. Seventy-per cent of the elite club studies used a medical staff registration system, 10% used a player self-report system, 10% used a player self-report and medical staff registration system, and 10% used a trainer, coach and medical staff registration system to record injuries (online supplemental files 3 and 8). All international studies used a medical staff registration system.

Study quality

The rationale for the development of the consensus statement on data collection procedures in studies of football (soccer) injuries was to enhance the scientific rigour of football injury surveillance studies.[39] By following the recommendations in the consensus statement, consistency in data collection is ensured, which allows for accurate comparisons to be made across injury surveillance studies from different geographical locations and levels of the game. More than 1 in 10 of the studies included in our review did not include a definition of injury (table 7). We suggest that sufficient data should be reported in studies to allow independent verification of the outcome metrics presented; in the case of IIR data, this would include the reporting of the number of injuries (eg, the number of injuries sustained during matches) and the total exposure hours (eg, number of match exposure hours).

Statistical analysis

There is evidence of considerable heterogeneity as measured by I^2, between the studies included in several of our meta-analyses ($I^2>75\%$, Wald χ^2 $p<0.05$). This suggests that a large proportion of variability in the IIR estimates is due to real study differences and not chance. This reflects the scatter of study IIR estimates with little overlap in their confidence intervals within some of the analysis models, as seen in online supplemental file 5. Tau estimates are a helpful absolute measure to understand the variance in the true IRR range around the summary/pooled IIR. Overall, when interpreting Tau estimates for the random-effects meta-analyses included in our review, it is clear that there is not a lot of variability in true IIR around the summary/pooled IIR (despite medium-to-high I^2 values).

Future directions

Randomised controlled trials (RCTs) are required to establish the efficacy of injury prevention and performance enhancement programmes in women's football.[67] However, it may be unrealistic to undertake high quality, methodologically rigorous RCTs in women's elite club football, due to the time, money, equipment and energy required, all of which can be compounded by difficulties in accessing players and coaches who are willing to engage in the research.[68] To overcome this, Minas *et al*[69] suggested that the development of a relevant evidence-base can be established using expert consensus techniques. McCall *et al*[70] undertook a Delphi survey of 21 experienced practitioners in the big-5 men's leagues in Europe (England, Germany, Spain, Italy, France), with the objective of informing muscle injury prevention strategies. A similar Delphi survey of experienced practitioners in women's elite club football would provide valuable insight in to current best practice and could help to inform key priorities for injury prevention in women's football. We also think it is critical that players and medical personnel involved in the different levels of senior women's football are consulted when developing consensus on the design and implementation of user friendly and pragmatic injury risk reduction systems.[71]

Including a generic injury prevention and performance enhancement programme (eg, FIFA 11+, Prevent Injury and Enhance Performance, Knäkontroll) in the training week for women's amateur club football seems like a prudent approach to take for all coaches at the amateur level of the game, due to the evidence supporting their use in adolescent and college-level female footballers.[67 72] At international level, the challenge is the integration of players from a variety of clubs in to a different training environment with the added complications of fixture congestion, travel and time-zone differences. In this environment it is critical that there are ongoing and clear communication lines between international and club coaching, medical and fitness staff.[73 74] Practical solutions to this challenging scenario involve collaboration between club and international teams' staff in relation to readiness to play and training status, overall load management, injury prevention and/or strength programmes, and nutrition strategies.[73 74]

Limitations

As part of our data extraction template, we only documented data related to location of injury stratified by main grouping and type of injury stratified by main grouping (online supplemental file 2). Future data aggregation studies should also include data related to location of injury stratified by category and type of injury stratified by category. The low number of studies included in the meta-analyses is explained by differences in injury and severity definitions and variations in data collection methods. The lack of data on number of days lost per injury within the included studies meant that it was not possible to report on injury burden.

CONCLUSIONS

When a 'time-loss' definition of injury is used, overall, match and training IIRs are similar between women's elite club football and women's international football. 'Time-loss' training IIRs in women's elite club football and women's international football are approximately 6–7 times lower than their equivalent match IIRs. Consideration should be given to the design of training sessions to ensure that players are sufficiently prepared for the physical demands of match play. Injuries to the lower limb, and head and neck have the

highest IIRs in both women's elite club football and women' international football. The prevention of lower limb joint and ligament and muscle, and tendon injuries should be a central focus of injury prevention interventions in senior women's football.

What is already known?

⇒ Injury in amateur club, elite club and international women's football is common.
⇒ Knee, ankle and thigh injuries are frequently injured locations in women's football.
⇒ Severe injuries to the lower extremity are incurred in women's football but it has not been possible to calculate injury burden in the majority of studies on women's football to date.

What are the new findings?

⇒ 'Time-loss' overall, match and training IIRs are similar between women's elite club football and women's international football.
⇒ Women's elite club football studies showed overall highest to lowest 'time-loss' IIRs by location main grouping as follows: lower limbs, head and neck, trunk, and upper limbs.
⇒ The injury types with the highest IIRs in women's elite club and international football are joint, ligament, contusion, muscle and tendon injuries.
⇒ Muscle and tendon injuries of the lower limb (and particularly the thigh) are a primary problem in women's elite club football.
⇒ Training 'time-loss' IIRs in women's elite club football and women's international football are approximately 6–7 times lower than their equivalent match IIRs.
⇒ The majority of injuries in women's international football are of minimal severity, whereas the IIRs of minimal, mild and moderate injuries in women's elite club football are similar.

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Contributors DH and ED are the guarantors of the review. ED developed the eligibility criteria. DH, FB and ED developed the search strategy. DH and ED performed abstract, title and full-text screening. Any discrepancies in study selection were arbitrated by MH. DH and ED performed data extraction, with any discrepancies arbitrated by MH. Statistical expertise was provided by FB and CB. Contextual expertise on football was provided by DH, SK, and MH. All authors approved the final protocol.

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